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Methods of aggregate assessment in project decisions

K e y   w o r d s: aggregate assessment, analysis of preferences, ranking method, scoring method, quotient standardisation method

S u m m a r y: The paper discusses the following: the preliminary notes, the analysis of preferences as a universal concept of aggregate assessment, the ranking method, the score method, the quotient standardisation method.

The preliminary notes give an interpretation of aggregate assessment. It consists in general assessment of the value of an object by combining individual assessment criteria into one entirety. Aggregate assessment has broad applications, in reference to both projects and processes, phenomena, and all types of objects. It is used in diagnostic research and in making decisions (related to, e.g., the selection of the optimum project variant).

Then, the analysis of preferences as a universal concept of aggregate assessment is provided. Analysis of preferences in common understanding is a research approach which consists in qualifying objects according to a specific scale, which is expressed in hierarchy of importance of the objects. This part of the text presents also the research process cycle. Its main components are: the object, a set of objects or a system, the values characteristic for the object, assessment criteria, aspects of preferences, the procedure of calculation of the weighted value of the object.

Then the ranking method is discussed which is used for qualification of projects (project variants) in the scale of natural numbers. The research workflow in the ranking method is as follows: 1) defining the ranking range, 2) collecting the data for ranking, 3) preferential organising (calculating total ranks, calculating averaged ranks, determining the position of the project in the ranking).

Then the score method is discussed along with its special form of the score aggregation. Qualification is done here, unlike in ranking, in the scale of real or integral numbers. The research proceedings in the score aggregation method follows the following steps: determining the universal formula for the weighted value, score standardisation for selection criteria, aggregate assessment (calculation of the IPP_i index), categorisation of the IPP_i index.

The basic text is concluded with the quotient standardisation method discussed. This method is the aggregate approach of the index-based assessment of projects. The essence of quotient standardisation is in unifying values of individual selection criteria by referring them to predefined

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master values. The central step in this method is calculation of the indexes Z_i and Z_i^*. They constitute the simple or weighted arithmetic mean of the aggregate assessment of the project. The project with the highest index is the optimum solution.

1. Preliminary notes

A g g r e g a t e   a s s e s s m e n t is a general assessment of the values of a certain object which consists in combining individual assessment criteria into one unity.[1] This value may be positive or negative and refers to various types of aspects, e.g. utilitarian, technical, economic, social, depending on what is the objective and the subject matter of the research.

The attitude represented by aggregate assessment is a multicriteria qualification of the given object, which means that it is subject to assessment with a larger number of criteria (at least two). This method of assessment is justified with the fact that multicriteria qualification is more complete than monocriteria assessment, thus giving a more comprehensive image of the actual condition or of the proposed solution.

The characteristic discriminant of aggregate assessment is the principle of merging individual criteria to get answer to the question about *general value of the object*. Perception of the object in one dimension, that is with only one criterion, gives a very limited view on its actual value. For example, limitation only to assessment of economic effectiveness of the investment or operational programme, bypassing the market and utilitarian aspects or technical functionality, will be basically different from the required scope of diagnostic research or from the competent selection of the project variant.

This paper presents in more detail the basic methods of aggregate assessment, namely: ranking, scoring, quotient standardisation. Moreover, attention has been paid to the problem of weighing assessment criteria, running the ranking and categorisation of projects.

It has to be noted that the presented methods of aggregate assessment have bidirectional references:

– one applies to comparative analysis in diagnostic research;
– the other is related to selection of the rational (optimum) project.

Comparative analysis in diagnostic research is aimed at assessment of the actual condition of the given object, which may be a company, an executed strategy, or any process or subsystem. Diagnostics may be expanded with assessment of external factors which constitute the surroundings of the studied object.

Comparative analysis focused on selection of the rational (optimum) variant applies to assessment of the projects of the proposed improvements which have been

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[1] The term "object" is treated here very broadly, including all types of things, processes, phenomena. It includes both existing and planned systems.

developed in reference to the shortcomings disclosed during diagnosis of the object. In this case, designing is based on the principle of "improving or perfecting the system."

Apart from the comparisons made on the set of proposed improvements, the analysis may be referred to another case which is a set of base projects, thus being new (original) solutions, developed on the principle of "creating from the scratch."

In the above directions of studies, the multi-criteria approach is recommended, that is both in diagnostics and in solving the project tasks. This approach has a definite substantial advantage over single-criterion approaches, thus the stipulation of binding individual assessment criteria in a complementary system. It is a problem of *type and quantity selection of assessment criteria*, which is one of the basic issues in the process of making project decisions.

2. Analysis of preferences as a universal concept of aggregate assessment

2.1. Framework approach to analysis of preferences

Analysis of preferences in common understanding is a research approach which consists in qualifying objects according to a specific scale, which is expressed in hierarchy of importance of the objects. This hierarchy is represented in the ordered (decreasing or increasing) preferential series. The need of qualifying objects is a natural necessity in measuring their share and significance in a specific community or system (economic, social, technical). The method of this measuring and its practical objectivisation constitute the essence of the presented concept.

Analysis of preferences as a management tool is a research approach used in diagnostics and designing technical, economic and organisational systems.[2] The general objective of this approach is multi-criteria aggregate assessment directed to both analytical and comparative studies, as well as to selection of variant solutions.

The basic methods of analysis of preferences in project management are ranking and scoring.[3]

T h e   r a n k i n g   m e t h o d is a procedure which consists in determining validity of a specific object in the given set for predefined aspects of preferences. Ranking is used for putting objects into series so that comparative and diagnostic studies could be run with a view on various premises and points of view. This method is also used

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[2] Apart from technical, economic and organisational applications, analysis of preferences is used in the marketing assessment of products, in sociological research and public opinion polls, in general statistics, didactics, sport.

[3] The auxiliary methods, mostly used for identification and diagnostics, are questionnaire studies, interviews, check lists.

in determining the order of priority, e.g. quality of organisational solutions, validity (significance) of production and market tasks, urgency of investment enterprises.

The scoring method in general consists in assessment of objects with points (in any scale of real numbers). Directing studies in this method applies to the following areas:

– comparative assessment;
– verifying assessment;
– varianting.

In the comparative opinion, scoring means qualification of validity of individual objects (systems, parameters, assessment criteria, etc.) in the context of the relationships between them. This type of assessment is also used in analysis of the effect of specific factors, for example, on effectiveness of an organisation and functioning of a company, an institution, a macroeconomic system, etc.

The verifying assessment performs a different role. It is a test which is used to prove to what degree the agreed requirements are respected by the given system. The verifying assessment answers to the questions whether the system is well organised (or improperly organised and to what degree), how it is functioning, what is its effectiveness (e.g. high, average, low).

Scoring in varianting has yet another meaning. In this case, the verifying assessment is run as well, yet not in the diagnostic nature but directed to selection of the rational (optimum) project solution. Assessment covers specific variants in the range specified by a set of selection criteria. Variants are subject to selection for their utilitarian suitability (functionality), project risk, and the scale of economic benefits.

It has to be noted that analysis of preferences is used along with standard research methods, e.g. with the index method for assessment of financial standing of a company, the discriminative analysis and the statistical standardisation methods.

2.2. The research process cycle

The main components of the cycle in the research process on analysis of preferences are:

1. The object;
2. The set of objects or the system;
3. The characteristic values of the object;
4. The assessment criteria;
5. The aspects of preferences;
6. The procedure of calculation of the weighted value of the object.

The object
The notion of the object has universal nature. It is regarded as the subject of research, e.g. a thing, a factor, a feature, a structure, a system, an element. In the commercial area, the object is the enterprise (the company), the organisation, the area of

activities, the management process, the product, the quality feature of the product and of the service, the type of resource. Specific external or internal effects and project solutions may also be the object. The term of the object thus extends to the "actual condition" and to all types of projects and models.

The set of objects or the system

The analysis of preferences is based on classification (typology) of any type of objects which may create a distributive or collective set. In the first case, the point is about classes or type groups of objects, in the second about constituent parts of the organised entireties. Industry-specific groups of companies, classifiers of all types of resources, stock exchange quotes of companies, currency exchange rates, commercial sectors, segments of the market, classes of products, etc., may be examples of distributive sets. The following may be listed as examples of collective sets: organisational units of a company, stage of the production process, functions of technical systems, a system of functional features of the product, organisation of country administration.

Knowledge of the structure of the objects is the condition necessary for conducting analysis of preferences, as it presents a conglomerate of components which are the subject matter of scheduling. This conglomerate, after turning into a set or a system constitutes the proper subject of study in comparative analysis as well as in diagnostics and procedures concerning selection of the rational variant of the project.

Characteristic values of the object

These are the features specific to a given object. They may be features of quantity or quality (specified quantitatively or in the nominal scale). The characteristic values assume the form of parameters and empirical or theoretical functions. They may have a descriptive or axiological form. In this last case, they are regarded as resulting values corresponding with the applied assessment criteria.

Assessment criteria

Assessment criteria are measures used to run diagnostic studies or performing the role of testers in project work in reference to selection of the rational (optimum) solution. In both cases, assessment is done but focused on separate areas of application. Assessment criteria are used in diagnosis for determination of the actual condition, while in project work they decide which variant is best. Assessment criteria are features or parameters of axiological (evaluative) nature.

Organising aspects

Organising aspects perform the function systematising various objects. These aspects may be divided into: classification and preferential. *Classification aspects* are the features of division of any community into classes or type groups, or into constituent parts in case of systems. *Aspects of preferences* are points of view, views accord-

ing to which importance of objects is specified by hierarching them by assignment of ranks or points. Ranks and points are used to relativisation and scheduling of objects (in the sense of relationships of majority, minority or equivalence). Any determinants which are material or intangible values are assumed as aspects of preferences. These may be the objectives or the situations or circumstances according to which significance (meaning) of objects or assessment criteria is analysed.

Procedure of calculation of the weighted value of the object

This procedure is a research procedure which consists in quality analyses of the objects, e.g. in terms of their allocated use or functionality. The stages of this procedure are as follows:

1. Development of the template for assessment of the object;
2. Selection of aspects of preferences;
3. Determination of weights of assessment criteria;
4. Conducting verifying assessment and the final qualification of the object.

The diagram for this procedure is presented in Figure 1.

Development of the template of object assessment is one of the most important activities in the procedure. The assessment template is the summary of criteria assessment which make up a certain aggregate which constitutes a multi-criteria evaluative system. Assessment templates may be of standard or stipulation nature.

Standard templates are expressed with values (features, parameters) given in advance which are regarded as optimum (theoretically or practically), or they are determined obligatorily as preset (planned) values. They are by definition regarded as extreme values whose exceeding or not achieving is a shortcoming. Standard templates are also called *nominants*.

Stipulative masters assume two forms:

– one comes as *stimulants*, that is the features for which the increasing trend is desired;
– the other comes as *destimulants*, that is the features for which the decreasing trend is desired.

The difference between standard templates (nominants) and stipulation templates (stimulants and destimulants) lies in the fact that the deviation up or down for standard templates is assessed negatively, while in case of stipulation templates every situation of increase in the value of the stimulant is regarded positively and, similarly, every case of decrease in the value of the destimulant is assessed positive.
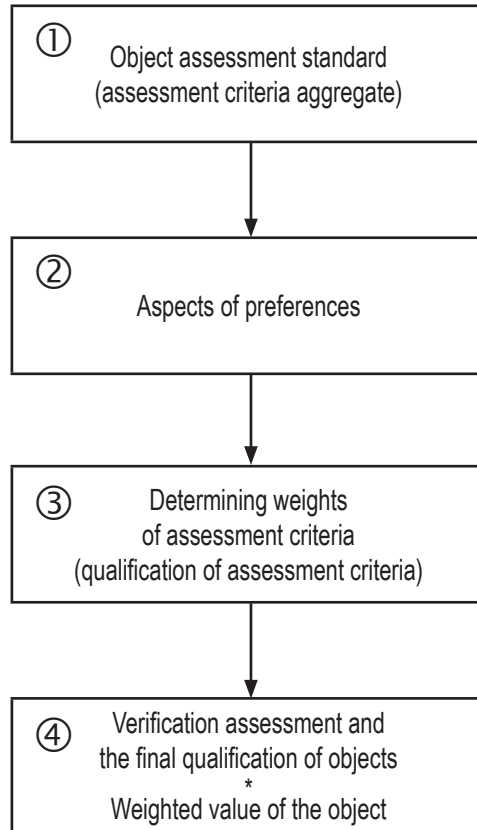
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┌─────────────────────────────────────┐
│ ①   Object assessment standard      │
│     (assessment criteria aggregate) │
└─────────────────────────────────────┘
                    │
                    ▼
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│ ②                                   │
│     Aspects of preferences          │
│                                     │
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                    │
                    ▼
┌─────────────────────────────────────┐
│ ③   Determining weights             │
│     of assessment criteria          │
│     (qualification of assessment criteria) │
└─────────────────────────────────────┘
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┌─────────────────────────────────────┐
│     Verification assessment and     │
│ ④   the final qualification of objects │
│                   *                 │
│     Weighted value of the object    │
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Figure 1. Procedure of calculation of the weighted value of the object

S o u r c e: author's own study.

Another step is the *selection of aspects of preferences*. In this case they perform a special role, as they are used for rational and objective determination of assessment criteria weights. Aspects of preferences qualify assessment criteria in the dimensions of purposefulness: economic, organisational, technical, social, etc. These aspects are selected in correspondence with the scope and substantial sense of the conducted research.

After the selection of preferential aspect, *assessment criteria weights* are determined. Weights express importance, significance, validity of a factor (these are measures used in a special way, as they are referred to the assessment criteria which constitute the original basis of assessment). This step in the procedure is the basic factor which determines weighted assessment of the objects, because it can only be done by determining preferences for individual assessment criteria.

The presented procedure is completed with the stage of *verifying assessment and the final qualification of the object*. The verifying assessment means measuring the degree of meeting the specific requirements, e.g. the degree of meeting the standards, functionality, the level of quality, and the final qualification of the object is its weighted value. The following formula expresses it:

$$V_{ij} = w_j \cdot q_{ij},\qquad(1)$$

where:

V_{ij}—weighted value of the i object due to the j assessment criterion
w_j—weight of the j assessment criterion
q_{ij}—the verifying assessment referred to the i object due to the j assessment criterion
$i = 1 \ldots m$—the objects
$j = 1 \ldots n$—the assessment criteria.

The aggregate weighted value A_i is calculated from the formula:

$$A_i = \sum_{j=1}^{n} V_{ij}.\qquad(2)$$

The weighted average A_i^* may also be calculated:

$$A_i^* = \frac{1}{W}\left(\sum_{j=1}^{n} w_j \cdot q_{ij}\right),\qquad(3)$$

where:

W—the sum of weights w_j.
It has to be noted that the verifying assessment q_{ij} is a standardised value.[4]

2.3. Verifying assessment in diagnostics and designing

As it was stated earlier, the verifying assessment is to indicate whether the given object observes the assumed requirements. It is thus used, e.g., for determination of results of company on the basis of specific measuring scale, which is to allow at the same time interpretation of successes or failures of the studied business unit. Interpretation of the results in the verifying assessment is done in the context of their trends, with a view on the adopted assessment criterion. The reason is that different assessments will be applied for decreasing trend in the indexes of sale profitability than for decreasing trends for energy consumption index. In the former case, the decreasing trend of the index will have negative significance, in the latter—positive. Interpretation of the results and their trends is the basic issue, which allows the proper verify-

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[4] The essence of standardisation is presented in section 5.

ing assessment, especially in the situation of applying a multi-criteria model in which individual criteria are of the stimulant, destimulant or nominant nature.

The "verifying assessment" term will be understood as the result of the comparison of the original condition with the master, that is a standard or stipulative condition. Thus, verifying assessment is at the same time *standardised* (unified) *measure* referred to diagnostic variables, assessment criteria, parameters, features. With standardisation, the values originally different may be compared and algebraical operations may be done with them.

In case of the project, verifying assessments will be expressed, for example, with functionality, accuracy, importance, level of quality, thus in general referring to effectiveness. Verifying assessment is thus a special type of measurement in which a certain value with positive or negative sense (usually the verifying assessment is subject to categorisation) is subjected to the characteristic value.

Verifying assessment may be expressed in the scoring or index methods. The *scoring* form of assessment is proper for using the range scale (in the predefined range of the multi-grade assessment). The *index* form is the expression of using the quotient scale.

In both approach, reference of the actual condition to the template is done. In diagnostics, it may be a "result-planned" comparison or assessment of meeting some function by the given system. The level of compliance between the measured characteristic values and the standard condition is determined on the basis of the score (in the agreed scale) or with the effectiveness index. Both the scoring and the index verifying assessment are traditional measures for task completion or functionality (and other similar forms of performance), that is achieving a pre-defined result intended as the objective. The power of the measuring scale in which the specific assessment criterion can be expressed decides whether the scoring or index assessment should be applied.

As it was stated earlier, verifying assessment is defined by the *original condition–standard relation*, and the standard is understood as the standard or stipulative condition. Interpretation of this relation, however, is different in diagnostics than in designing, which should be explained with different objectives in these research directions.

For diagnostics, the original condition means the actual (real) condition of the object which is subject to verifying assessment, and the standard is the reference. In diagnostic research, the standard may come, for example, in the form of the planned or pre-set value, and it may also be an empirical value or the perfect structure.

In designing, it is assumed that the above relation is a comparative system which is to be used as the base for making decisions in selection of the rational (optimal) project. In this case, the original condition is represented by a set of projects or project variants from which the best solution has to be selected. The question may be asked whether referring individual projects to the standard is thus necessary. Finding the best solution in the given choice space does not mean that it meets the expectations

of the company management, of the investor or of another user. Therefore, the action should be taken into consideration in the decision procedure, which is verifying assessment, which will confirm whether the individual projects are eligible for the further stages, e.g. of the tender proceedings. This verification is to give answer to the question whether the proposed solutions meet the conditions of acceptability. The list of specific conditions of acceptability forms the standard in the designing process, which is thus the measure of the requirements which must be met by the designer and by the contractor. It has to be added that perfect standards may be designed, that is theoretical models which form references of higher level for the set of projects—apart from the acceptability standard. In this last case, the standard may be understood as the perfect option, perfection model. The prototypes standing out in terms of excellence may be treated in a similar way. This type of reference allows categorisation of the selected project, thus marking its level of quality.

3. Ranking method

The ranking method is used for qualification of projects (project variants) in the scale of values of natural numbers, from the best project to the worst (or the other way round). This method enables comparing heteronymous values, that is non-additive values of features which may be summed up when converted into ranks.

In diagnostic research and in selection of the rational variant, the additive, multi-criteria assessment of projects is based on the assumption of equivalence of significance of features which have been adopted for the analysis. Thus, the features with the assigned value sense are treated as criteria of selection, without differentiating their validity.

In ranking, the importance of the projects in a given set is determined according to adopted criteria of selection. Preferences for individual projects are specified in sequential ordering, and significance of the projects in the assumed set is expressed with the ranking number. *Ranking number* (rank) is an ordinal number which means the degree of validity of the project. It has to be stated here that there is no universal interpretation rule related to increase or decrease of the ranking number. In some cases, its increase may mean a higher rank of the object, in other the situation will be reversed and increase of the ranking number may express decrease in validity. The following are examples of the convention which consist in that the higher the rank (degree, category), the higher the digit which stands for it: grading groups (categories), medical specialisations, degrees of difficulty of work. The reverse convention may be used to qualify the capacity of the system to thwart threats, product qualities, levels of quality.

The research workflow in the project ranking method is as follows:
1. Defining the ranking range.
2. Collecting the data for ranking.

3. Preferential sequencing:
    – calculation of total ranks;
    – calculation of averaged ranks;
    – determining the item in the project.

Defining the ranking range

Ranking projects conducted on the basis of one criterion is a single-criterion ranking. If there are more criteria, we refer to it as multi-criteria ranking. In the latter case, ranking assumes the aggregate form in two variations:
    – ranking with the basic ranking potential;
    – ranking with high ranking potential.

Ranking potential is the number of selection criteria which are used for ranking. For example, the basic potential may have 2–10 criteria, while high potential may have more than 10 of them. Please note that there are no unanimous indications to define the ranking range at the basic or high levels. The practical needs and experience of the researcher will decide what ranking potential should be assumed.

Collecting data for ranking

The elementary data are necessary for ranking at this stage, namely: a set of projects and their characteristic values. The latter are the result values which correspond with the applied selection criteria.

The basic problem in the ranking method is the choice of selection criteria and the result values interpreted accordingly. The choice of selection criteria and ranking in itself require substantial knowledge of a specific empirical area, which constitutes the subject matter of specialised expert opinions. Interpretation of the result values is mostly related to determination of preferences which are assigned to them, as well as changes (increase, decrease) in these values.

The following solutions may be used in building the table of characteristic values:
1. The choice of selection criteria may be limited only to stimulants or destimulants.
2. If the summary of selection criteria includes both stimulants and destimulants, their ranking should be done in the reverse ways: for stimulants from the highest value to the lowest, for destimulants from the lowest value to the highest.
3. If nominants are included in the set of selection criteria, their ranking should be referred to the absolute difference Δ_{ij} between the nominant and the actual result value for individual projects:

$$\Delta_{ij} = \text{nom} \left| x_{0j} - x_{ij} \right|, \qquad (4)$$

where:

x_{0j}—the value of the nominant

x_{ij}—the actual result value.

Preferential sequencing

Calculating of the total ranks (sums of ranks) and the averaged ranks is done according to the formulae:

$$R_i = \sum_{j=1}^{n} R_{ij},\qquad(5)$$

$$\overline{R}_i = \frac{R_i}{n},\qquad(6)$$

where:

R_i—the total rank (the rank aggregate) for the i project, where $i = 1 \dots m$

R_{ij}—the rank assigned to the i project due to the j criterion of selection, where
  $j = 1 \dots n$

$\overline{R}_i$—the average rank of the i project

n—the ranking potential (the number of selection criteria).

The ranking results are given in Table 1.

Table 1

Individual and total ranks

Projects	Selection criteria (j)					R_i (sum of ranks)
	x_1	x_2	x_3	x_4	x_5	
P_1	1	1	1	2	2	7
P_2	3	4	4	4	4	19
P_3	6	5	5	3	3	22
P_4	4	3	3	5	5	10
P_5	2	2	2	1	1	8
P_6	5	6	6	6	6	29

Source: author's own study.

The shortcoming of the ranking method is that it uses sequential scale, while strong scales (range and quotient types) may only be used in reference to quantitative characteristic values. In case of average ranks, the measurement has quasi-distance nature because it does not apply to natural or index distance, and only to the ranking distance (sequential).

Determining position of the project is the stage finishing the basic ranking process. It is, however, always relative for the given sets and it is a procedure resulting in the ranking of projects with the assumed assessment criteria (Table 2).

Moreover, determination of the position, that is the place of the project in the ranking, is done in the way reverse to that used in determination of ranks. The higher the ranking number, the higher the general level of the project. The position means the successive place in the ranking list (from the best to the worst), and the number 1 means the best position, 2 is a lower position, etc.

T a b l e 2

Average ranks, project positions, ranking

Projects	R_i (average rank)	Position	Ranking
P_1	1.4	6	1. P_6
P_2	3.8	4	2. P_3
P_3	4.4	2	3. P_4
P_4	4.0	3	4. P_2
P_5	1.6	5	5. P_5
P_6	5.8	1	6. P_1

S o u r c e: author's own study.

R a n k i n g

Ranking may also be used in diagnostic studies, for example in comparative analysis of companies, products (of the same type), employees, managerial personnel. Ranking is used as an auxiliary tool in gradation of development barriers, too, in setting hierarchy for factors of threat or for the factors which are determinants positively affecting functioning of a system, etc. In this case, ranks are weights for particular factors and these are, on the principle of analogy, equivalents of assessment criteria. Diagnostic analysis is then used to give an answer to the question about the rank (importance) of the effect of a given factor on the studied system, and this effect is estimated with a view of the adopted aspects of preferences.

4. Scoring method

4.1. General characteristics of the scoring method

The scoring method is the method of qualifying projects in the conventional numerical scale with a specific system of assessment. The values of the features (parameters) of the projects or results (obtained or prospective)[5] form the basis of assessment.

In the scoring method (unlike in ranking), qualification is done in the scale of real or integral numbers. The scales may be built in three areas:

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[5] Point (in scoring) is a conventional unit in calculation of results in diagnostic studies and in designing.

– as single-pole positive scales (with or without zero);
– as single-pole negative scales (with or without zero);
– as two-pole scales (positive-negative with or without zero).

Single-pole scales are used for assessment of results for features interpreted as positive or negative.[6] These scales are thus applied in assessment of alternative features or phenomena. Two-pole scales are used for combined assessment which takes into account both positive and pejorative features. Interpretation of differences between positive and negative assessments is then an important issue.

Two-pole scales may assume symmetric or asymmetric form. The symmetric scale is used most often when there is no need for radical juxtaposing of positive and negative features. The asymmetric scale with positive extreme value, more distant than the negative extreme value (e.g. 5, 4, 3, 2, 1, 0, –1, –2, –3), occurs when the system of qualifications emphasising positive assessment degrees is used, otherwise more strict qualification is applied (with or without a critical point), emphasising negative assessment degrees.

The system for assessing projects performs the basic role in the scoring method. This system constitutes regulations for assigning scores on the basis of preferential system for assessment criteria and with calculation techniques of the verifying assessment. Assessing system should have its own methods, as freedom in scoring is common in practice, and it makes this very important tool of quality multi-criteria assessment imperfect.

4.2. Analytical proceedings in the score aggregation method

The proceedings in the score aggregation method is formed of the following steps:

1. Determination of the universal formula for weighted value.
2. Score standardisation of selection criteria.
3. Determination of weights of selection criteria.
4. Aggregate assessment (calculating the index for project variants IPP_i).
5. Categorisation of the index IPP_i.

The analytical approach to the scoring aggregation method is presented below.

1. The universal formula for weighted value:

$$V_{ij} = w_j \cdot q_{ij}, \tag{7}$$

where:

The markings as in Formula (1).

2(A). Expanded score standardisation of selection criteria

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[6] Negative assessment may be expressed in positive or negative scales. For reasons of interpretation, in this case it is better to use the negative scale, e.g. in counting penalty points.

2.1. The verifying score assessment:

Positive qualification (assessment degrees)	Score (positive scale)
I. Distinguishing factor	6
II. High usability factor	5
III. Good condition	4
IV. Average condition	3
V. Satisfactory condition (admissible)	1–2

Negative qualification (assessment degrees)	Score (negative scale)
I. Labile condition	(1–2)
II. Limited possibilities condition	(3–6)
III. Critical condition	(7–8)

2.2. Interpretation of assessment degrees:
→ presentation of their interpretation as meeting specific requirements, appropriate for the assumed ranges in the qualification scale.

2.3. Essence of verifying assessment:
→ finding equivalence between the characteristic condition for individual project variants and a specified assessment degree (in line with the interpretation of individual assessment degrees).

2(B). Reduced score standardisation of selection criteria (low resolution)
■ The verifying score assessment:

Positive qualification (assessment degrees)	Score (positive scale)
I. Very good condition (distinguishing)	6
II. Good condition	4
III. Satisfactory condition (admissible)	3

Negative qualification (assessment degrees)	Score (zero and negative scale)
I. Neutral condition	0
II. Unsatisfactory condition	(1–2)

3. Weights of selection criteria:
4—criteria absolutely necessary (dominant)

2—criteria required (basic)

1—criteria useful (good).

4. Aggregate assessment (the scoring index of project variants *IPP$_i$*)

$$IPP_i = \sum_{j=1}^{n} w_j \cdot q_{ij}, \qquad (8)$$

where:

Markings as above.

5. Categorisation of the index *IPP$_i$*

C a t e g o r y S (distinguishing)—the value of the index *IPP$_i$* above 80% of the maximum value

C a t e g o r y A (leading)—the value of the index *IPP$_i$* within 61–80% of the maximum value

C a t e g o r y B (average)—the value of the index *IPP$_i$* within 40–60% of the maximum value

C a t e g o r y C (low usability)—the value of the index *IPP$_i$* below 40% of the maximum value.

The calculated index *IPP$_i$* expresses the total scoring value for individual projects (project variants). The project with the highest score is the optimum solution (with the assumption that it meets the threshold conditions).

The last step is categorisation of the index *IPP$_i$* the essence of which is quality qualification of individual projects. Categorisation is thus an additional assessment of projects referred to the maximum score value achievable for the index *IPP$_i$*.

5. Quotient standardisation method

The standardisation method is the aggregate approach to index assessment of projects. The essence of quotient standardisation is in unification of the values of individual selection criteria by referring them to the pre-set standard values. Standard values of selection criteria are in the range from 0 to 1: the closer they are to one, the higher is the verifying assessment of the project. The opposite is true, too: the closer they are to zero, the lower is the verifying assessment.

The quotient standardisation method is used in the following steps:

1. Determination of the universal formula for weighted value.
2. Quotient standardisation of selection criteria.
3. Determination of weights of selection criteria.
4. Aggregate assessment (calculating the indexes Z_i and Z_i^*).
5. Categorisation of the indexes Z_i and Z_i^*.

The analytical formalisation of the quotient standardisation method is presented below.

1. The universal formula for weighted value:

$$V_{ij} = w_j \cdot q_{ij},$$
(9)

where:

The markings as in Formula (1).

2. Quotient standardisation of selection criteria:

$$z_{ij} = \frac{x_{ij}}{\max_i \{x_{ij}\}} \quad \text{for } j \in S$$

(stimulants)
(10)

$$z_{ij} = \frac{\min_i \{x_{ij}\}}{x_{ij}} \quad \text{for } j \in D$$

(destimulants),
(11)

where:

x_{ij}—the value of the *j* selection criterion for the *i* variant

z_{ij}—the standard value of the *j* selection criterion for the *i* variant.

$$z_{ij} = \frac{x_{ij}}{x_{nom}}, \quad \text{when } x_{ij} \le x_{nom},$$
(12)

$$z_{ij} = \frac{x_{nom}}{x_{ij}}, \quad \text{when } x_{ij} > x_{nom},$$
(13)

where:

x_{nom}—the nominant value

x_{ij}—the actual condition referred to the appropriate type of nominant.

3. Weights of selection criteria:
    4—Criteria absolutely necessary (dominant)
    2—Criteria required (basic)
    1—Criteria useful (good).

4. Aggregate assessment:

$$Z_i = \frac{1}{n} \sum_{j=1}^{n} z_{ij},$$
(14)

$$Z_i^* = \frac{1}{W}\left(\sum_{j=1}^{n} w_j \cdot z_{ij}\right) \tag{15}$$

where:

$$W = \sum_{j=1}^{n} w_j \tag{16}$$

5. Categorisation of the indexes Z_i and Z_i^*.
0.96–1.00 the distinguishing level (taxation 6.0)
0.81–0.95 the high usability level (taxation 5.0)
0.61–0.80 the average level (taxation 4.0)
0.51–0.60 the satisfactory level (taxation 3.0)

$$\left.\begin{array}{l} 0 \le Z_i \le 0{,}50 \\ 0 \le Z_i^* \le 0{,}50 \end{array}\right\} \text{ the unsatisfactory level (taxation 2.0).}$$

The indexes Z_i and Z_i^* constitute simple arithmetic average or weighted arithmetic average of the aggregate assessment of the projects. The project with the highest index is the optimum solution (with the assumption that it meets the threshold conditions).

Just like in the score aggregation method, the last step of the procedure is categorisation of the indexes Z_i and Z_i^*. It will show in which range of the general (total) assessment the assessed project (project variant) is located. It has to be remembered that the best project does not need to be the distinguishing solution or high usability solution.

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Metody oceny agregatowej w podejmowaniu decyzji projektowych

S t r e s z c z e n i e: W artykule wyróżniono następujące punkty: uwagi wstępne, analiza preferencji jako uniwersalna koncepcja oceny agregatowej, metoda rangowania, metoda punktacji, metoda normalizacji ilorazowej.

W uwagach wstępnych podana została interpretacja oceny agregatowej: polega ona na syntetycznym oszacowaniu wartości jakiegoś obiektu, poprzez połączenie w jedną całość pojedynczych kryteriów oceny. Ocena agregatowa ma szerokie zastosowanie, zarówno w odniesieniu do projektów, jak i do procesów, zjawisk, wszelkiego rodzaju rzeczy. Wykorzystuje się ją w badaniach diagnostycznych i w podejmowaniu decyzji (np. w związku z wyborem optymalnego wariantu projektowego).

Kolejny punkt artykułu to analiza preferencji jako uniwersalna koncepcja oceny agregatowej. Ogólnie pojmowana analiza preferencji jest podejściem badawczym polegającym na kwalifikowaniu obiektów w określonej skali, czego wyrazem jest hierarchia ważności obiektów. W tym fragmencie tekstu przedstawiono również cykl procesu badawczego. Jego główne składowe to: obiekt, zbiór obiektów lub system, wielkości charakterystyczne obiektu, kryteria oceny, aspekty preferencyjne, procedura obliczania wartości ważonej obiektu.

W następnym punkcie tekstu omówiono metodę rangowania. Służy ona kwalifikacji projektów (wariantów projektowych) na skali wartości liczb naturalnych. Tok postępowania badawczego w metodzie rangowania przebiega następująco: 1) określenie zakresu rangowania, 2) zestawienie danych do rangowania, 3) porządkowanie preferencyjne (obliczenie rang sumarycznych, obliczenie rang uśrednionych, ustalenie pozycji projektu w rankingu).

Dalszy punkt został poświęcony metodzie punktacji i jej szczególnej formie, mianowicie agregacji punktowej. Tu kwalifikację przeprowadza się – w odróżnieniu od rangowania – na skali wartości liczb rzeczywistych lub całkowitych. Postępowanie badawcze w metodzie agregacji punktowej wyrażają następujące kroki: ustalenie uniwersalnej formuły wartości ważonej, normalizacja punktowa kryteriów wyboru, przeprowadzenie oceny agregatowej (obliczenie indeksu IPP_i), kategoryzacji indeksu IPP_i.

Tekst zasadniczy zamyka punkt dotyczący metody normalizacji ilorazowej. Metoda ta jest agregatowym ujęciem oceny wskaźnikowej projektów. Istota normalizacji ilorazowej sprowadza się do ujednolicenia wartości poszczególnych kryteriów wyboru poprzez odniesienie ich do ustalonych wartości wzorcowych. Centralnym krokiem tej metody jest obliczenie wskaźników Z_i i Z_i^*. Stanowią one średnią arytmetyczną prostą lub ważoną oceny agregatowej projektu. Projekt o najwyższym wskaźniku jest rozwiązaniem optymalnym.