Complex Expert Assessment of the State of Business Enterprises

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Abstract: The commercial success of businesses depends to a large extent on the ability to quantify the current situation at the desired point in time. It helps to make the right strategic development decisions and reveals weaknesses. The state of development of a company is a complex phenomenon, therefore, it can be described only by a certain number of indicators. They are multidimensional and of unequal importance, therefore, multiple-criteria methods are used to combine their values into one generalising quantity. They rely to a large extent on expert assessments to determine the weights of indicators, as well as the values of indicators that are difficult to formalise. An integral part of such assessments is the examination of the consistency of expert opinions. Existing methods for determining the level of consistency of expert assessment are intended to determine the importance of indicator weights, and it is not possible to determine the consistency of expert assessment of indicator values on their basis. This is because, when determining the importance of an indicator, the estimate of the importance of one indicator follows from the context of the importance of all other indicators, whereas in the second case, the value of each indicator is determined separately, i.e., it does not follow from the context of the values of the other indicators. In order to determine the consistency of the expert assessment of the values of indicators, it is necessary to calculate the actual and maximum possible level of uniformity or non-uniformity of the assessment. The consistency of the expert assessment will be demonstrated by the ratio of these values. The aim of the article is to propose and approve a methodology for determining the compatibility of expert assessment of the values of difficult-to-formalize indicators that increase the commercial success and competitiveness of business enterprises.

Keywords: business enterprises; multiple-criteria methods; compatibility of expert assessments

1 Introduction

In the context of global economic integration, economic operators seek to be on an equal footing in international markets. This is especially true for Eastern and partly for Central European countries. The main challenge for their businesses is to be competitive. Competitiveness is often understood as the share in both foreign and domestic markets. It is an integral result of business development. Assessing the importance of competitiveness is comprehensively examined in many scientific studies. Basically, they are all conducted for one purpose – finding the ability to change the state of a business, i.e., to pursue its success. In other words, ways to manage business development in a targeted manner are being sought. Global scientists Drucker and Sukhart have identified an essential condition for solving this problem – the development process can be managed if there is a possibility to quantify its condition at a desired time. Thus, in order to improve business results, at least two things are required: first, to know what business development depends on; and second, how to quantify its current situation. Only then can the right business development strategic decisions be made.

Solving these tasks is not easy. This is because business development is a complicated complex socio-economic process, which includes both the complex of interacting people and the necessary material and technical and other resources – materials, equipment, technologies, information flows, etc. This allows business to be seen as a socio-economic system. Due to their complexity, such systems manifest themselves in reality in a number of aspects of the most diverse nature. When formalised, they become indicators that reflect the state of the system. They can be expressed in different dimensions and vary in opposite directions. This means that an increase in some of their values improves the situation, while increases in others worsens it. For example, the higher a company's advertising costs, the higher the expected sales of products or services and the better the performance. Rising advertising costs of competitors can make these results worse. In addition to the above, another factor is no less important – some indicators can be easily formalised, while others – with a degree of difficulty. The said advertising costs can be accurately estimated by the amount of money spent for that purpose. Meanwhile, it is not possible to accurately "measure", for example, a company's ability to assess the competitors' market behaviour. Another problematic aspect to consider when assessing a business situation is the unequal importance of the factors that affect it.

In order to get a general picture of the business situation, it is necessary to combine important indicators expressing the contradictory factors that affect it into one generalising index. Research in recent years has shown that multiple-criteria approaches are best suited to address this issue. Long-term practice has highlighted two conditions for their application: first, indicators expressed in different dimensions and moving in the opposite direction need to be made comparable with each other, i.e., dimensionless, and their relevance to the phenomenon in question, i.e., business development, must be quantified. Knowing the normalised values of

the indicators and their importance, the simplest way to obtain the generalised index is to sum up the sum the product of the values and importance of the indicators, or by other developed multiple-criteria assessment methods.

The weights of the indicators, as well as the values of the indicators that are difficult to formalise, are determined by experts. It is no coincidence that in the theory of multiple-criteria assessment, they are given a special role. The purpose of the expert assessment is to reflect the situation under assessment as adequately as possible. On the other hand, despite the professionalism of the team of experts, their opinions tend to differ. In order to use the obtained results in further calculations, it is necessary to determine whether they are consistent. A number of studies and various methodologies have been devoted to this problem. Their analysis shows that they all address the issues of consistency in the expert assessment of indicator weights. Meanwhile, the evaluation of indicator values have practically not been performed. The average of the estimates is used for further calculations. This may be due to the fact that no appropriate methodologies have been proposed. In this situation, the question arises as to whether the methods of consistency of expert assessment of indicator weights are also suitable for determining the consistency of assessment of indicator values. If not, by increasing the adequacy of the application of multiple-criteria methods to the assessment of the state of business enterprises, appropriate ways to determine consistency need to be sought.

2 Literature Review

The main purpose of a business is profit making, except for non-profit organisations. To achieve it, a group of stakeholders forms a structure, i.e., creates production and organisational/management staff, and a social system, into which it integrates the necessary material, technical and other resources. This structure, once validated, acquires the appropriate status of an official organization or company. Thus, structure can be seen as a means to an end. It can only be achieved through the constant development of the company [1]. The targeted development process does not happen by itself – it needs to be managed. This requires being able to quantify its condition at a desired point in time.

The problem of quantifying the condition of socio-economic systems, such as business enterprises, has received a lot of attention in research. By their nature, they are large and complex, thus, the number of indicators that reflect their situation can be quite large. Combining them into one generalising quantity or index is difficult due to their contradictory nature – they are of different dimensions, can change in opposite directions, some of them must reflect difficult to formalise factors and are not equally important for the phenomenon under consideration. In recent years, multiple-criteria methods have been successfully applied to calculate such indices. The most well known and most widely used are SAW [2], TOPSIS [3], VIKOR [4],

COPRAS [5, 6], ELECTRE III, ELECTRE IV [7, 8], PROMETHEE [9], LINMAP [10], MOORA, MULTIMOORA ([11, 39] and others.

The essence of multiple-criteria assessments is most clearly reflected by the SAW method [3]:

$$K_j = \sum_{i=1}^{n} w_i \widetilde{q_{ij}} \quad (1)$$

where K_j – significance of the multiple-criteria evaluation of the j[th] alternative of the analysed phenomenon by the SAW method; w_i – weight of the i[th] indicator; $\widetilde{q_{ij}}$ – normalised value of j[th] alternative of i[th] indicator; n – number of indicators (i=$\overline{1,n}$).

As can be seen from formula (1), in multiple-criteria evaluations, each indicator is expressed in two quantities: importance and significance [3, 12, 13, 14, 15, 16].

It is true that there are also methods of multiple-criteria evaluation, where indicators are expressed only in terms of significance, i.e., without weights [17, 18, 19, 20, 21].

Indicator weights are usually determined on the basis of subjective methods, i.e., their importance is determined by experts [3, 22, 23, 19, 24, 25, 26, 27, 28, 29]. The objective weight determination methods are also sometimes used, where the importance of an indicator is determined by its significance [30, 31].

The situation is different with the significances of indicators. They can be conditionally divided into two groups. The first group are easily formalised indicators. Their significances are determined precisely because all the necessary information can be found in various sources – statistical publications, normative materials, different reports, project documentation, or simply determined through calculations. Indicators that are difficult to formalise include those whose significance in the chosen evaluation system can be determined only by experts. All this variety of setting indicator weights and significances is demonstrated in Figure 1.

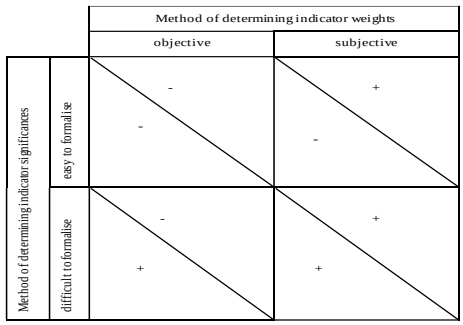

Figure 1

The need for expert assessments in determining the weights and significances of multiple-criteria assessment indicators of the state of SES development (source: compiled by the authors)

As demonstrated in Figure 1, it appears that in only one of the four possible cases it is not necessary to use expert assessments at all. Thus, their importance in multiple-criteria assessments is high.

Determining the level of consistency of expert opinions is inseparable from expert assessments. This important issue is given a lot of attention in the theory of expert assessment, because the results of assessment can be used in further calculations only if the opinions of experts are consistent.

The analysis of literature sources shows that research to determine the consistency of opinions is predominant [32, 33, 34, 35, 36, 37]. It makes sense to see whether the proposed methodologies are also suitable for determining the consistency of expert assessment of indicator values.

In recent years, the methodologies for assessing the consistency of expert assessment proposed by Kendall and Saaty have been the most widely used. The methodology proposed by Saaty is specific, it is integrated into the AHP method for determining indicator weights, therefore, it cannot be treated as an independent or universal methodology [38]. The commonly used Kendall method has a different nature. In this case, the expert assessment of the importance of the indicators is based on the matrix $R=\|q_{ij}\|$. It lists the assessments of importance of each indicator q_{ij} (q_{ij} – is the score of the i^{th} indicator given by the j^{th} expert in the adopted evaluation system, $i = \overline{1,m}$, $j = \overline{1,r}$, where m – is the number of indicators, r – is the number of experts) [32] (Figure 2).

$$Q = \begin{vmatrix} q_{11} & q_{12} & q_{13} & \cdots & q_{1j} & \cdots & q_{1r} \\ q_{21} & q_{22} & q_{23} & \cdots & q_{2j} & \cdots & q_{2r} \\ q_{31} & q_{32} & q_{33} & \cdots & q_{3j} & \cdots & q_{3r} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ q_{i1} & q_{i2} & q_{i3} & \cdots & q_{ij} & \cdots & q_{ir} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ q_{m1} & q_{m2} & q_{m3} & \cdots & q_{mj} & \cdots & q_{mr} \end{vmatrix}$$

Figure 2
Matrix of expert assessment of the importance of indicators

The next step in the consistency assessment is ranking of Q estimates in the matrix (Fig. 3). The result is matrix R, which shows the ranks of all indicators (r_{ij} – the rank of ith indicator given by the jth expert).

$$R = \begin{vmatrix} r_{11} & r_{12} & r_{13} & \dots & r_{1j} & \dots & r_{1r} \\ r_{21} & r_{22} & r_{23} & \dots & r_{2j} & \dots & r_{2r} \\ r_{31} & r_{32} & r_{33} & \dots & r_{3j} & \dots & r_{3r} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ r_{i1} & r_{i2} & r_{i3} & \dots & r_{ij} & \dots & r_{ir} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ r_{m1} & r_{m2} & r_{m3} & \dots & r_{mj} & \dots & r_{mr} \end{vmatrix}$$

Figure 3
Matrix of expert assessment of the importance of indicators

The method for determining the consistency of expert assessments depends on the number of indicators. If it does not exceed 7 ($m \leq 7$), the degree of compatibility is indicated by the coefficient W:

$$W = \frac{S_f}{S_{max}} \tag{2}$$

$$S_f = \sum_{i=1}^{m} \left(\sum_{j=1}^{r} r_{ij} - \bar{r} \right)^2 \tag{3}$$

$$\bar{r} = \frac{\sum_{i=1}^{m} \sum_{j=1}^{r} r_{ij}}{m} \tag{4}$$

$$S_{max} = \frac{r^2 m(m^2-1)}{12} \tag{5}$$

where S_f – the sum of the deviations of r_i values from the mean r_{ij}; $\bar{r}$ – the total average of r_{ij} values; S_{max} – the maximum possible deviation of r_i values from the mean r_{ij}.

The closer the value of the coefficient W is to 1, the more consistent the expert opinion.

When the number of evaluated indicators is greater than 7 ($m > 7$), the Pearson correlation factor χ^2 is calculated:

$$\chi_f^2 = \frac{12 S_f}{rm(m+1)} \tag{6}$$

The actual value of χ_f^2 coefficient obtained is compared with the critical value χ_{kr}^2, which depends on the number of degrees of freedom $\gamma (\gamma = m - 1)$ and the α level of significance chosen (in the social science, the α value is usually equal to 0.05, i.e., (1-0.05)x100 = 95 %). If $\chi_f^2 > \chi_{kr}^2$, the opinions of the experts are consistent.

The analysis of Kendall's method for determining the consistency of expert assessment allows to draw an essential conclusion – the importance estimate of i^{th} indicator follows from all other estimates of assessment of this indicator. In other words, when giving an estimate of importance of i^{th} indicator, the expert must weigh its relation to the importance of all other indicators for the phenomenon in question.

This is very clearly demonstrated by the essential condition for determining the importance of indicators, which looks as follows [3]:

$$\omega_1 + \omega_2 + \omega_3 + \ldots + \omega_i + \ldots + \omega_m = \sum_{i=1}^{\min} \omega_i = 1.0 \quad (7)$$

Therefore, in determining the weights of indicators of the phenomenon under consideration, the rows of the matrix in Fig. 2 are interrelated. It is from this condition that all known subjective methods for determining indicator weights arise [32, 22, 23, 19, 24, 26, 30].

The situation is different with the determination of consistency of expert assessment of the values of indicators that are difficult to formalise. Unlike determining the consistency of the expert assessment of indicator weights, in this case the value of the indicator in question does not depend on the estimates of other indicators. In this case, the expert assessment of i^{th} indicator will be based on a matrix $\mathbf{Q}_i$ with only one row (Fig. 4).

$$\mathbf{Q}_i = |p_{i1} \quad p_{i2} \quad p_{i3} \quad \ldots \quad p_{ij} \quad \ldots \quad p_{ir}|$$

Figure 4

Matrix of expert evaluation of the value of ith indicator of the analysed phenomenon

Figures 2 and 3 demonstrate that the methods for determining the consistency of expert assessment of the importance of indicators are not suitable for determining the consistency of expert assessment of indicator values.

3 Methodology

The desired level of compatibility of the expert assessment of the indicator values must meet the following requirements:

1) The value of the desired indicator must vary from 0 to 1.

2) If the opinion of all experts is unanimous, i.e., if they all give the same estimate for the indicator in question, the value of the compatibility indicator must be equal to 1.

3) If the experts gave the most divergent estimates on the adopted rating scale to the indicator in question, the value of the compatibility indicator must be close to 0.

4) It must be possible to quantify both the actual and the maximum possible uniformity of expert opinions depending on the specific situation, i.e., both from the indicators of the phenomenon in question and the number of experts evaluating them.

5) When assessing the limitations of points 1 to 4, the required indicator must be determined as the ratio of the actual and the maximum possible uniformity of the estimates provided by the experts to the specific situation.

The proposed indicator of the level of consistency of the expert assessment of the values of indicators must meet all the applicable requirements:

$$W_i = 1 - \frac{W_i^f}{W_i^{max}} \text{ or } W_i = \frac{W^{max} - W_i^f}{W^{max}} \quad (8)$$

where W_i – the indicator of consistency of the expert assessment of the value of the indicator in question; W_i^f – the actual indicator of non-uniformity in the expert opinions of indicator i[th]; W_i^{max} – the most likely indicator of non-uniformity of expert opinions of indicator i[th].

As the formula (7) shows, in the ideal situation, i.e., when $W_i^f = W_i^{max}$, $W_i = 0$, as the W_i^f value approaches 0, the value of the compatibility indicator W_i also approaches 1. Consequently, it ranges from 0 to 1.0.

Thus, the task of determining the degree of compatibility of an expert assessment consists of determination of values W^f and W^{max}.

Determination of actual non-uniformity, i.e., value W_i^f „ of the expert assessments of i[th] indicator of the analysed phenomenon. The degree of non-uniformity of expert assessment depends on the degree of dispersion of the expert assessment estimate, therefore, W^f will be calculated as follows:

$$W_i^f = \sum_{i=1}^{r} \left| \bar{q}_i - q_{ij} \right| \quad (9)$$

where $\bar{q}_i$ – the average of the expert assessment of the i[th] indicator value.

The value $\bar{q}_i$ is determined as follows:

$$\bar{q}_i = \frac{\sum_{i=1}^{r} q_{ij}}{r} \quad (10)$$

Formula (9) demonstrates that if the estimates of all the experts are the same, then $W_i^f = 0$.

Determination of maximum non-uniformity, i.e., value W_i^{max}, of the expert assessments of i[th] indicator of the analysed phenomenon.

The value W_i^{max} reflects the situation where the expert assessment estimates differ the most. In this case, the matrix $\tilde{q}_i = \left\| q_{ij} \right\|$ of expert assessment of significance of i[th] indicator of the analysed phenomenon will look as follows (Fig. 5).

$$\tilde{q}_i = \left|\tilde{q}_{i1}^{max}\, \tilde{q}_{i2}^{min}\, \tilde{q}_{i3}^{max}\, \tilde{q}_{i4}^{min} \ldots \tilde{q}_{ij-1}^{max}\, \tilde{q}_{ij}^{min}\, \tilde{q}_{ij+1}^{max} \ldots \tilde{q}_{ir-1}^{max}\, \tilde{q}_{ir}^{min}\right|$$

Figure 5

Matrix of expert assessment of the significance of ith indicator of the phenomenon in question, when the opinions of the experts differ the most (q_ij^max – the highest possible estimate of significance of i[th] indicator given by the jth expert; q_ij^min – the same, the lowest possible estimate)

As with the determination of W^f, W^{max} shall be calculated as follows:

$$W_i^{max} = \sum_{i=1}^{r}\left|\tilde{\tilde{q}}_i - \tilde{q}_{ij}\right| \tag{11}$$

The value $\tilde{\tilde{q}}_i$ is determined as follows:

$$\tilde{\tilde{q}}_i = \frac{\sum_{i=1}^{r}\tilde{q}_i}{r} \tag{12}$$

where $\tilde{\tilde{q}}_i$ – the average of the expert assessment of the value of i[th] indicator, when the expert opinions differ the most; $\tilde{q}_i$ – the significance of i[th] indicator, when expert opinions differ the most.

It is not difficult to notice that when the number of experts is even, then $W_i^{max} = (\tilde{\tilde{q}}_i - 1) \times r$. Table (1) presents the values of W^{max} when r varies from 2 to 10.

Table 1

Values of Wmax significance depending on the number of experts

Number of experts	2	3	4	5	6	7	8	9	10
Value W^{max} significance	9.00	12.00	18.00	21.00	27.00	30.86	36.00	40.00	45.00

The value W^{max}, like the value W^f, essentially reflects the greatest possible degree of non-uniformity depending on the number of expert's r.

4 Empirical Research

The proposed methodology for determining the consistency of expert assessment of the indicator significance has been tested on the basis of a real example. The experts provided the following estimates of difficult-to-formalize indicators of the commercial success of the examined business in a ten-point system (Table 2).

The three indicators (age of company, advertising costs and new product development costs) in Table 2 are easy to formalise because their values are known precisely, while all other indicators are difficult to formalise, the values of which have been determined by experts. It is necessary to assess whether their opinions are consistent based on the proposed methodology.

Table 2

Estimates of the evaluated company's commercial success indicators and the results of calculation of consistency of the expert assessments

Measurement unit	Row No	Indicator	$\bar{q}_i$	W^f	W^{max}	W_i	Consistency assessment results
Score points	1	Country's level of infrastructure	5.75	34	36	0.61	Inconsistent
Years	2	Age of company	-	-	-	-	-
Score points	3	Appropriate business development strategy	7.75	7.0	36	0.82	Consistent
Euro	4	Advertising costs	-	-	-	-	-
Score points	5	Employee incentive system	5.75	8.0	36	0.78	Consistent
Score points	6	Quality of products	7.25	10	36	0.72	Inconsistent
Score points	7	Packaging of products	4625	9.0	36	0.75	Consistent
Score points	8	Country's level of economic development	6.00	11	36	0.69	Inconsistent
Euro	9	New product development costs	-	-	-	-	-
Score points	10	Manager competence	5.00	8.0	36	0.78	Consistent

Determining the value W_i^f of the actual non-uniformity of expert assessment of the indicator significance.

According to formula (9), the average of the expert assessment of the values of the first indicator, the country's level of infrastructure, will be equal to:

$$\bar{q}_1 = \sum_{i=1}^{r} \frac{q_{ij}}{r} = \frac{46}{8} = 5.75$$

The value W_1^f according to formula (9) will be equal to:

$$W_1^f = (5.75 - 4) + (5.75 - 4) + (5.75 - 8) + (5.75 - 3) + (5.75 - 7) + (5.75 - 6) + (5.75 - 5) + (5.75 - 9) = 14.$$

Determining the value W_i^{max}, of the maximum non-uniformity of expert assessment of the indicator significance.

The situation of expert assessment of the indicator significance, when expert opinions are most inconsistent, will look as follows (Table 3):

Table 3

Maximum and minimum values of expert assessment (scale 10 points)

Experts	1	2	3	4	5	6	7	8	Total
Estimates	10	1	10	1	10	1	10	1	44

The average of the expert assessment of the significance of the first indicator, based on formula (12) and Table 3, will be equal to:

$$\tilde{\tilde{q}}_i = \frac{44}{8} = 5.5$$

The value W_1^{max}, according to formula (11) will be equal to:

$$W_1^{max} = \sum_{i=1}^{r} \lfloor \tilde{\tilde{q}}_1 - \tilde{q}_1 \rfloor = 4 \times |5.5 - 10| + 4 \times |5.5 - 1| = 36, arba\ W_1^{max} = (5.5 - 1) \times 8 = 36$$

Mean significance $\tilde{\tilde{q}}_i$ and value W_i^{max} significance were determined in the same way (Table 2).

According to formula (8), the value W_i for the first indicator will be equal to:

$W_1 = 1 - \frac{34}{36} = 0.06$; $W_1 = \frac{36-34}{36} = 0.06$.

The significances of value W_i are presented in Table 2. It demonstrates that four of the seven indicators assessed are consistent, while three are not. Another conclusion is that the opinions of the experts differed the most in those indicators that reflect the external environment of the business enterprise. The critical limit of the consistency coefficient W is 0.75. It is based on empirical research and expert evaluations. The performed calculations confirmed the suitability of the proposed methodology for expert assessment of significances of difficult-to-formalise indicators.

5 Discussion

In multiple-criteria evaluations, the expert assessments of significance of the difficult-to-formalise indicators have some unresolved issues. Meanwhile, there may be a number of indicators that reflect the development aspects of a business enterprise. This is illustrated by the example presented in this article. The analysis

of the literature sources dedicated to this question, including the defended dissertations, demonstrated that such an assessment is hardly ever performed. This issue is ignored. The simplest way taken – determining the arithmetic mean of the expert estimates and treating it as the significance of the indicator sought. This has a strong impact on the adequacy of multiple-criteria assessment.

Undoubtedly, there may be other methods for determining the consistency of expert assessment of significance of difficult-to-formalise indicators. The mathematical statistics methods could open up wide possibilities for this, but their application is limited by insufficient statistical information. This is due to the fact that the system of indicators of the phenomenon in question usually consists of too few indicators in terms of mathematical statistical methods. If their number is large enough, the related indicators are grouped to increase the adequacy of the assessment. This allows forming a hierarchical system of indicators, which makes it possible to reduce the number of indicators evaluated simultaneously.

It can be expected that when this problem is understood to the required extent, it will receive more attention and more reasoned suggestions will be offered.

The proposed methodology can find wide application both in research and in practice, as business people today are increasingly beginning to understand the importance of strategic planning. Quantitative assessment of the current state of the business plays an important role in this process. It is necessary for forecasting changes, solving problems of sustainability of enterprise development, etc.

Conclusions

The experts have an important role to play in multiple-criteria quantitative assessments of the state of development of socio-economic systems, such as businesses. They help to determine the weights of indicators of the phenomenon in question, as well as the significance of the indicators that are difficult-to-formalise. An integral part of such assessments is the determination of the level of consistency of expert opinions. The most common and widely used are the methods for determining the level of consistency of expert assessment of the importance of indicators, while less attention is paid to the consistency of expert assessment of indicator significance. Meanwhile, the methods of expert assessment of the importance of indicators are not suitable for determining the level of consistency of expert assessment of indicator significances. This is because in the case of determining the level of consistency of the expert assessment of indicator weights, the assessment of the importance of the indicator in question is derived from all other estimates of the assessment of the importance of this indicator. Whereas, in the case of expert assessment of the indicator significances, the significance of the analysed indicator does not depend on the estimates of other indicators.

The proposed indicator of the level of consistency of the expert assessment of the significance of the indicator in question ranges from 0 to 1, and thus, reflects the extremes of the assessment, when the expert opinions are completely uniform or

completely different. The indicator is defined as the ratio of the actual and the maximum possible uniformity of the estimates provided by the experts to the specific situation, which is characterised by the number of indicators and experts. The performed calculations confirmed the appropriateness of the proposed methodology. It is universal and can be used in quantitative assessments of the state of development of a wide variety of phenomena.

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