

# THE COMPREHENSIVE EVALUATION OF MANAGEMENT DECISION EFFICIENCY

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**Abstract:** *The article presents an approach to the construction of the integral index of management decision efficiency. The concept of efficiency examines and defines the algorithm of the index construction that contains of five stages. The feature of the proposed approach is the simultaneous use of metric and non-metric partial criteria of efficiency. Here quantitative indicators were built on metric components, and non-metric components were used to refine weight coefficients. The paper also presents an approach to the interpretation of the results of an integrated evaluation of an alternative efficiency with the definition of the degree of decision acceptability, in which is substantiated the expediency of introducing a special coefficient into the construction procedure. Also it is established the correspondence between an integral index scale and Harrington's scale, in which the degree of desirability is shown in verbal form, which is very convenient to illustrate the results which submit the projection rule of constructed integral values on the scale of desirability.*

**Keywords:** *management decisions, integral index, efficiency, additive convolution, Harrington's scale, interpretation of the integral index.*

## INTRODUCTION

In developing management decisions it is important to evaluate the current situation truly for alternative decisions and to identify the characteristics of an effective decision that meets the company's objectives. The term "management decision efficiency" describes the degree of usefulness of predicted or actually received results as the decision effect. Herein, effect is a certain result of implementation of a decision. Promising direction in evaluating the decisions efficiency is to build a composite index.

A significant contribution to the development of mathematic models of building process integrated parameter performed by S.°Ayvasyan [1], M.°Anielski [2], P.°Aven, I.°Muchnik, A.°Oslo [3], F.°Borodkin [4], M.°Khovanov [5], M.°Nardo, M.°Saisana, A.°Saltelli [6], P.°Zhou, W.°Ang [12] and others.

The theoretical basis for integrated assessment of latent qualities make scientific advances in the field of quality control, theory of utility functions, construction of economic and social indicators, correlation and regression analysis, multivariate statistical analysis, such as the reduction of dimension, multidimensional scaling, discriminant analysis [1, 3-6, 9-11].

## MATERIALS AND METHODS

It is possible to distinguish the following approaches to the integral index construction depending on the forms of benchmark representations adopted among the general ones [9]:

- The criteria approach: If the benchmarks have evaluation character and aggregates of objects are the alternatives which have to be chosen then the best decision is regarding these alternatives and accepting some alternatives according to some criteria but they are not acceptable bases for others;

- The discrimination approach: If the benchmarks are represented in the form of "object-quality", and some structure, which determine relations between objects, is dividing them into classes which do not intersect the given facts;

- The conclusive approach: If the matrix of symmetrical binominal ratios plays the role of the benchmarks;
- The expert and statistic approach: If the data represent the results of expert evaluation of the researched qualities.

## RESULTS

Proposing the improved criteria approach to the construction of the integral index by considering both metric and non-metric criteria [7], the initial data for the calculation will perform correlation matrix of partial factors. The integral index is interpreted as some latent quality, reflecting the effectiveness of partial criteria. In this case, the metric component of partial criteria will be used to calculate the numerical values of the integral index and non-metric for specification of weight coefficients. The procedure of construction the integrated parameter is implemented by next algorithm.

1) Defining the complex of indicators to be included as a partial criteria of the integral index:

$$X = \{X^{(1)} | X^{(2)}\} = \{X_1^{(1)}, X_2^{(1)}, \dots, X_{k_1}^{(1)}, X_1^{(2)}, X_2^{(2)}, \dots, X_{k_2}^{(2)}\}, \quad (1)$$

where  $X^{(1)} = \{X_i^{(1)}\}$ ,  $X^{(2)} = \{X_i^{(2)}\}$  – subsystems of metric and non-metric (ordinal) indicators severally,  $i=1,2,\dots, k_1$ ,  $i=1,2,\dots, k_2$ ;  $k_1, k_2$  – number of indicators in each subsystem,  $k_1+k_2=n$ .

2) Normalization of metric indicators for detection compliance between the increase of their values and better quality. This procedure is necessary in order to built integral index within [0, 1]. Assumed that the normalized aggregate has the same designation with an initial one.

3) Calculation of the correlation matrix R. Herein, according to relation nature and form between indicators is suggested to use the pair correlation coefficient, ratio correlation, ordinal coefficient, coefficient of concordance, index of associability, biserial coefficients, Gower's coefficient.

4) Building an integral index using the following five-stage procedure. The first stage is the calculation of the first principal component for the initial set of indicators. It corresponds to the first (largest modulo) own values correlation matrix R. In this case, it must satisfy the condition [1]:

$$\frac{\lambda_1}{\sum_{j=1}^{k_1} \lambda_j} \geq \delta_\lambda, \quad (2)$$

where  $\delta_\lambda$  – specified level of informativeness of the first principal component,  $\delta_\lambda$  – own values of the correlation matrix R,  $j=1, 2, \dots, n$ . Further carried out a calculation of factor loadings of the first principal components:

$$W = \{w_1^{(1)}, w_2^{(1)}, \dots, w_{k_1}^{(1)}, w_1^{(2)}, w_2^{(2)}, \dots, w_{k_2}^{(2)}\}. \quad (3)$$

The second step is proposed to identify the most significant factor loadings by the rule:

$$|w_{i_j}^{(j)}| \geq \delta, \quad (4)$$

where  $\delta$  – specified significance level;  $j=1, 2$ ;  $i_1=1, 2, \dots, k_1$ ;  $i_2=1, 2, \dots, k_2$ .

At the third step selected the initial criteria, that will be included as a partial indicator of integral index:

$$Y = \{Y^{(1)} | Y^{(2)}\} = \{X_s^{(1)}\} \cup \{X_t^{(2)}\}, \quad (5)$$

where  $Y^{(1)} = \{X_s^{(1)}\}$ ,  $Y^{(2)} = \{X_t^{(2)}\}$  – partial metric and non-metric indicators severally;  $s \in S$ ,  $t \in T$ ; S and T – sets of index numbers of metric and non-metric variables, for which performed the condition (4).

The first group will be directly used to build a quantitative value of the integral index. The second group will be used to refine the weighting coefficients of the components of the

first group. In the fourth stage carried out the calculation of weighting coefficients for metric components of integral index. Their values are obtained by taking into account the influence of non-metric indicators that were a part of the partial indicators:

$$\alpha'_j = \left| w_j \prod_{i \in T} r_{ij}^{(2)} \right| \quad (6)$$

where  $w_j$  - factor loading of the first principal components of  $j$ -th metric element of  $Y^{(1)}$ ,  $r_{ij}^{(2)}$  - pair correlation coefficient value between  $j$ -th metric element of  $Y^{(1)}$  and  $i$ -th metric element of  $Y^{(2)}$ ,  $i \in T, j \in S$ ;  $|z|$  - absolute value of  $z$ .

Inasmuch as the obtained values  $\alpha'_j$  totally may differ from unity, requires normalization:

$$\alpha_j = \frac{\alpha'_j}{\sum_{i \in S} \alpha'_i} \quad (7)$$

At the fifth stage, defined the integral index using additive convolution of partial metrics:

$$I = \beta \cdot \sum_j a_j \cdot X_j^{(1)} \quad (8)$$

Coefficient  $\beta$  is needed for improve the interpretation of the results.

5) Interpretation of the integral index. When comparing the efficiency of alternatives in terms of the acceptability of proposed decision we propose to use desirability Harrington's scale. Known, that it can determine the advantages of the measured characteristics based on its subjective perception. The basis of its construction is using the Harrington's function, which generally has the form:

$$d = \exp(-\exp(-z)) \quad (9)$$

where  $d$  - value of desirability scale,  $z$  - value of coded linguistic scale  $Z$ , located on some interval  $[-Z_1^*; Z_2^*]$ . Typically, these values are selected in the range from 3 to 6 on the basis of subjective considerations.

## DISCUSSION AND CONCLUSIONS

Project the value of the index  $I$  on the scale of desirability  $d$ . For this, carry out the matching of the values of scale  $I$  with values of coded linguistic scale  $[Z_1^*; Z_2^*]$ , the boundaries of which are elected on the basis of subjective considerations. Limit values  $Z_1^*$  and  $Z_2^*$  selected from the condition of the ensuring the accuracy of calculations. Convert the scale will be executed according to the formula:

$$z = I + Z_1^* \quad (10)$$

For select the coefficient  $\beta$  use the principle of rational compliance [8]. Its essence lies in the fact, that a decision, which can be considered as a very good for the integral indicator should have the same level for the Harrington's scale.

The minimum value of desirability scale  $d$  for the level of desirability of 'very good' is  $d = 0.8$ , which corresponds to  $z = 1$ . Represent the integral index as the product:

$$I = \beta \cdot I_1, \quad (11)$$

where  $I_1$  is an auxiliary index,  $0 \leq I_1 \leq 1$ .

Assuming that the value of the integral index  $I_1$  should also not be less than 0.8 for the category 'very good' and lower value of coded linguistic scale is  $Z_1^* = -2$ , we obtain  $\beta = 4.37$ . For the construction a table of conformity between the value of the integral index and quality of the decision for the estimated coefficient  $\beta$  can be use the relationship:

$$I_1 = \frac{z - Z_1^*}{\beta}, \quad (12)$$

where  $z$  corresponds to the respective limit value of coded linguistic scale.

Table 1

Conformity between quantitative values of integral index and its verbal values

The range of values for auxiliary index $I_1$	The range of values for integral index $I$	The range of values for Harrington's scale of desirability $d$	Desirability
0,00..0,35	0,00..1,52	0,00..0,20	Very bad
0,30..0,46	1,52..2,00	0,20..0,37	Bad
0,46..0,63	2,00..2,77	0,37..0,63	Acceptable
0,63..0,80	2,77..3,50	0,63..0,80	Good
0,80..1,00	3,50..4,38	0,80..1,00	Very good

We note that some properties built ranges of categories 'good' and 'very good' on the scale of desirability matching with corresponding ranges of the auxiliary integral index. According to our proposed principle of rational compliance the decision that belongs to the categories of 'good' and 'very good' in terms of scale of  $I_1$ , will have the same categories on the Harrington's scale. This is further evidence of our proposed approach evaluating the effectiveness of management decisions. The practical significance of the developed integral evaluation model of efficient management decisions lies in the fact that it is possible to determine not only the best alternative, but also to set the level of applicability for alternatives of choice as a decision. Decisions that were the best by an integrated evaluation does not satisfy the decision-maker can choose another, which may be worse on quality, but more sufficient and acceptable.

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