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FINANCIAL AND LEGAL EVALUATION OF THE CONSISTENCY OF INDIVIDUAL PREFERENCES ASKED IN THE FORM OF CHOICE FUNCTIONS

Abstract. Two possible matching measures are being investigated. In the framework of the statement of the group choice problem, individual preferences are set in the form of selection functions and the group solution is defined as a selection function. To find the median according to the definition of the choice function, the analog of the Hamming metric is used. The ambiguity associated with the construction of a formal theory of behavior of many experts within the framework of a particular system of managing economic and legal, socio-labor objects determines one of the problems of methodological support for the coordination of interests of various parties in the framework of collective interaction. Essentially different aspects of this problem formulation are investigated. There may be a conflict when making decisions, formed by the danger degree that resources will not be naught. A possible solution to the conflict's a group solution and checking the consistency of this solution.

Keywords: group choice, individual preferences, agreement coefficient, median, measure of proximity, profile of preferences.

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ФІНАНСОВО-ПРАВОВА ОЦІНКА УЗГОДЖЕНОСТІ ІНДИВІДУАЛЬНИХ ПЕРЕВАГ ЗАДАНИХ У ВИГЛЯДІ ФУНКЦІЙ ВИБОРУ

Анотація. У статті досліджуються дві можливих заходів узгодження. В рамках постановки задачі групового вибору індивідуальні переваги задаються у вигляді функцій вибору і групове рішення визначається як функція вибору. Для знаходження медіани згідно з визначенням функції вибору використовується аналог метрики Хеммінга. Неоднозначність, пов'язана з побудовою формальної теорії поведінки безлічі експертів в рамках певної системи управління соціально-економічними об'єктами визначає одну з проблем методологічного забезпечення узгодження інтересів різних сторін в рамках колективної взаємодії. Досліджуються істотно різні аспекти даної постановки завдання. Можливий конфлікт при прийнятті рішень, що формується ступенем небезпеки того, що ресурсів буде недостатньо. Можливим варіантом вирішення конфлікту є групове рішення і перевірка узгодженості цього рішення. Як очікуваних результатів відображаються всі можливі прямі і непрямі, позитивні та негативні оцінки, які можуть з'явитися в процесі реалізації програми і після її завершення: фінансово-правові; соціально-трудові, в тому числі і іміджеві; контролюючі. Необхідно, щоб очікувані результати мали вимірні якісні та кількісні характеристики. Оцінка фінансової стійкості підприємств важлива не тільки для суб'єктів господарської діяльності, а саме - для акціонерів, клієнтів, інвесторів, а й для власників організації, роботодавців. Саме тому наявність сильного корпоративного управління, організації праці є критично важливим. Фінансово-правова діяльність управління спрямована на захист інтересів вкладників зі зведенням до мінімуму асиметрії інформації між структурами управління підприємства, його вкладниками і клієнтами. Перспективно використання методів оцінки якості експерта, заснованих на зіставленні узгодженості. Підвищення ступеня об'єктивності може досягатися в деяких експертизах і за допомогою урахування можливого кон'юнктурних експерта. Зустрічаються експертизи при обмежених можливостях експертів, об'єктивно не зацікавлених в результатах експертизи.

Ключові слова: груповий вибір, індивідуальні переваги, коефіцієнт згоди, медіана, міра близькості, технології обробки, фінансова інформація.

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ФІНАНСОВО-ПРАВОВАЯ ОЦЕНКА СОГЛАСОВАННОСТИ ИНДИВИДУАЛЬНЫХ ПРЕДПОЧТЕНИЙ ЗАДАНЫХ В ВИДЕ ФУНКЦИЙ ВЫБОРА

Аннотация. В статье исследуются две возможные меры согласования. В рамках постановки задачи группового выбора индивидуальные предпочтения задаются в виде функций выбора и групповое решение определяется как функция выбора. Для нахождения

медианы, согласно определению функции выбора, используется аналог метрики Хемминга. Неоднозначность, связанная с построением формальной теории поведения множества экспертов в рамках определенной системы управления социально-экономическими объектами, определяет одну из проблем методологического обеспечения согласования интересов различных сторон в рамках коллективного взаимодействия. Исследуются различные аспекты данной постановки задачи. Возможен конфликт при принятии решений, формируемый степенью опасности того, что ресурсов будет недостаточно. Возможным вариантом разрешения конфликта является групповое решение и проверка согласованности этого решения. В качестве ожидаемых результатов отражаются все возможные прямые и косвенные, позитивные и негативные оценки, которые могут появиться в процессе реализации программы и после ее завершения: финансово-правовые; социально-трудовые, в том числе и имиджевые; контролирующие. Необходимо, чтобы ожидаемые результаты имели измеримые качественные и количественные характеристики. Оценка финансово-правовой устойчивости предприятий важна не только для субъектов хозяйственной деятельности, а именно - для акционеров, клиентов, инвесторов, но и для собственников предприятий, работодателей. Именно поэтому наличие сильного корпоративного управления, организации труда является критически важным. Финансово-правовая деятельность управления направлена на защиту интересов вкладчиков со сведением до минимума асимметрии информации между структурами управления предприятия, его вкладчиками и клиентами. Перспективно использование методов оценки качества эксперта, основанных на сопоставлении согласованности. Повышение степени объективности может достигаться в некоторых экспертизах и с помощью учета возможной конъюнктурности эксперта. Встречаются экспертизы при ограниченных возможностях экспертов, объективно не заинтересованных в результатах экспертизы.

Ключевые слова: групповой выбор, индивидуальные предпочтения, коэффициент согласия, медиана, мера близости, технологии обработки, финансовая информация.

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Introduction. The procedures for obtaining collective decisions pose a number of questions for the process organizers: the types of measurement scales in which individual and group opinions are implemented; selection of a rule for harmonizing individual assessments; selection of requirements for a group profile; assessment of the consistency profile of individual preferences [1—3; 23—25]. Obtaining quantitative estimates of the consistency of the entire profile of individual preferences is the subject of research by many authors working in the field of expert estimates and methods of statistical analysis [5; 10; 15; 16—21]. The use of one or another coefficient of consistency depends on the type of rating scale and the opinion of the person making decisions regarding the «fairness» of taking into account the preferences of all participants in the group selection process [4; 9]. The formation of a reasonable set of collective agreement measures and the determination of their relationship enables managers to conduct expert assessments to use not only their opinions and preferences, but also justify the calculations of the applied coefficients. This determines the need for research in the analysis of aggregation of qualitative data.

Analysis of recent studies. There are several basic approaches to solving the problem of reconciling various individual assessments into group assessments or obtaining a collective opinion. The axiomatic approach requires the coordination of certain principles of group choice. Five principles of coordination for the formation of group choice are incompatible. This manifestation of the problem of collective decision is the «Arrow paradox» [1].

The metric approach [3; 10; 15; 17]. The opinion of each individual is equally taken into account in group preference, and the concept of «distance between a set of relations of experts» is introduced to determine the measure of proximity. The best group solution is based on the principles of discrete mathematics. The question of adequacy is being reduced.

The geometric approach [4; 13; 14]. The study of bulge structures can be defined in a variety of preferences. A distinctive feature is the consistent use of geometric concepts. However, the

introduced group choice rules are completely abstracted from the specific physical content of the practical problem being solved. Expert opinions are considered as a choice of points in some formalized model of space.

Heuristic approach [7—12]. This approach assumes: an increase in the number of factors taken into account leads to an increase in the accuracy of calculations; the need to determine the «weight» of each factor; the final conclusion is made by the decision maker; the administrative structure apparatus participates in the development of assessments, or forms a description of the main provisions of the conditions of group choice. The emerging shortcomings of this approach are, first of all, determined by the adequacy of the questions posed to the expert and the need to find a specialist in the field of sequence of questions during the examination.

When processing quantitative data in order to obtain a collective solution, the use of metric models is considered one of the most correct approaches for matching various individual estimates [27; 28]. The main assumption of these models is that individuals are equal and their opinions are equally taken into account in group preference. Group preference is «the closest» to all individual preferences received at the same time. To determine the measure of proximity, one or another distance is introduced between a set of individual preferences.

The need for a preliminary analysis of individual preferences in order to obtain a quantitative assessment of the consistency of the totality of preferences involves the calculation of the coefficient of consistency. These coefficients are often investigated during group examination [10; 14; 23; 24], multi-round processes for finding collective solutions [6; 22; 24]. The question of the relationship between different indicators of measures of agreement, using different measurement scales is also relevant.

The purpose of the study: to investigate and develop compliance measures when individual preferences are defined as a choice function and a group decision is defined as a choice function using an analogue of the Hamming metric.

The results of the study. The proposed coefficients of the measure of agreement $T(H)$, $G(H)$ for the selection functions, to some extent simplify the verification of the consistency of the collective assessment and, for the simplified version, coincide with finding the median, Candell's coefficient of agreement, respectively.

Group selection mathematical models. When processing qualitative data in order to obtain the «the best» collective solution, the use of mathematical models is considered one of the most correct approaches for matching various individual estimates [9; 18].

It is characteristic of this approach that each individual assessment is equally taken into account in group preference. Group preference is «the closest» to all individual preferences received at the same time. To determine the proximity measure, one or another distance is introduced between a set of individual preferences [16; 23].

Often when obtaining a group decision, there is a need for a preliminary analysis of individual preferences in order to obtain a quantitative assessment of the consistency of the entire set of preferences. This paper explores two possible measures of agreement. In the framework of the statement of the group choice problem, when individual preferences are set in the form of selection functions and the group solution is determined as a choice function, an analog of the Hamming metric is used to find the median as a group choice function [2; 14; 24]. Using this metric, two coefficients that determine the consistency in the space of individual selection functions are introduced. One of the coefficients is directly related to finding the median [14]. The second is an analogue of the Candell's coefficient of agreement for binary preference relations [2].

We denote by $N = \{1, 2, \dots, n\}$ many individuals, and through $A = \{1, 2, \dots, m\}$, $m \geq 2$ — many alternatives (options, objects, projects, etc.). To represent individual and group opinions (ratings, preferences), binary relations on the set A and selection functions are used in the work.

Binary relations on the set A (i.e., subsets of the Cartesian square $\rho \subseteq A^2$) will be called preference relations (PR): a pair of alternatives (x, y) belongs ρ , if the alternative x is not worse y .

Let \wp be some family of subsets of the set A . The sets S on \wp are called admissible (sometimes they are called «agendas» or «budget subsets»). The selection function (SF) is the mapping $S \rightarrow h(S) \subset S$, which associates with any set $S \in \wp$ a subset of the «best» alternatives of $h(S)$ [14].

The opinions of a group of individuals N are expressed by a finite sequence of preference relations $R = (R_1, R_2, \dots, R_n)$ or $H = (h_1, h_2, \dots, h_n)$ of choice functions. H and R are some classes of CF and PR defined on the family of admissible sets \wp ; H^n is the n th Cartesian degree of H .

The selection procedure we consider is a degenerate case of FC, i.e. $\wp = \{A\}$. Such approval procedures are sometimes referred to as decision rules on multiple ballots. However, if the FC does not impose structural conditions that interconnect the choice of various subsets of $S \in \wp$, then the general situation reduces to the one considered [9; 14; 25].

The problem of matching individual FCs reduces to constructing a map $\upsilon: F(A)^n \rightarrow F(A)$, where $F(A)$ is the set of all subsets of A . The reconciliation rule υ is called the group choice rule (GSR). The result of matching individual FCs from profile H according to the rule $\upsilon(H)$ is a group selection function (GSR).

Let R_i , the preference relation of the i individual, is ($i \in N$). Then the opinions of all individuals are expressed by a finite sequence of (R_1, R_2, \dots, R_n) preference relationships. We call this sequence the profile of individual preferences and denote R . We assume that preference relationships of individuals belong to a certain class of binary relations \mathfrak{R} . Many different profiles of individual preferences, i.e. all sequences of the form (R_1, R_2, \dots, R_n) will be denoted by \mathfrak{R}^n .

Similarly, the selection function (FC) of an individual from N will be denoted by h_i . The opinions of all individuals are expressed by the final sequence of FC (h_1, h_2, \dots, h_n) .

The profile of individual FCs is denoted by H . Individual FCs can belong to a certain class of selection functions defined on λ . The set of various profiles of the form (h_1, h_2, \dots, h_n) is denoted by Q .

In the first statement of the group choice problem, individual opinions are defined as preference relations belonging to a certain class of binary relations. A group solution is found as mapping a profile of individual preferences into a certain group preference, also belonging to a certain class of binary relations. This mapping is a group preference function. A group preference function (GSR) is a mapping that maps to any $R = (R_1, R_2, \dots, R_n)$ profile a group preference from a certain class of binary relations on A . Let us designate this statement of the group choice problem as « $\Pi \rightarrow \Phi \Pi$ » (individual preferences are mapped to the group preference function).

The mapping of individual opinions into a group is carried out using a predefined rule for obtaining group opinions.

In the second statement of the group choice problem, individual opinions are set in the form of FC. A group solution is found as mapping an individual FC profile to a group selection function (GSR). This mapping is carried out according to the group selection rule (GSR), which is defined as a mapping υ that maps to any $H = (h_1, h_2, \dots, h_n)$ profile the $\upsilon(H)$ group selection function from an arbitrary class \mathfrak{S} FC defined on λ . This statement of the group choice problem is denoted as « $\Pi \Phi \rightarrow \Phi \Gamma \Pi$ » (individual selection functions are reflected in the group selection function).

In the third statement of the group choice problem, individual opinions are set in the form of $R = (R_1, R_2, \dots, R_n) \in \mathfrak{R}^n$ preference relations, and the group decision is defined as the mapping R into the group choice function, i.e. profile R is mapped to FC from an arbitrary class \mathfrak{S} . Similarly to the above, this mapping is carried out according to the group selection rule for relations (GSR). We will designate this statement of the problem as « $IP \rightarrow GPF$ » (individual preferences are displayed in the group preference function).

A fourth setting is possible, when the individual opinions are FC, i.e. « $IP \rightarrow GPF$ » (individual selection functions are reflected in the group selection function). In the literature on the

theory of collective choice, this statement of the group choice problem is not considered. It is believed that, determining the opinions of individuals in such a general form as FC, it is inexpedient to seek a group solution in the form of GSR.

The procedures for developing a solution in the framework of the first and third formulations of the group choice problem have been known for a long time, however, a special interest in them arose after the work of K. Arrow, who fully used the ideas and methods of modern discrete mathematics. Among a large number of methods for the analysis and synthesis of complex systems, management, of considerable theoretical and practical interest are those that take into account the peculiarities of people's behavior when making decisions.

Defining a metric for a selection function. We introduce the following notation for FC h :

$$\forall S \in \wp, x \in S \quad C_{x,S} = \begin{cases} 1, & \text{если } x \in h(S) \\ 0, & \text{если } x \notin h(S) \end{cases} \quad (1)$$

For the selection functions h' and h_k , the notation will be $C'_{x,S}$ and $C^{(k)}_{x,S}$, respectively.

We define [2] the distance d between two arbitrary FC h' and h_k , as:

$$d(h, h') = \sum_{S \in \wp} \sum_{x \in S} |C_{x,S} - C'_{x,S}| \quad (2)$$

The restrictions on the set $S \in \wp$ for FC h' and h_k are denoted by h'_S and h'_S , respectively, then

$$\sum_{x \in S} |C_{x,S} - C'_{x,S}| = d(h_S, h'_S) \quad (3)$$

By definition, $d(h, h')$ — is the power of the symmetric difference $[h(S) \setminus h'(S)] \cup [h'(S) \setminus h(S)]$ of the sets h_S and h'_S . A measure of symmetric difference is often used as the distance between sets [20, 21].

For an arbitrary profile $H = (h_1, h_2, \dots, h_n)$ FC (h_1, h_2, \dots, h_n) , the median of this profile in the class $\mathfrak{N} \in \mathfrak{N} \wp$ is the FC $h^* \in \mathfrak{N}$ at which the minimum $\sum_{i=1}^n d(h, h_i)$ value is achieved for all $h \in \mathfrak{N}$, i.e.

$$\sum_{i \in N} d(h^*, h_i) = \arg \min_{h \in \mathfrak{N}} \sum_{i \in N} d(h, h_i) \quad (4)$$

When conducting a group selection, GSR υ , defined as $\upsilon(H) = h^*$ for any individual FC profile, can be used. Denote this GSR by $\upsilon^n(H)$.

If for any $S \in \wp$, $H \in \mathfrak{N}^n$ $\upsilon_H(S)$ consists of those and only those $x \in S$ alternatives for which $\text{card}(I_x(H, S)) \geq \frac{n}{2}$, where n is the number of individuals, then $\upsilon_H(S)$ is determined by the group choice rule by the majority of υ^n .

Similarly, the υ^υ GSR is called the strict majority when $\text{card}(I_x(H, S)) \geq \frac{n}{2}$ is under conditions similar to $\upsilon^\bar{\upsilon}$. The theorem states [22] that, the selection function h^* is the median in the class \mathfrak{N}_\wp for an arbitrary profile $H = (h_1, h_2, \dots, h_n)$ FC (h_1, h_2, \dots, h_n) if and only if for any $S \in \wp$ $\upsilon^\bar{\upsilon}(S) \subset \upsilon_H^\mu(S) \subset \upsilon_H^\upsilon(S)$, where $\upsilon_s^\bar{\upsilon}(S)$ and $\upsilon_H^\upsilon(S)$ are GSR for the profile H and $S \in \wp$, respectively determined by GSR by a strict majority and by the majority.

The algorithm for constructing the median for the profile of individual FC $H = (h_1, h_2, \dots, h_n)$ for any $S \in \wp$ is quite simple, from the point of view of implementation on a computer, and is not given here. It should only be noted that if the number of n individuals is an odd value, then the GSR h^* is uniquely determined by the rule of most υ^υ . If n is even, then the group

choice according to the rules of strict majority and majority for arbitrary H may not coincide ($v^{\bar{v}}(S) \subset v^v(S)$). In this case, the GSR h^* does not define a single FC.

Let's find the number of such FCs.

Building Consent Measures for a Selection Function. Let for any subset $S \in \wp$ and any alternative $x \in S$ the selection functions defined by GSR v^v and $v^{\bar{v}}$ correspond to the values of the variables C_x^v and $C_x^{\bar{v}}$ (by expression (1)). Then the number of GSR coinciding with the median

$$(4) \text{ is } 2^{\sum_{x \in S} |C_x^v - C_x^{\bar{v}}|}.$$

Using the distance d (2), we construct the agreement measures of individual selection functions as quantitative estimates that make it possible to judge the proximity of two or more individual FCs on each $S \in \wp$. At the stage of the preliminary analysis, checking the consistency of individual opinions will allow more reasonably choosing the final group decision.

Let h_s and h'_s be two arbitrary FCs defined for any $S \in \wp$. Moreover, the number of alternatives in S is S , that is, $\text{card}(S) = 1$.

Note the FC property:

$$\max d(h_s, h'_s) = 1$$

and for any FC h_s there is a unique FC \bar{h}_s such that

$$d(h_s, \bar{h}_s) = 1$$

FC \bar{h}_s will be called opposite to h_s .

Let H_s be the profile of individual FCs on the set $S \in \wp$ and h_s^i the FC from the profile H_s , where $i \in N$. Taking into account expression (1), we call the selection matrix C_s^i of the individual $i \in N$ one-dimensional matrix of Boolean variables of dimension 1 such that

$$C_s^i = \{C_{x,S}^i | \forall x \in S \text{ and } S \in \wp, C_{x,S}^i = 1, \text{ if } x \in h_s^i \text{ and } C_{x,S}^i = 0, \text{ if } x \notin h_s^i\} \quad (5)$$

For the elements of the selection matrices h_s and \bar{h}_s , the relation holds:

$$C_{x,S} + \bar{C}_{x,S} = 1, \quad x \in S. \quad (6)$$

Consider the functional

$$d(H) = \sum_{h_s, h'_s \in H_s} d(h_s, h'_s) \quad (7)$$

It is assumed that the FC does not impose conditions that combine the choice of different sets of H . Therefore, the consistency of individual FCs is determined separately for each $S \in \wp$.

We call the $d(H_s)$ functional the profile distance H_s . Based on the definition of $d(h_s, h'_s)$ (3) and the values of $C_{x,S}$ and $C_{x,S}$ (1), the following statement is obvious.

Calculation of measures of consistency of individual opinions. Statement. The maximum profile scattering [24] of the H_s selection functions on any $S \in \wp$ set for the $d(H_s)$ functional is:

$$\max d(H_s) = \begin{cases} \frac{\ln^2}{4}, & \text{if } n - \text{even number}, \\ \frac{l(n^2 - 1)}{4}, & \text{if } n - \text{odd number}. \end{cases} \quad (8)$$

We define the measure of agreement of the H_s profile as a linearly decreasing function of the functional $d(H_s)$:

$$d(H_s) = \sum_{x \in S} \left\{ \sum_{h_s \in H_s} C_x (n - \sum_{h'_s \in H_s} C'_x) + \sum_{h_s \in H_s} C'_x (n - \sum_{h_s \in H_s} C_x) \right\} = \sum_{x \in S} v_x (n - v_x) \quad (9)$$

Further

$$\frac{1}{2}d(H_S) = \sum_{x \in S} \gamma_x (1 - \gamma_x) = \sum_{x \in S} \left\{ \frac{1}{4} - (\gamma_x^2 - \gamma_x + \frac{1}{4}) \right\} = \frac{1}{4} - \sum_{x \in S} (\gamma_x - \frac{1}{2})^2 \quad (10)$$

Based on the expression (5) we obtain the calculated formula for the coefficient:

$$T(H_S) = 1 - \frac{4d(H_S)}{n^2 - 1} = 1 - \frac{4}{1} \left\{ \frac{1}{4} - \sum_{x \in S} (\gamma_x - \frac{1}{2})^2 \right\} = \frac{4}{1} \sum_{x \in S} (\gamma_x - \frac{1}{2})^2 \quad (11)$$

We rewrite in final form:

$$T(H_S) = \frac{4}{\text{card}(S)} \sum_{x \in S} \left(\frac{\Pi_x(H, S)}{\Pi} - \frac{1}{2} \right)^2 \quad (12)$$

Expression (7) allows us to interpret the $T(H_S)$ coefficient as the standard deviation from the case when the opinions of individuals regarding the choice of each alternative were divided in half.

Define the relationship between the $T(H_S)$ coefficient and the measure of agreement of the $T(M)$ profile of individual preference relationships. Let individual opinions be given by a set of binary relations $R = (R_1, R_2, \dots, R^k, \dots, R_n)$ and for any $k \in N$ $R^k \subseteq S \times S$. The $T(M)$ consent measure is defined as follows:

$$T(M) = \frac{4}{l^2 - 1} \sum_{i \neq j} \left(\frac{1}{n} \sum_{k \in N} r_{ij}^k - \frac{1}{2} \right)^2 \quad (13)$$

Suppose that a preference relationship from profile R belongs to a relationship class \mathfrak{R}_1 of the following form

$$\forall k \in N \quad R^k : (B \times S) \subset R^k, (\bar{B} \times S) \cap R^k = \emptyset \quad (14)$$

where B is some set of «best» alternatives ($B \subset S$),

and \bar{B} is the complement of B in S .

Then you can write:

$$T(M) = \frac{4}{l^2 - 1} \sum_{i \in S} \sum_{j \in S} \left(\frac{1}{n} n_x(H, S) - \frac{1}{2} \right)^2 \quad (15)$$

since any $R \in \mathfrak{R}_1$ profile can be associated with a profile of rational selection functions (3)

$$H_R = (h_{R_1}, h_{R_2}, \dots, h_{R_n}).$$

Further. Given that $i \neq j$ and $\text{card}(S) = l$

$$T(M) = \frac{4}{l^2 - 1} \sum_{i \in S} (l - 1) \left(\frac{\Pi_x(H, S)}{n} - \frac{1}{2} \right)^2 = \frac{4}{1} \sum_{i \in S} \left(\frac{\Pi_x(H, S)}{n} - \frac{1}{2} \right)^2 \quad (16)$$

Thus, in this particular case, the expressions for calculating $T(M)$ and $T(H_S)$ coincide.

With the definition of the median h^* for the profile $H = (h_1, h_2, \dots, h_n)$, the following measure of agreement between individual FCs on a variety of S alternatives can be directly related. Let h^* be determined from expression (4). Then FC \bar{h}^* will, in a sense, be the opposite of h^* , i.e.

$$\sum_{i \in N} d(\bar{h}^*, h_i) = \arg \max_{h \in N} \sum_{i \in N} d(h, h_i) \quad (17)$$

The measure of consent will be defined as

$$G(H_S) = 1 - \frac{\sum_{i \in N} d(h_S^*, h_S^i)}{\sum_{i \in N} d(\bar{h}_S^*, h_S^i)} \quad (18)$$

for each $S \in \wp$.

Using (3), we write expression (8) in the following form:

$$G(H_S) = \frac{\sum_{i \in N} \sum_{x \in S} |\bar{C}_{x,S}^* - C_{x,S}^i| - \sum_{i \in N} \sum_{x \in S} |C_{x,S}^* - C_{x,S}^i|}{\sum_{i \in N} \sum_{x \in S} |\bar{C}_{x,S}^* - C_{x,S}^i|} \quad (19)$$

where $\bar{C}_{x,S}^*$, $C_{x,S}^*$, $C_{x,S}^i$ — designations according to (1) for the selection functions \bar{h}_S^* , h_S^* , h_S^i , respectively.

After transformations similar to those for the $T(H_S)$ coefficient, we obtain:

$$G(H_S) = \frac{\sum_{x \in S} (\bar{C}_{x,S}^* - C_{x,S}^*) (n - 2n_x(H,S))}{\sum_{x \in S} \bar{C}_{x,S}^* (n - 2n_x(H,S)) + n_x(H,S)} \quad (20)$$

From the expression (9) it is obvious that the coefficient takes the maximum value of $G(H_S) = 1$ when the opinions of individuals completely coincide. The minimum value of the $G(H_S) = 0$ coefficient reaches with even n , when the opinions of individuals regarding the choice of each alternative were divided in half, i.e.

$$\sum_{i \in N} d(\bar{h}_S^*, h_S^i) = \sum_{i \in N} d(h_S^*, h_S^i) = \frac{n}{2} \quad (21)$$

At its core, $G(H)$ is an analogue of the $T(M)$ coefficient.

Here is an example to compare the values of the coefficients $T(H_S)$ and $G(H_S)$. Note that the $T(H_S)$ and $G(H_S)$ values are more convenient to calculate using (7) and (9), respectively.

Example.

Let the number of alternatives in the set S be $l = 5$, the number of individuals $n = 4$.

The profile of individual FCs will be denoted as a matrix of dimension $l \times n$, where each column is an individual selection matrix C_S^i , $i \in N$, determined by expression (5). The table below shows some possible profiles of individual FCs and the corresponding values of the coefficients of consistency. In the selection matrix corresponding to the median h_S^* , the value of the $C_y^* = x$ element indicates that the choice of an alternative $y \in S$ ($C_y^* = 1$ or $C_y^* = 0$) for FC $v_H^u(S)$ is not equivalent to selection (Tabl.1).

In a preliminary analysis of the FC set, it is of interest to verify the consistency of individual opinions on all acceptable sets of $S \in \wp$ alternatives in general. Assuming that a selection from a subset of $S' \in \wp$ ($S \neq \wp'$) can be written:

$$T(H) = \frac{\sum_{S \in \wp} T(H_S)}{\text{card}(\wp)}, \quad (22)$$

$$G(H) = \frac{\sum_{S \in \wp} G(H_S)}{\text{card}(\wp)} \quad (23)$$

Discussion of the research results. The coefficients take maximum values ($T(H_S) = 1$, $G(H_S) = 1$) only if the opinions of all individuals for each valid subset of $S \in \wp$ alternatives are the same. If n - is even and the opinions of individuals regarding the choice of any alternative $x \in S$ for each admissible subset of $S \in \wp$ are divided in half, then the coefficients take the minimum values $T(H_S) = 0$, $G(H_S) = 0$.

The feasibility of using this coefficient is applicable for multilevel expert assessment procedures.

Table 1

Table of values of the coefficients of consistency of the selection functions ($l = 5, h = 4$)

Custom Matrix Profiles $C_S^i, i \in N$	Selection matrix corresponding to the median h_S^*	The value of the coefficient of consistency	
		$T(H_S)$	$G(H_S)$
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0 0 0 0 0	1	1
1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0 0 0 0 0	$\frac{17}{20}$	$\frac{18}{19}$
1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	1 0 0 0 0	1	1
1 0 0 0 1 0 0 0 1 0 0 0 1 0 0 0 1 0 0 0	0 0 0 0 0	$\frac{1}{4}$	$\frac{2}{3}$
1 1 0 0 1 1 0 0 1 0 0 0 1 0 0 0 1 0 0 0	x x 0 0 0	$\frac{3}{20}$	$\frac{6}{13}$
1 1 1 0 1 1 0 0 1 1 0 0 1 0 0 0 1 0 0 0	1 x x 0 0	$\frac{3}{20}$	$\frac{6}{13}$
0 0 0 1 0 0 1 1 0 0 1 1 0 1 1 1 0 1 1 1	0 x x 1 1	$\frac{3}{20}$	$\frac{6}{13}$
1 1 0 0 1 1 0 0 1 1 0 0 1 1 0 0 1 1 0 0	x x x x x	0	0
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	1 1 1 1 1	1	1

These coefficients allow you to form a sequence of choices and directions for the development of the process of harmonizing the «common opinion». It is assumed that the formation of group choice is an iteration.

Conclusions. In the statement of the problem, which was considered in this article, the coordination of the final solution is determined by the selection of the group of «best» alternatives from the set of compared ones. Such a decision is often sufficient when processing the results of a collective examination. In addition, the group choice determined on the set of binary relations is not always unambiguous. For example, when using the majority rule. The proposed coefficients of the measure of agreement, for the selection functions, to some extent simplify the verification of the consistency of the collective assessment and, for the simplified version, coincide with finding the median, Candell's coefficient of agreement, respectively.

Directions for further research: the imposition of restrictions on structural conditions.

Література

1. Arrow K. I. Social choice and individual values / K. I. Arrow. — New York : Wiley, 1951. — 124 p.
2. Бешелев С. Д. Математическо-статистические методы экспертных оценок / С. Д. Бешелев, Ф. Х. Харвич. — Москва : Статистика, 1980. — 264 с.
3. Грабовецкий Б. С. Метод экспертных оценок: теория, методология, напрямки використання : монографія / Б. С. Грабовецкий. — Вінниця, 2010. — 171 с.
4. Gibbard A. Manipulation of voting schemes: A general result / A. Gibbard // *Econometrica*. - 1977. — Vol. 41. — № 4.
5. Goodwin P. How to integrate management judgment with statistical forecasts / P. Goodwin // *Foresight*. — 2005. — № 3. — P. 8—12.
6. International vocabulary of metrology: Basic and general concepts and associated terms (VIM 3) // *JCGM 200*. — 2012. — 90 p.
7. Данелян Т. Я. Формальные методы оценок / Т. Я. Данелян // *Экономика. Статистика*. — 2015. — № 1. — С. 183—187.
8. Кини Р. Л., Райфа Х. Принятие решений при многих критериях: предпочтения и замещения / Р. Л. Кини, Х. Райфа. — Москва : Радио и связь, 1981. — 560 с.
9. Кузьмин В. Б. Построение групповых решений в пространстве четких и нечетких бинарных отношений / В. Б. Кузьмин. — Москва : Наука, 1982. — 168 с.
10. Литвак Б. Г. Разработка управленческого решения / Б. Г. Литвак. — Москва : Дело, 2004. — 392 с.
11. Lootsma F. A. Saaty's priority theory and the nomination of a senior professor in operations research / F. A. Lootsma // *European Journal of Operational Research*. — 1980. — Vol. 4. — Is. 6. — P. 380—388.
12. Lutsenko I. Development of a verification method of estimated indicators for their use as an optimization criterion / Lutsenko I., Fomovskaya E., Oksanych I., Koval S., Serdiuk O. // *Eastern-European Journal of Enterprise Technologies*. — 2017. — № 2 (4(86)). — P. 7—23.
13. Лындина М. И., Орлов А. И. Математическая теория рейтингов [Электронный ресурс] / М. И. Лындина, А. И. Орлов // *Научный журнал КубГАУ*. — 2015. — № 104 (10). — Режим доступа : <http://ej.kubagro.ru/2015/10/pdf/01.pdf>.
14. Масленников Е. В. Возможности использования экспертных знаний в качестве ыстичника концепций развития организации / Е. В. Масленников // *Вестник Московского университета. Социология и политология*. — 2017. — № 23 (2). — С. 229—249.
15. Миркин Б. Г. Проблема группового выбора / Б. Г. Миркин. — Москва : Наука, 1974. — 250 с.
16. Мотало В. Аналіз шкал вимірювань / В. Мотало. — Львів : НУ «Львівська політехніка», 2015. — С. 21—35.
17. Новосад В. П. Кількісні методи експертного оцінювання / В. П. Новосад, Р. Г. Селіверстов, І. І. Артım. — Київ, 2009. — 36 с.
18. Романов В. Н. Теория измерения. Методы обработки результатов измерений / В. Н. Романов. — Санкт-Петербург : СТЗТУ, 2006. — 127 с.
19. Саати Т. Л. Принятие решений при зависимостях и обратных связях. Аналитические сети / Т. Л. Саати. — Москва, 2008. — 360 с.
20. Семенов С. С. Оценка качества и технического уровня сложных систем: практика применения метода экспертных оценок / С. С. Семенов. — Москва, 2015. — 352 с.
21. Шубин А. Н. Применение метода экспертных оценок при построении рейтинга / А. Н. Шубин, А. Д. Суб // *Инновации и инвестиции*. — 2014. — № 10. — С. 208—217.
22. Trishch H. M. System of dependencies for assessment of enterprises quality management processes / H. M. Trishch // *Eastern-European Journal of Enterprise Technologies*. — 2013. — № 4 (3(64)). — P. 60—63.
23. Фисун К. А. Построение групповой функции выбора / К. А. Фисун // *Коммунальное хозяйство городов*. — 1997. — Вып. 10. — С. 169—177.
24. Фисун К. А. Использование экспертных технологий в стратегическом планировании / К. А. Фисун // *Ринкова трансформація економіки України : проблеми регулювання : монографія / за ред. В. Ф. Беседіна, А. С. Музиченка*. — Київ : НДЕІ, 2005. — С. 414—424.
25. Фисун К. А. Проблемы использования экспертной информации при формировании инвестиционных проектов / К. А. Фисун // *Проблемы развития внешнеэкономических связей и привлечения иностранных инвестиций: региональный аспект : сб. науч. тр.* — Донецк : ДонНУ, 2008. — С. 621—626.
26. Фисун К. А. Реализация методов группового выбора в теории ограничения систем / К. А. Фисун // *Кибернетичне управління та інформаційні технології*. — 2014. — № 1. — С. 52—61.
27. Хованов Н. В. Математические основы теории шкал измерения качества / Н. В. Хованов. — Ленинград : Изд. ЛГУ, 1982. — 210 с.
28. Юрин А. Ю. Методы группового выбора для адаптации решений, полученных в результате рассуждений на основе прецедентов / А. Ю. Юрин // *Искусственный интеллект и принятие решений*. — Москва, 2013. — № 3. — С. 78—85.

29. Юринець Р. В. Формування експертних груп з використанням економіко-математичних моделей рішень / Р. В. Юринець, І. З. Саврас // Вісник соціально-економічних досліджень : зб. наук. пр. ОДЕУ / за заг. ред. М. І. Зверкова. — 2008. — № 30. — С. 413—417.

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References

1. Arrow, K. I. (1951). Social choice and individual values. New York: Wiley.
2. Beshelev, S. D., & Harvich, F. H. (1980). *Matematicheskko-statisticheskie metody ekspertnykh ocenok [Mathematical and statistical methods of expert estimates]*. Moscow: Statistika [in Russian].
3. Hrabovetskyi, B. Ye. (2010). *Metod ekspertnykh otsinok: teoriia, metodolohiia, napriamky vykorystannia [The method of expert evaluation: theory, methodology, directions of use]*. Vinnytsia [in Ukrainian].
4. Gibbard, A. (1977). Manipulation of voting schemes: A general result. *Econometrica*, 41, 4.
5. Goodwin, P. (2005). How to integrate management judgment with statistical forecasts. *Foresight*, 3, 8—12.
6. International vocabulary of metrology: Basic and general concepts and associated terms (VIM 3). (2012). *JCGM 200*.
7. Danelyan, T. Ya. (2015). Formal'nye metody ocenok [Formal estimation methods]. *Ekonomika. Statistika — Economics. Statistics*, 1, 183—187 [in Russian].
8. Kini, R. L., & Rajfa, H. (1981). *Prinyatie reshenij pri mnogih kriteriyah: predpochteniya i zameshcheniya [Decision making under many criteria: preferences and substitutions]*. Moscow: Radio i svyaz' [in Russian].
9. Kuz'min, V. B. (1982). *Postroenie gruppovykh reshenij v prostranstve chetkih i nechetkih binarnykh otnoshenij [Construction of group solutions in the space of clear and fuzzy binary relations]*. Moscow: Nauka [in Russian].
10. Litvak, B. G. (2004). *Razrabotka upravlencheskogo resheniya [Development of management decisions]*. Moscow: Delo [in Russian].
11. Lootsma, F. A. (1980). Saaty's priority theory and the nomination of a senior professor in operations research. *European Journal of Operational Research*, 4, 6, 380—388.
12. Lutsenko, I., Fomovskaya, E., Oksanych, I., Koval, S., & Serdiuk, O. (2017). Development of a verification method of estimated indicators for their use as an optimization criterion. *Eastern-European Journal of Enterprise Technologies*, 2 (4(86)), 17-23.
13. Lyndina, M. I., & Orlov, A. I. (2015). Matematicheskaya teoriya rejtingov [Mathematical theory of ratings]. *Nauchnyy zhurnal KubGAU — Scientific journal KubSAU*, 104 (10). Retrieved from <http://ej.kubagro.ru/2015/10/pdf/01.pdf> [in Russian].
14. Maslennikov, E. V. (2017). Vozmozhnosti ispol'zovaniya ekspertnykh znaniy v kachestve ystichnika koncepcij razvitiya organizatsii [Opportunities for using expert knowledge as a cleaner for concepts of organization development]. *Vestnik Moskovskogo universiteta. Sociologiya i politologiya — Moscow University Herald. Sociology and political science*, 23 (2), 229—249 [in Russian].
15. Mirkin, B. G. (1974). *Problema gruppovogo vybora [The problem of group choice]*. Moscow: Nauka [in Russian].
16. Motalo, V. (2015). *Analiz shkal vymiriuvan [Analysis of measurement scales]*. Lviv: NU «Lvivska politekhnika» [in Ukrainian].
17. Novosad, V. P., Seliverstov, R. H., & Artym, I. I. (2009). *Kilkisni metody ekspertnoho otsiniuvannia [Quantitative methods of expert evaluation]*. Kyiv [in Ukrainian].
18. Romanov, V. N. (2006). *Teoriya izmereniya. Metody obrabotki rezul'tatov izmerenij [Theory of measurement. Methods of processing measurement results]*. Saint-Petersburg [in Russian].
19. Saati, T. L. (2008). *Prinyatie reshenij pri zavisimostyah i obratnykh svyazyah. Analiticheskie seti [Decision making with dependencies and feedbacks. Analytical Networks]*. Moscow [in Russian].
20. Semenov, S. S. (2015). *Ocenka kachestva i tekhnicheskogo urovnya slozhnykh sistem: praktika primeneniya metoda ekspertnykh ocenok [Assessment of the quality and technical level of complex systems: the practice of applying the method of expert evaluations]*. Moscow [in Russian].
21. Shubin, A. N., & Sub, A. D. (2014). Primenenie metoda ekspertnykh ocenok pri postroenii rejtinga [Application of the method of expert assessments in building a rating]. *Innovatsii i investitsii — Innovations and Investments*, 10, 208—217 [in Russian].
22. Trishch, H. M. (2013). System of dependencies for assessment of enterprises quality management processes. *Eastern-European Journal of Enterprise Technologies*, 4 (3(64)), 60—63.
23. Fisun, K. A. (1997). Postroenie gruppovoy funktsii vybora [Construction of a group function of choice]. *Kommunal'noe hozjajstvo gorodov — Communal services of cities*, 10, 169—177 [in Russian].
24. Fisun, K. A. (2005). *Ispol'zovanie ekspertnykh tekhnologiy v strategicheskoy planirovani [Use of expert technologies in strategic planning]*. Rynkova transformatsiia ekonomiky Ukrainy: problemy rehuliuivannia [Market transformation of Ukraine's economy: regulatory issues]. V. F. Besedin, A. S. Muzychenko (Eds.). Kyiv [in Russian].
25. Fisun, K. A. (2008). Problemy ispol'zovaniya ekspertnoy informatsii pri formirovani investitsionnykh proektov [Problems of using expert information in the formation of investment projects]. *Problemy razvitiya vneshneekonomicheskikh svyazey i privlecheniya inostrannykh investitsiy: regional'nyy aspekt — Problems of developing foreign economic relations and attracting foreign investment: regional aspect*. Donetsk [in Russian].
26. Fisun, K. A. (2014). Realizatsiya metodov gruppovogo vybora v teorii ogranicheniya sistem / [Implementation of group choice methods in the theory of system restriction]. *Kibernetychne upravlinnia ta informatsiini tekhnologii — Cybernetic management and information technology*, 1, 52—61 [in Russian].
27. Hovanov, N. V. (1982). *Matematicheskie osnovy teorii shkal izmereniya kachestva [Mathematical foundations of the theory of scales for measuring quality]*. Leningrad [in Russian].
28. Yurin, A. Yu. (2013). Metody gruppovogo vybora dlya adaptatsii reshenij, poluchennykh v rezul'tate rassuzhdenij na osnove precedentov [Methods of group choice for adapting decisions obtained as a result of reasoning based on precedents]. *Iskusstvennyy intellekt i prinyatie reshenij — Artificial Intelligence and Decision Making*, 3, 78—85 [in Russian].
29. Iurynets, R. V., & Savras, I. Z. (2008). Formuvannia ekspertnykh hrup z vykorystanniam ekonomiko-matematychnykh modelei rishen [The formation of expert groups using economically mathematical models of decisions]. *Visnyk sotsialno-ekonomichnykh doslidzhen: zb. nauk. pr. ODEU — Bulletin of socio-economic research: Coll. Sciences ODEU*, 30, 413—417. M. I. Zvierkov. (Ed.) [in Ukrainian].

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