Methods for detecting and eliminating false measurements are well known in the theory of metrology. However, the relevant methodology is not adapted to the needs of the qualitative assessment of the impact of the human factor on expert decision-making.

The "systematic survivorship bias" refers to the following: when involving experts in conducting examinations, they usually focus on that part of them, where statistically probable agreed opinions are observed based on the results of these examinations. Other experts are considered "marginal", their opinions are discarded and not taken into account, which defines the "systematic survivorship bias", also called the "paradox of information availability". Although the specified "marginality" may be a consequence of the unique experience of conducting examinations or, for example, the use of modern technologies by a specific specialist, little known to the general public. It should be noted that manipulation of statistical data with an orientation only on "successful" cases could be really dangerous, for example, in studies of the human factor in complex ergastic active and organizational management systems, in particular aviation.

The rationale and implementation of the algorithm for detecting and eliminating the "systematic survivorship bias" have been given in this paper. m=90 specialists who are usually involved in various examinations by UkrINTEI took part in the research. The actual elimination of the "systematic survivorship bias" occurs after the implementation of a certain number of iterations of the algorithm given in the current work.

As a result of iterations of the above-mentioned algorithm, it was established that four subgroups can be distinguished from the initial sample with the number of m=90, with the following numbers: m_C=30 people, m_H=12 people, m_M=11 people, m_T=6 people. For the specified subgroups, the consistency of group opinions satisfies the entire spectrum of hypothesis testing criteria established in this paper

Keywords: scientific and technical expertise, "marginal" opinions, "survivorship bias", statistical sampling

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ELIMINATING "SYSTEMATIC SURVIVORSHIP BIAS" IN THE ATTITUDE OF SPECIALISTS TO THE SIGNIFICANCE OF INVESTMENT ATTRACTIVE FEATURES OF EXAMINED OBJECTS

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1. Introduction

The solidarity of progressive humankind with the people of Ukraine, who are carrying out uncompromising resistance to Russian invaders, involves, among other things, the introduction of harsh international sanctions and the implementation of military supplies, which ensure the effectiveness of resistance to the aggressor. On the other hand, the preparation of certain measures to attract foreign direct investments (FDI) in the post-war development of the country should be considered important. At the same time, one should focus on the identified more promising objects in the relevant sectors of the specified investments (Fig. 1) [1]:

– energy, especially "green", taking into account the security risks associated with traditional energy sources and existing climate commitments;

– machinery and equipment, including military equipment such as drones. Ukraine has its own production but given the constant security risks, it will welcome foreign investment in domestic production according to NATO standards;

– information computer technologies (ICT) and communication. The sector is intensively developing even despite the war and should become one of the key drivers of the country's exports;

– agriculture and food industry. The sector is internationally competitive and has proven to be quite resilient to

security shocks. Despite the war, the export of the corresponding products convincingly testifies to this;

– construction and building materials. The unprecedented need for reconstruction – given the extent of the destruction – will make this sector a Klondike for domestic and foreign investors. In addition, the development of modern infrastructure that meets EU standards will be a task for years, offering investment opportunities also in the form of public-private partnerships;

– metallurgy. The significant destruction of existing production capacity, combined with the available resources and skilled labor force, makes recovery of the industry attractive;

– production of medical products and pharmaceutical stuff.

Since foreign partners are focused specifically on the victory of Ukraine, it should be expected that the overall positive course of the war with the Russians will activate FDI, making the above industries even more attractive for potential investors. And from this follows the urgent need for a full, comprehensive, and objective analysis of specific objects of these sectors, which is an urgent task, especially in the part of scientific and methodological support of examinations with more advanced technologies.

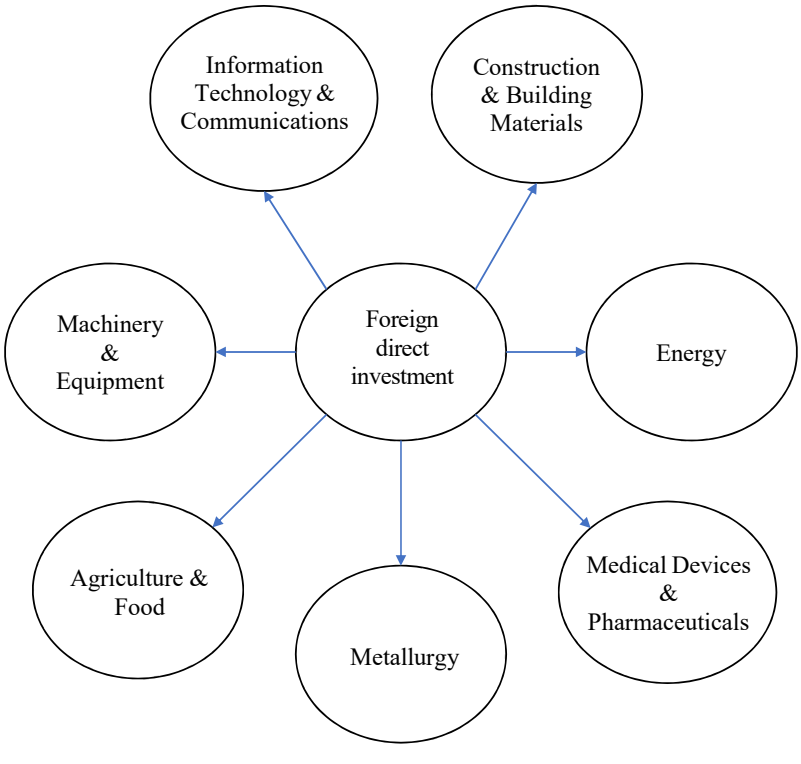

Fig. 1. Predicted structure of more attractive sectors for direct foreign investment in the post-war economy of Ukraine

2. Literature review and problem statement

In work [2] it was found that in the absence of answers to 38–45 % of requests, such requests were rejected and not taken into account. This, in turn, affects the significant distortion of observations. At the same time, this study does not provide suggestions for eliminating the survivorship bias, but only its effect on the results of observations.

Regarding suggestions for procedures to eliminate survivorship bias, [3] provides guidance on how to deal with and reduce survivorship bias in empirical research. At the same time, this research concerns only financial funds. It is similar to study [4], in which a shift correction method for statistical samples is proposed, but again, the proposals relate to enterprises and companies and their creditworthiness. That is, the given procedures for eliminating the survivorship bias do not take into account the quality of the influence of the human factor.

Another example of studying the survivorship bias is paper [5], in which the positive effect of a suppressed immune system on protection against the most severe consequences of infection was investigated. At the same time, it should be emphasized that the work does not provide a procedure for eliminating the error of the one who survived on one side. In addition, this study concerns only the 1918 influenza pandemic.

Thus, as of 2023, there are no studies of survivorship bias occurring among S&T practitioners.

It is clear that the determination of the degree of investment attractiveness (DIA) of any object of examination (OE) will be considered more perfect the more features of its investment attractiveness (FIA) will be considered during the relevant study. On the other hand, the introduction of a vague scale of the degree of expressiveness (DE) of a certain FIA in a specific OE under study will contribute to the implementation of the technology for obtaining an integral assessment of the OE SIP, which and only which has the inherent systemic property of emergency [6]. The specified technology is implemented by assigning the appropriate normalized coefficients of FIA significance and estimates of their DE in a specific OE, on the one hand. On the other hand, using a multiplicative approach to the aggregation of relevant indicators into an integral assessment, which contributes to obtaining a more careful, and therefore reliable, result compared to the additive approach.

It is convenient to establish the coefficients of significance, based on the analysis of work [7], using the mathematical method of prioritization. This method is also known as the "problem about the leader" [8] and is based on the systems of advantages (SA) of the spectrum of characteristic FIAs (CFIAs) and indicators of the DE of these features in a specific OE. At the same time, SA in the context of research is understood as a well-founded and orderly sequence of researched FIAs: from more attractive, weighty, significant, etc. to less weighty.

It is not difficult, based on the methodology of fuzzy mathematics, to introduce the scale of linguistic evaluations "DE FIA" [6]. The obvious priority of the indicators of the CB CFIA in OE contributes to the application of MRP to establish the appropriate weighting factors.

This allows us to assert that there is a need to establish a well-founded, reliable, even "reference" SA on the set of CFIA OE. And since expert technologies are used for this, the problem of identifying and sifting out marginal opinions and eliminating the "systematic survivorship bias" immediately arises. Ukrainian scientists, representatives of the scientific school of one of the co-authors of paper [9] deal

with this problem in the post-Soviet space. At the same time, foreign scientists have been studying this phenomenon for more than 70 years. Beginning with the Aircraft Vulnerability Study [10], which consists of publications from 1943 on methods for estimating the vulnerability of various parts of an aircraft based on the damage of surviving aircraft, however, is only the beginning of the study of "survivorship bias". Subsequent studies and publications have addressed the "boom" in the popularity of science after World War II [11], but this study does not provide a method for identifying or eliminating "survivor error." Some of them [12] are even forced to justify the absence of "survivor error" in the study of the relationship between liver diseases and mortality in older people but do not indicate ways to eliminate such an error. Other scientists insist [13] that without taking into account the results of research on the profitability of investment funds, it should be considered "incomplete", and they propose to check this by calculating the profitability of the merger of such funds. Some consider the research of the 2000s to be largely "distorted" [14] and provide simulations that show that research methods tend to confirm errors, but do not provide methods to eliminate them. It is worth noting that there are really few studies of "survivorship bias", which is evidenced by the fact that scientists study previous publications of well-known authors. For example, in work [15], researchers study the impact of the low citation of the work of an influential economist in 1987 on the development of the world economy. In addition, the study of "survivorship bias" is also applied in sociological research [16], which shows the influence of different indicators of the standard of living on the results of sociological studies in the Arabian Peninsula. At the same time, the study found that when the "survivorship bias" is eliminated, the effect of "oil" is reduced to a minimum, which encourages a wider perception of the process of data generation and collection. At the same time, specific technologies for detecting and eliminating the "systematic survivorship bias" are not given in the above-mentioned publications, as a rule, due to the insufficient number of practical studies. Also, in the publications where the methods of eliminating the "systematic survivorship bias" are given such methods do not take into account the need for the quality measurement of the influence of the human factor, so they cannot be applied to the examination process.

It should be noted that in the theory of metrology there are well-known methods for detecting and eliminating false measurements [17]. However, the relevant methodology is not adapted for the needs of the qualitative assessment of the impact of the human factor (HF) on expert decision-making. Although it is easy to imagine expert activity as a continuous chain of decisions that are produced and implemented in explicit/implicit forms and under the influence of various factors: internal/external, objective/subjective, especially risks of a stochastic and non-stochastic nature.

The "systematic survivorship bias" is thus imagined. Involving experts to carry out examinations, they usually focus on that part of them, where, based on the results of these examinations, statistically probable agreed opinions are observed. Other experts are considered "marginal", their opinions are discarded and not taken into account, which defines the "systematic survivorship bias", also called the "paradox of information availability". Although the specified "marginality" may be a consequence of the unique experience of conducting examinations or, for example, the use of modern technologies by a specific specialist, little known to the general public, which led to expert conclusions that do not coincide with the opinion of the "majority". It should be noted that the manipulation of statistical data with an orientation only on "successful" cases can be really dangerous, for example, in studies of the human factor (HF) in complex energetic active and organizational management systems [18], in particular aviation [19].

Thus, on the basis of the analysis of scientific studies related to the study of survivorship bias, it is necessary to note that there are two main unsolved problems:

– most studies do not provide methods for eliminating "survivorship bias", but only state the fact of detecting such errors;

– in the studies where are the procedures for eliminating the survivorship bias? the qualitative impact of the human factor is not taken into account, so the results cannot be applied to the examination process.

Therefore, the problem that remains unsolved is the lack of methods and technologies for identifying and eliminating the "systematic survivorship bias" during the scientific and technical examination of scientific works.

3. The aim and objectives of the study

The purpose of this study is to devise a technology for detecting and eliminating the "systematic survivorship bias" in the attitude of specialists to the significance of FIA OE, which will allow weeding out the so-called "marginal" opinions and form a new sample that will be considered and researched as the original.

To achieve this goal, the following tasks were set:

– to identify subgroups with statistically probable agreement of opinions;

– to establish the coincidence of group systems of preferences of isolated subgroups.

4. The study materials and methods

The object of our study is the process of evaluation of objects of expertise (OE) and investment projects. The subject of the study is the research technology of the degree of investment attractiveness (DIA) of OE, including the identification and screening of marginal opinions.

The main hypothesis of the research assumes that the opinions of experts regarding DIA OE or the significance of the features of investment attractiveness (FIA) of the specified objects, conditionally recognized as marginal, should not be rejected, but should be further investigated. Since the specified "marginality" may be, among other things, a consequence of the unique experience of carrying out examinations by an individual specialist(s) or their use of some original methods/approaches not yet known to the general public. That, in essence, reveals the concept of "systematic survivorship bias."

The peculiarity of our scientific work is that the proposed solutions are unique from the point of view of the study of the influence of HF on decision-making. Given that the more well-known technologies, methods, procedures for eliminating the "systematic survivorship bias", which were considered in the second part of this publication, are not adapted specifically to take into account the effect of HF.

And since the satisfaction of the introduced criteria of system-information coherence of opinions may not be achieved already on the 1st iteration of the application of the proposed technology of detection and screening of marginal opinions, then we are talking about a multi-step technology.

In order to provide a comprehensive analysis of OE, a list of n=18 CFIAs was formed (Table 1) [20]. As listed in Table 1, CFIA OE are ambiguous in significance, then the question arises of forming a representative expert group to determine the appropriate *SA*, or, according to the provisions of the theory of informatics, a tuple [10, 19, 21–24].

Table 1

Characteristic features of investment attractiveness of the objects of examination

FIA	Feature sense
FIA_1	Business co-owners
FIA_2	Perspective of the object of examination
FIA_3	Risks
FIA_4	Investor return plan
FIA_5	Socio-economic effect
FIA_6	Investment plan
FIA_7	The price of the offer
FIA_8	Consumer market
FIA_9	Stage of implementation
FIA_{10}	Payback period
FIA_{11}	Legal protection
FIA_{12}	Competitive environment
FIA_{13}	Management, staff
FIA_{14}	Marketing
FIA_{15}	Guarantees of return of funds to the investor
FIA_{16}	Life cycle
FIA_{17}	Contractual relations
FIA_{18}	Net profit

Individual SAs (ISAs) are usually built by the method of pairwise comparison and normative determination of part of the total significance of alternatives. And group SAs (GSP) – with the help of such a very popular group decision strategy as summation and averaging of ranks [10–12, 19, 22, 25].

m=90 specialists who are usually involved in various examinations by UkrINTEI took part in the research. The results of their survey are given in Table 2. It is clear that the large number of applied CFIAs, commensurate with the futility coefficient [26], and the large volume of the expert sample led to significant variability of opinions. This, in turn, inevitably affected the absolute value of the Kendall concordance coefficient W (W=[0, 1]), which integrally determines the overall group agreement of opinions: W=0.4772. Although the application of the chi-square test revealed its statistical probability at an unusually high level of significance α=1 %:

$$\begin{cases} \chi^2_{emp} >> \chi^2_{table} = \chi^2_{k=m-1,\alpha,\%} \Leftrightarrow \\ \chi^2_{emp} = 730.059 >> \chi^2_{k=89,\,\alpha=1\%} = 127.11, \end{cases} \quad (1)$$

where χ^2_{emp} is the empirical value of the chi-square hypothesis testing statistical criterion. The corresponding formula for its calculation is known [8–10, 19, 27], so it is not given in this paper;

χ^2_{table} – the theoretical value of the chi-square criterion, which is determined from special tables [28] taking into account the number of degrees of freedom k=m–1=89 and the level of significance α=1 %.

Thus, the upper part of expression (1) should be considered the first criterion for establishing the consistency of group opinions (CGO). The next CGO criterion should be the limit on the absolute minimum acceptable value of Kendall's concordance coefficient, proposed in work [20]:

$$W \geq 0.7...0.8. \quad (2)$$

It can be considered that during the analysis of GSP, one should not focus only on criteria (1), (2) but should also use the indicators of the coincidence of ISA with each other and the ISA with the GSA, which is determined using the Spearman rank correlation coefficient, which is well known in expert research [8–10, 19, 27]. Therefore, based on known formulas for calculating the specified coefficient and establishing its statistical probability using the Student's t-test, it was determined that the minimum acceptable statistically probable empirical value of the specified coefficient should be equal to:

$$\begin{cases} t_{emp.} = R_S \sqrt{\dfrac{n-2}{1-R_S^2}} >> t_{table} = t_{k=n-2,\alpha\,\%} \Rightarrow \\ R_S^{\min_S^{k=18,\alpha=1\%}}, \end{cases} \quad (3)$$

where t_{table}=$t_{k=n-2,\ a\%}$ is the theoretical value of the Student variable, determined for the number of degrees of freedom k=n–2=16 and the significance level α=1 % [28].

Criterion (3) is applied in research as follows. Let the criteria (1), (2) be fulfilled, but a situation may arise when the ISA of an individual expert does not coincide with the GSP. This is quite possible since the construction of the GSP uses, as indicated above, an additive approach to the aggregation of ISAs, namely the strategy of summation and averaging of ranks. That led to the need to formulate the appropriate CGO criterion:

$$\forall E_j, \overline{j=1,m_k}: R_S\left(\mathrm{ISA}_{E_j}, \mathrm{GSA}_{m_k}\right) > R_{S\min}, \quad (4)$$

where $R_{S\min}$ is the minimum statistically probable and acceptable value of the Spearman rank correlation coefficient determined by criterion (3).

Thus, criterion (4) requires that all ISAs coincide with the GSA selected for analysis with statistical probability.

As a result of the implementation of the additive approach to the aggregation of ISA in the GSA, a situation may arise when criterion (4) is fulfilled. That is, the opinions of a certain expert regarding the importance of CFIA, although they coincide with the general group opinion but do not agree with the opinion of the majority of the group members, which is unacceptable. To eliminate such an undesirable situation, a corresponding criterion is introduced:

$$\underset{j=\overline{1,m_1},\, i\neq k}{m\left(R_S\left(\mathrm{ISA}_{E_j}, \mathrm{ISA}_{E_k}\right) > R_{S\min}(\ )\right)}, \quad (5)$$

$$\underset{j=\overline{(m_1+1),m},\, i\neq k}{mm\left(R_S\left(\mathrm{ISA}_{E_j}, \mathrm{ISA}_{E_k}\right) > R_{S\min}(\ )\right)}$$

where $R_{S\min}$ is the minimum statistically probable and acceptable value of the Spearman rank correlation coefficient determined by criterion (3).

Table 2

Generalization of individual systems of experts' preferences into a matrix of decisions (fragment)

E_j	Ranks of characteristic features of investment attractiveness of objects of expertise in individual systems of preferences, r_{ij}																	
	FIA_1	FIA_2	FIA_3	FIA_4	FIA_5	FIA_6	FIA_7	FIA_7	FIA_9	FIA_{10}	FIA_{11}	FIA_{12}	FIA_{13}	FIA_{14}	FIA_{15}	FIA_{16}	FIA_{17}	FIA_{18}
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
E_1	1	6	4	5	7	11	16.5	13	15	14	12	16.5	10	9	2.5	18	2.5	8
E_2	2	17	4	2	2	14	9	11	14	14	12	18	10	8	5.5	16	5.5	7
E_3	4	10	15	18	14	3	13	5.5	1.5	1.5	10	16	10	5.5	7	12	8	17
E_4	6	10	4.5	2	1	7	8	11	18	16	12	15	13	14	3	17	4.5	9
E_5	7	15	5	2	4	12	13	9	14	10.5	8	16.5	10.5	16.5	1	18	3	6
E_6	7	9	5	5	5	10	11	8	16.5	13	14	16.5	18	15	2	12	1	3
E_7	7.5	10	2.5	2.5	2.5	10	7.5	10	18	17	16	13	15	14	2.5	12	5	6
E_8	8	11.5	5	2.5	2.5	16	11.5	9.5	17	13	9.5	18	15	14	6.5	6.5	2.5	2.5
E_9	9	9	2	2	2	18	9	13	16	11.5	11.5	14	7	17	5	15	4	6
E_{10}	9	10	5	6	4	18	17	13	13	11	8	15	16	13	1	7	3	2
E_{11}	10	7	12.5	8.5	6	18	15	11	8.5	16.5	14	16.5	2	5	1	12.5	3	4
E_{12}	10	8	3	4	2	18	16.5	16.5	13	13	6	13	15	11	1	9	7	5
E_{13}	10	8	4	3	2	18	16.5	16.5	13	13	6	13	15	11	1	9	7	5
E_{14}	10	8	5	5	5	11.5	11.5	9	17	16	15	18	7	13	1	14	3	2
E_{15}	10	8	7	4	5	14	17	12	11	9	6	15	18	13	3	16	2	1
E_{16}	10	9	1	6.5	12.5	12.5	6.5	6.5	12.5	15	3	16	6.5	18	4	2	12.5	17
E_{17}	10.5	4	5	3	2	15	7	13	9	16	12	10.5	6	17	18	14	8	1
E_{18}	10.5	7.5	3.5	2	1	10.5	12	7.5	14.5	17	17	14.5	6	5	17	3.5	9	13
E_{19}	10.5	7.5	3.5	2	1	10.5	12	7.5	15	17	17	13	14	6	5	17	3.5	9
E_{20}	11	7.5	4	4	4	12	15.5	13	10	17	14	18	15.5	6	1	9	2	7.5
E_{21}	11	7	6	5	8	9	10	4	18	16	17	12	15	14	1	13	2	3
E_{22}	11.5	7.5	6	5	1.5	17	16	14	18	13	7.5	9.5	9.5	11.5	3	15	1.5	4
E_{23}	12	11	6.5	2	3	17	9.5	6.5	18	15	14	13	4	6.5	1	16	6.5	9.5
E_{24}	12	13	2	2	2	17	16	18	14	9	8	15	11	7	5	10	4	6
E_{25}	12	4	6	6	6	13	10	2	16	10	10	16	18	16	1	14	3	8
E_{26}	12	7	4	4	4	18	9	11	17	9	9	16	13.5	13.5	1	15	2	6
E_{27}	12	11	6.5	2	3	17	9.5	6.5	18	15	14	13	4	6.5	1	16	6.5	9.5
E_{28}	12	13	2	2	2	17	16	18	14	9	8	15	11	7	5	10	4	6
E_{29}	12	7	4	4	4	18	9	11	17	9	9	16	13.5	13.5	1	15	2	6
E_{30}	12	10	6	4	5	13	11	9	17	8	7	16	18	15	1	14	2	3
E_{31}	12.5	6	9.5	3	2	15	7	5	17	12.5	9.5	16	11	14	1	18	4	8
E_{32}	13	9	2.5	2.5	2.5	18	16	17	15	11	10	7	8	12	2.5	14	5	6
E_{33}	13	12	7	5.5	8.5	16.5	15	16.5	8.5	10	11	18	14	2.5	2.5	5.5	1	4
E_{34}	13	7	6	1	3	11	14	8	17	16	10	18	12	9	2	15	5	4
E_{35}	13	8	5	1	2	18	15	11	13	6	4	17	10	9	13	16	3	7
E_{36}	13	10	5	6	4	12	15	11	16	9	8	17	7	14	1	18	3	2
E_{37}	13.5	5	10	7	6	11	2.5	2.5	13.5	16	16	8	9	12	18	16	1	4
E_{38}	14	4	18	8	5	12	10	11	14	6.5	6.5	16.5	16.5	9	1	14	3	2
E_{39}	14	4	13	8	12	16	1	2	18	6.5	5	17	6.5	15	9.5	3	9.5	11
E_{40}	14	11	5	4	1.5	12	7	6	15	13	10	16	9	17.5	1.5	17.5	3	8
E_{41}	14	12	2	3.5	3.5	6	8	9	18	11	10	13	16	15	1	17	7	5
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
E_{88}	18	12	5	1	2	14	11	9	17	13	15.5	15.5	10	7	8	6	4	3
E_{89}	18	16.5	16.5	15	14	13	12	11	10	9	8	7	6	4.5	4.5	3	2	1
E_{90}	18	9.5	4	5.5	2	17	11.5	14	7	15	13	16	8	11.5	1	9.5	5.5	3
$\sum$	1,243	890.5	564.5	380	377	1,183.5	1,014.5	905.5	1242	1,053.5	928.5	1,238	1,073	947.5	333	1,073	383	560
$\overline{r_i}$	13.81	9.89	6.27	4.22	4.19	13.15	11.27	10.06	13.8	11.71	10.32	13.76	11.92	10.53	3.7	11.92	4.26	6.22
r_i	18	7	6	3	2	15	11	8	17	12	9	16	13.5	10	1	13.5	4	5

So, there is a question of identifying and eliminating "marginal" ISAs at the initial stage of analyzing the results of the expert survey. That is implemented by applying the methods of pattern recognition theory [12, 14, 19, 29–31], using the appropriate algorithm (Fig. 2).

Elimination of the "systematic survivorship bias" occurs after the implementation of a certain number of iterations of the algorithm from Fig. 2. After that, a subgroup with, say, m_k people is selected from the base group, with the number of m=90 people, in which the CGO indicators fully

satisfy all the defined criteria (1) to (5). Then the original sample is reduced to the appropriate number of persons and a new subgroup with the number of $m_l=(m-m_k)$ persons is obtained, which is taken as the base and among whose members "marginals" are identified and screened out. Iterations of the algorithm from Fig. 2 are carried out until all possible options for reducing the initial number of experts and identifying subgroups with intra-group consistency of opinions satisfying criteria (1) to (5) have been analyzed.

The implementation of the considered algorithm will also lead to the discovery of some subgroup in which CGO does not satisfy criteria (1) to (5), its members will then really be considered "marginals" that should not be involved in the relevant examinations.

So, this is exactly how the "systematic survivorship bias" should be eliminated in the process of determining the attitude of specialists to the significance of OE's FIA.

Each subsequent iteration of the algorithm from Fig. 2 leads to a consistent reduction of the original sample of experts involved in the tests.

Therefore, the question arises as to the establishment of the minimum quantitative composition of the subgroup that can be separated from the original sample of respondents, whose opinions regarding the significance of OE CFIA satisfy criteria (1) to (5). As of the beginning of 2023, no consensus has actually been reached regarding the lower quantitative limit of the expert group [29, 32], and the relevant issues are usually associated with the contribution to the average group error [10–12, 19, 30, 33]. Therefore, it can be considered that the control criterion is also the excess of the number of experts over the number of investigated factors. However, crossing the lower limit of Miller's so-called "magic number" is impractical.

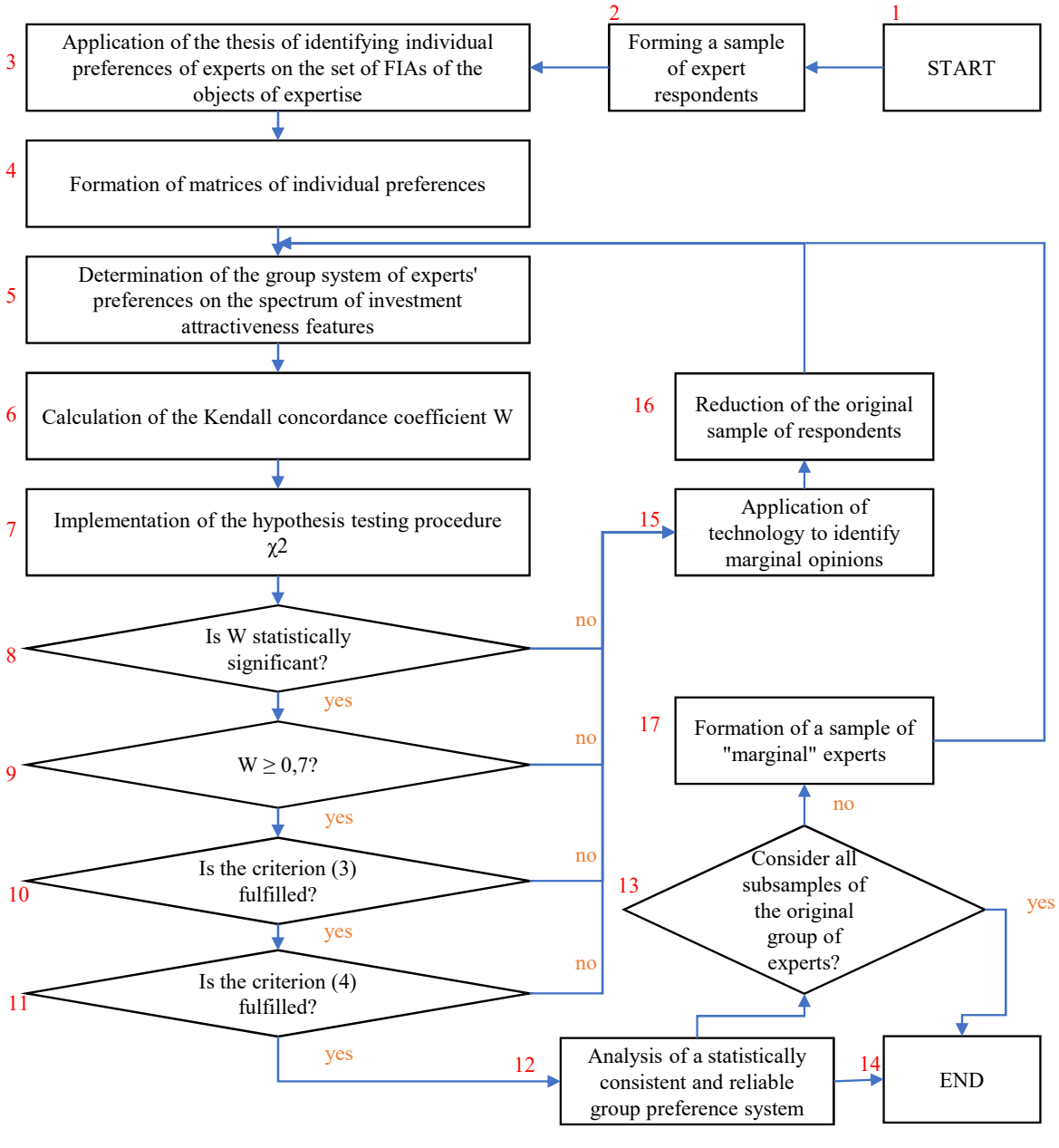

Fig. 2. A multi-step algorithm for identifying "marginal" opinions of experts and eliminating the "statistical survivorship bias"

5. Results of elimination of "systematic survivorship bias"

5. 1. Results of identifying subgroups with statistically probable agreement of opinions

As a result of iterations of the algorithm from Fig. 2 it is established (Table 3) that from the initial sample with the number of m=90, four subgroups can be distinguished, with the following numbers: m_C=30 people, m_H=12 people, m_M=11 people, m_T=6 people. For the specified subgroups, CGO meets the entire range of criteria (1) to (5).

It is necessary to pay attention to the need for an additional iteration of the algorithm from Fig. 2 to the ISA of members of subgroup m_B, numbering m_B=47 people. The fact is that despite the fulfillment of criteria (1) to (4), a person (expert E_{55}) was identified in subgroup m_B, whose opinions regarding the significance of OE CFIA do not coincide with the majority (68.09 %) of group members, i.e., criterion (7) is not fulfilled. At the same time, for eleven experts (E_4, E_{23}, E_{24}, E_{27}, E_{28}, E_{35}, E_{42}, E_{53}, E_{85}, E_{86}, E_{88}), the rate of disagreement with other members of the m_B subgroup is very noticeable (at least a third) and climbs to an average of 38.68 %.

Iterations of the algorithm from Fig. 2 was terminated after processing the ISA by expert members of the m_X subgroup.

First, because criterion (2) is not fulfilled:

$$W_{mX}=0.6021<W_{\min}=0.7.$$

Secondly, criterion (4) is not fulfilled for four (44.44 % of the quantitative composition of the m_X subgroup) subjects (experts E_2, E_{48}, E_{62}, E_{79}):

$$\begin{cases} R_S\left(\mathrm{ISA}_{E_2},\mathrm{GSA}_{m_X}\right)=0.5332<R_{S\min}, \\ R_S\left(\mathrm{ISA}_{E_{48}},\mathrm{GSA}_{m_X}\right)=0.4762<R_{S\min}, \\ R_S\left(\mathrm{ISA}_{E_{62}},\mathrm{GSA}_{m_X}\right)=0.4997<R_{S\min}, \\ R_S\left(\mathrm{ISA}_{E_{79}},\mathrm{GSA}_{m_X}\right)=0.5883<R_{S\min}. \end{cases}$$

Finally, thirdly, ⅔ of the members of subgroup m_X have a statistically probable disagreement about the significance of the CFIA OE with the majority of this subgroup (the average rate of disagreement is 72.23 %).

Taking into account the above justification of the minimum quantitative composition of the group, further application of the algorithm from Fig. 2 and reducing the quantitative composition of subgroup m_X is impractical.

5. 2. Results of identification of coincidences of group systems of preferences of isolated subgroups

Based on the results of identifying subgroups with statistically probable agreement of opinions, it should be noted that the entire composition of subgroup m_U, numbering m_U=31 people, should be classified as marginal from the initial sample of m=90 experts. This number is a third (34.44 %) of the total quantitative composition of the subjects. We consider the mentioned statistics of "marginals" whose opinions regarding the significance of OE CFIA to be culled, as a whole understandable, because:

– firstly, in the created list of FIA OE (Table 1) it is not possible to establish clear "markers" that indicate the obvious advantage of one FIA and which specialists should be guided by in the examination process;

– secondly, one should take into account the large number of alternatives arranged by experts, commensurate with the coefficient of futility, which causes a significant variation of opinions;

– thirdly, there are no regulatory recommendations regarding the importance of FIA OE;

– fourthly, since this kind of research was conducted for the first time, we, during the formation of the sample, focused on the largest possible number of

Table 3

Results of identifying and sifting out the marginal opinions of experts to eliminate the "systematic survivorship bias" in the attitude of experts to the significance of the features of the investment attractiveness of the objects of expertise

No. of entry	m_k	W	$\chi^2_{emp.}$	{>, <, =}	$\chi^2_{\alpha=1\%,k=m-1}$	$\bar{R}_S^{(\mathrm{GSA}_{mk},\mathrm{ISA}_j)}$	$\bar{R}_S^{(\mathrm{ISA}_j,\mathrm{ISA}_l)}$
1	2	3	4	5	6	7	8
1	m=90	0.4772	730.059	>>	127.11	0.6640	0.4685
2	m_A=69	0.6423	753.406	>>	101.78	0.7714	0.6355
3	m_B=47	0.7015	560.462	>>	74.44	0.8064	0.6932
4	m_C=30	0.7683	390.944	>>	52.34	0.8432	0.7593
5	m_D=60	0.3744	381.886	>>	90.72	0.5743	0.3623
6	m_E=46	0.5749	449.557	>>	73.17	0.6909	0.5371
7	m_F=34	0.6090	352.003	>>	57.65	0.7134	0.5953
8	m_G=21	0.6909	248.480	>>	40	0.7042	0.6784
9	m_H=12	0.8289	169.089	>>	26.76	0.7405	0.8112
10	m_I=48	0.3197	250.846	>>	75.7	0.5328	0.3037
11	m_J=35	0.5108	303.929	>>	58.96	0.6686	0.4948
12	m_K=24	0.5751	218.504	>>	44.18	0.6869	0.5540
13	m_L=17	0.6507	188.060	>>	34.27	0.7174	0.6249
14	m_M=11	0.7361	139.059	>>	25.19	0.7389	0.7026
15	m_N=37	0.2537	159.552	>>	61.58	0.4715	0.2320
16	m_O=24	0.4597	187.550	>>	44.18	0.6363	0.4360
17	m_P=18	0.4938	151.103	>>	35.72	0.6640	0.4636
18	m_Q=14	0.5500	130.899	>>	29.82	0.6854	0.5154
19	m_R=9	0.6270	95.938	>>	21.95	0.7050	0.5804
20	m_S=7	0.6964	82.875	>>	18.55	0.7260	0.6453
21	m_T=6	0.7077	72.189	>>	16.75	0.7341	0.6490
22	m_U=31	0.2259	119.059	>>	53.67	0.4207	0.1991
23	m_V=20	0.4218	143.411	>>	38.58	0.5734	0.3912
24	m_W=13	0.5057	111.757	>>	28.29	0.6196	0.4667
25	m_X=9	0.6021	92.120	>>	21.95	0.6203	0.5470

them, in order to outline as wide a spectrum of opinions as possible regarding the significance of FIA OE;

– fifthly, it turned out that representatives of the m_X subgroup are less experienced among all specialists involved in the tests.

That led to the "vagueness" of the opinions of the "marginals" and the need to get rid of their ISA in further research.

Group SAs, built from ISAs of experts-members of subgroups m_C, m_H, m_M, m_T with revealed statistically probable intra-group consistency of opinions satisfying criteria (1) to (5), are given in Table 4.

Let us emphasize the reliability of our results, and therefore the corresponding conclusions, because we are talking about an unusually high level of statistical hypothesis testing α=1 % accepted for HF research.

Table 4

Group preference systems of experts with intra-group consistency of opinions regarding the significance of features of investment attractiveness of expertise objects

Subgroup m_k	A group system of experts' preferences on a set of features of the investment attractiveness of objects of expertise
1	2
m_C=30	$\mathrm{FIA}_{15} \succ_{m_C} \mathrm{FIA}_5 \succ_{m_C} \mathrm{FIA}_4 \succ_{m_C} \mathrm{FIA}_{17} \succ_{m_C} \mathrm{FIA}_3 \succ_{m_C} \mathrm{FIA}_{18} \succ_{m_C} \mathrm{FIA}_8 \succ_{m_C} \mathrm{FIA}_2 \succ_{m_C} \mathrm{FIA}_{11} \succ_{m_C}$ $\mathrm{FIA}_7 \succ_{m_C} \mathrm{FIA}_{10} \succ_{m_C} \mathrm{FIA}_{13} \succ_{m_C} \mathrm{FIA}_{14} \succ_{m_C} \mathrm{FIA}_6 \succ_{m_C} \mathrm{FIA}_{16} \succ_{m_C} \mathrm{FIA}_1 \succ_{m_C} \mathrm{FIA}_{12} \succ_{m_C} \mathrm{FIA}_9$
m_H=12	$\mathrm{FIA}_{15} \succ_{m_H} \mathrm{FIA}_5 \succ_{m_H} \mathrm{FIA}_4 \succ_{m_H} \mathrm{FIA}_{18} \succ_{m_H} \mathrm{FIA}_3 \succ_{m_H} \mathrm{FIA}_{17} \succ_{m_H} \mathrm{FIA}_{11} \succ_{m_H} \mathrm{FIA}_{16} \succ_{m_H} \mathrm{FIA}_{14} \succ_{m_H}$ $\mathrm{FIA}_2 \succ_{m_H} \mathrm{FIA}_{13} \succ_{m_H} \mathrm{FIA}_9 \succ_{m_H} \mathrm{FIA}_{10} \succ_{m_H} \mathrm{FIA}_1 \succ_{m_H} \mathrm{FIA}_{12} \succ_{m_H} \mathrm{FIA}_8 \succ_{m_H} \mathrm{FIA}_7 \succ_{m_H} \mathrm{FIA}_6$
m_M=11	$\mathrm{FIA}_{15} \succ_{m_M} \mathrm{FIA}_4 \succ_{m_M} \mathrm{FIA}_5 \succ_{m_M} \mathrm{FIA}_{17} \succ_{m_M} \mathrm{FIA}_3 \succ_{m_M} \mathrm{FIA}_{18} \succ_{m_M} \mathrm{FIA}_8 \succ_{m_M} \mathrm{FIA}_2 \succ_{m_M} \mathrm{FIA}_7 \succ_{m_M}$ $\mathrm{FIA}_{14} \succ_{m_M} \mathrm{FIA}_6 \succ_{m_M} \mathrm{FIA}_{13} \succ_{m_M} \mathrm{FIA}_1 \succ_{m_M} \mathrm{FIA}_{16} \succ_{m_M} \mathrm{FIA}_{12} \succ_{m_M} \mathrm{FIA}_{11} \succ_{m_M} \mathrm{FIA}_{10} \succ_{m_M} \mathrm{FIA}_9$
m_T=6	$\mathrm{FIA}_4 \succ_{m_T} \mathrm{FIA}_5 \succ_{m_T} \mathrm{FIA}_3 \succ_{m_T} \mathrm{FIA}_2 \succ_{m_T} \mathrm{FIA}_{15} \succ_{m_T} \mathrm{FIA}_{17} \succ_{m_T} \mathrm{FIA}_{18} \succ_{m_T} \mathrm{FIA}_{11} \succ_{m_T} \mathrm{FIA}_{10} \succ_{m_T}$ $\mathrm{FIA}_9 \succ_{m_T} \mathrm{FIA}_8 \succ_{m_T} \mathrm{FIA}_{14} \succ_{m_T} \mathrm{FIA}_7 \succ_{m_T} \mathrm{FIA}_{16} \succ_{m_T} \mathrm{FIA}_6 \succ_{m_T} \mathrm{FIA}_{12} \succ_{m_T} \mathrm{FIA}_1 \succ_{m_T} \mathrm{FIA}_{13}$

Note: $\succ_{m_k}$, $\approx_{m_k}$ *– denote, respectively, the superiority and adequacy of features of the investment attractiveness of the examination objects in the corresponding group system of advantages*

As can be seen from Table 4, the GSA of the subjects-members of the m_C, m_H, m_M, m_T subgroups do not have related ranks, which indicates a high level of confidence of the members of the subgroups in their attitude to the significance of FIA OE. This, in turn, led to a strict arrangement of the researched FIA OE.

Comparison of GSA summarizing the opinions of members of subgroups m_C, m_H, m_M, m_T (Table 4) using Spearman's rank correlation coefficient led to the results given in Table 5.

The highest average agreement of opinions with others is demonstrated by the GSA constructed for members of subgroup m_C:

$$\bar{R}_S^{m_C} = 0.8019 > R_S^{\min}$$

and the lowest – GSA of members of subgroup m_H:

$$\bar{R}_S^{m_H} = 0.6904 > R_S^{\min}.$$

Table 5

Assessment of the concurrence of opinions of experts of different subgroups regarding the significance of the characteristic features of the investment attractiveness of the objects of expertise

m_k	m_C=30	m_H=12	m_M=11	m_T=6	$\bar{R}_S^{m_k}$
1	2	3	4	5	6
m_C=30	–	0.7152	0.8762	0.8142	0.8019
m_H=12	–	–	0.6078	0.7482	0.6904
m_M=11	–	–	–	0.6491	0.7110
m_T=6	–	–	–	–	0.7372

Based on the averaged indicators $\bar{R}_S^{m_k}$ (column 6, Table 5), it is possible to order the GSA of subgroups m_C, m_H, m_M, m_T according to efficiency as follows:

$$\bar{R}_S^{m_C} > \bar{R}_S^{m_T} > \bar{R}_S^{m_M} > \bar{R}_S^{m_H}. \qquad (6)$$

It should also be noted that the obtained ranking of type (6) is led by the indicators of subgroup m_C, which is more numerous among others, which was determined from the original sample of tested experts, numbering m=90 people. Also taking into account the absolute value of the indicator $\bar{R}_S^{m_C}$ and research experience [12, 19, 20], we believe that it is the GSA of this subgroup that should be optimized in the future in order to obtain the "reference" ranking of CFIA OE.

6. Discussion of results of implementing the algorithm for eliminating the "systematic survivorship bias"

Our findings are the result of the implementation of the multi-step technology and algorithm developed in this study for the detection and screening of marginal opinions, as well as the elimination of "systematic survivorship bias" (Fig. 2). Namely, from the original sample with the number of m=90 experts, four subgroups were distinguished (Table 3), with the number of m_C=30, m_H=12, m_M=11 and m_T=6 people, in which CGO meets the proposed spectrum of system and information consistency criteria, defined by expressions (1) to (5). With the help of the t-criterion for testing statistical hypotheses and the χ^2 criterion, the probability of the corresponding GSA $\left(\bar{R}_S^{m_C}, \bar{R}_S^{m_T}, \bar{R}_S^{m_M}, \bar{R}_S^{m_H}\right)$, was proven, and at an unusually high level of significance α=1 % for HF studies (columns 4, 9, 14, 21, Table 3).

It is considered that is the baseline for further optimization using the classical Savage decision criterion and the Kemeny median because:

– firstly, the specified has the highest coincidence with the GSA of experts members of other subgroups (Table 5): the average indicator of such coincidence is greater than the others by 12.56 %;

– secondly, it is a more numerous subgroup among others separated from the original sample of subjects, and therefore more reliable;

– thirdly, its numerical composition corresponds to the limit at which the average group measurement error stabilizes [34].

The reliability and validity of – results are determined by:

– a clearly formulated goal and tasks of research;

– their adequacy to the selected research methods;

– a positive result of the application of statistical hypothesis testing methods, and at an unusually high level of significance α=1 % for HF studies;

– the possibility of reproducing the experiment and confirming the relevant trends.

At the same time, more well-known technologies, methods, and procedures for eliminating the "systematic survivorship bias" are not focused on the study of the influence of HF on decision-making, in particular, the SA of experts. Therefore, at the current stage of research, it is not possible to make a comparative analysis of the relevant results.

The limitations of the proposed multi-step technology and algorithm for identifying and filtering out marginal opinions, as well as the elimination of the "systematic survivorship bias" stem from the limitations of measurements in the ranking scale, where ISA and GSA are built, and to which a small and strictly defined number of mathematical transformations can be applied. That is why the further application of the basic $\overline{R}_S^{m_C}$ for solving multi-criteria tasks of obtaining an integrative assessment of the investigated OEs or establishing "compromises" in the requirements for the DE of the CFIA should be accompanied by defuzzification of the ranks by giving them appropriate normalized weighting coefficients.

Distinctive features of the results are the following:

– the technology and algorithm for identifying and filtering marginal opinions and eliminating the "systematic survivorship bias" were developed and implemented;

– from the initial group of tested experts, four subgroups were singled out with high indicators of both CGO and matching of the corresponding GSA among themselves;

– it is substantiated that $\overline{R}_S^{m_C}$ is the basis for further optimization.

The resulting solutions actually close the problematic part related to eliminating the influence of "systematic survivorship bias" on the results of scientific examination. However, further work with experts, who "according to statistics" were classified as "marginal" in order to finally solve the true reasons for the significant deviation of their opinions from the general group, seems appropriate.

The proposed multi-step technology for identifying and filtering marginal opinions, as well as eliminating the "systematic survivorship bias", is simple enough and should not cause difficulties for implementation in other areas of expert research. This is the main advantage of the proposed technology compared to other studies. Under other conditions, other non-dispersive methods for finding the concordance coefficient (agreement) should be used. In particular, entropic, or fuzzy ones. That, in turn, requires clarification of the proposed system and information criteria of CGO.

The proposed technology will be used in the development of modern methods for organizing and carrying out scientific and scientific-technical examination of scientific works and will also be able to be applied in practice in order to improve the examination process.

It would also be interesting to take into account in the proposed technology and algorithm the indicators of expert competence determined by entropy, fuzzy, R_S and α-methods.

As a shortcoming of the study, one should point out the assumption regarding the possibility of normalizing the total deviation of ISA ranks from the current GSA in order to establish a criterion for determining marginal opinions. After all, the measurement of ISA and GSA is carried out in the ordering scale, where such mathematical transformations are generally unacceptable. However, focusing on the absolute values of the sum of deviations, the same results were obtained. And normalization was carried out in order to facilitate the construction of histograms, which give a visual representation of the trend of marginal opinions.

Therefore, in further research, it is necessary to focus on the Spearman rank correlation coefficient, which is based on the squared deviations of the ranks. This opens prospects for the application of a wider range of mathematical transformations.

Further research into the improvement of expert technologies for establishing DIA OE should be carried out in the following directions (not ranked):

– optimization of GSA of subgroup m_C and establishment of the "reference" GSA;

– establishment of the coefficients of significance of CFIA OE;

– application of the method of successive advantages to establish – criterion requirements for the DE CFIA in a specific OE;

– application of the method of successive concessions to establish "compromises" in the requirements for the DE FIA OE, etc.

7. Conclusions

1. As a result of the identification of subgroups with statistically probable agreement of opinions, the following results were obtained:

– a set of five criteria for establishing the consistency of GSA was built;

– a multi-step algorithm for identifying the marginal opinions of experts and eliminating the "systematic survivorship bias" in the attitude of experts to the significance of CFIA OE was substantiated and implemented. The essence of this "elimination" is that the "marginal" opinions of experts are not rejected, but are iteratively organized into a special group, where they are analyzed according to the proposed algorithm;

– from the initial sample of experts, numbering m=90 people, four subgroups m_C, m_H, m_M, m_T of different numbers with statistically probable intragroup agreement of opinions satisfying all accepted criteria were distinguished;

– the reasons for the marginality of the opinions of the members of the m_X subgroup, which make up 34.44 % of the total quantitative composition of the subjects, were clarified.

2. As a result of the analysis and identification of overlaps of the group systems of the advantages of the isolated subgroups, the following was established:

– the need to use GSA of the m_C subgroup for further optimization and establishment of the final "reference" ranking of the CFIA OE is substantiated;

– all the obtained results, and therefore the corresponding conclusions, are reliable since they were ob-

tained at an unusually high level of significance α=1 % for HF studies;

– based on the above, it is possible to draw a generalized conclusion regarding the development of the appropriate technology and the effective elimination of the "systematic survivorship bias" in studies of the attitude of specialists to the significance of CFIA OE.

Conflicts of interest

The authors declare that they have no conflicts of interest in relation to the current study, including financial, personal, authorship, or any other, that could affect the study and the results reported in this paper.

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Data availability

The data will be provided upon reasonable request.

Use of artificial intelligence

The authors confirm that they did not use artificial intelligence technologies when creating the presented work.

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