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ENTERPRISE STRATEGIES STRATIFICATION BASED ON THE FUZZY MATRIX APPROACH

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A stratification model of enterprise strategies on the basis of tools of fuzzy set theory and fuzzy matrix analysis was developed. Classic methods of strategic diagnostics of the company, fuzzy methods of multi-criteria evaluation (Fuzzy Extension of Simplified Best-Worst Method (Fuzzy SBWM) and Fuzzy SAW) and fuzzy matrices were used to achieve the goals set. The classic Quantitative Strategic Planning Matrix (QSPM) criteria were used to make a strategic choice. The developed model is based on defined term sets of expert linguistic assessments (8-level – for determining the importance of SWOT factors and 7-level – for evaluating strategic alternatives) with their subsequent conversion into fuzzy numbers with triangular membership functions. The Fuzzy SBWM was used to calculate the importance of SWOT factors for each area of analysis, and the Fuzzy SAW method was used to determine the fuzzy integral evaluations of strategic alternatives for these areas. Strategic alternatives were positioned in fuzzy matrices “O – T” and “S – W” using the α-section. Stratification of strategies is based on the superposition of fuzzy matrices and the application of production rules for the obtained integral fuzzy estimates of strategic alternatives. The framework has been developed in the Excel software application to carry out calculations according to this approach, which contains the following components: a block for entering linguistic expert information (for each direction of analysis and evaluation of strategic alternatives) and transforming these linguistic data into fuzzy numbers in a triangular form, a block for calculating factor weighting coefficients by best and worst approaches and their fuzzy integral values, a block for calculating fuzzy values of strategies in the directions of “opportunities-threats” and “strengths-weaknesses” at different values of α-section, a block of production rules for stratification of strategies to carry out calculations according to this approach. The methodical approach enables the top management of the enterprise to determine the weighting coefficients of the SWOT factors and identify the list of preferable strategic alternatives for implementation.

Keywords: *fuzzy set theory, fuzzy matrix analysis, linguistic variable, term set, strategy stratification, fuzzy SBWM, fuzzy SAW method*

JEL Classification: C51, C63, D04

Formulation of the problem

The deepening of crisis phenomena in the global and domestic economies, which is caused by the influence of various factors, primarily the long-lasting coronavirus pandemic and the military invasion of the Russian Federation in Ukraine, leads to significant changes in the operating conditions of enterprises, changes in the management paradigm, and even strategic imperatives in their activities. These conditions are characterised by an extremely high level of uncertainty, dynamism, and difficulty in forecasting, which necessitates the application of new scientifically grounded methodologies for analysis, evaluation, and consideration of trends to ensure adequate and timely responses to challenges generated by the external environment.

One of the most critical stages in the strategic process is the analysis of the developed strategic alternatives with their subsequent evaluation and selection of a strategy to be implemented at the company. Therefore, consideration of the possibilities of improving the toolkit for solving this problem by considering the vagueness and ambiguity of the input information is an utter priority.

Analysis of recent research and publications

A substantial number of studies have been conducted on the theoretical and methodological aspects of strategic planning of companies' activities, in particular, by such well-known scholars as: S. Abraham [1], I. Ansoff [4], F. David [8, 9], L. Fahey, R. Randall [12], K. Fleisher, B. Bensoussan [13], W. Glueck, L. Jauch [17], R. Grant [18], D. Hussey [23, 24], G. Johnson, K. Scholes, R. Whittington [26], Ph. Kotler, R. Berger, N. Bickhoff [28], J. Lampel, H. Mintzberg, J. Quinn, S. Ghoshal [32], S. Leleur [34], A. Thompson, A. Strickland [43], T. Wheelen, J. Hunger, A. Hoffman, C. Bamford [44] and others.

In the last decade, one of the most prospective areas of applied research in strategic management has been the use of methods and models of fuzzy set theory [45], which have a high degree of adaptability to expert data, are flexible enough and adequate to the input information. A large number of publications examine the problems of strategic management through the prism of applying classical tools in a fuzzy framework. Thus, in [37], a fuzzy QSPM model is suggested. The authors [25] use the Fuzzy ANP method to determine the internal dependence among the parameters of the SWOT model and calculate their importance to select the best strategies for a textile enterprise. A similar idea is used in the research [14], but the VIKOR method is used for ranking strategies. In [38], the classical QSPM model is used as the primary analysis tool, while fuzzy TOPSIS determines the priority of strategic alternatives.

In [16, 42], fuzzy additive weighting using the Fuzzy SAW method is applied for selecting a maintenance strategy. In [15], a hybrid model based on SWOT analysis and Fuzzy AHP is constructed, with criteria and sub-criteria for evaluation being determined through SWOT analysis, and the Fuzzy AHP method is used for evaluating and ranking internal and external factors affecting competition in the education sector. Strategic selection is based on synchronising strategies obtained from the IE matrix and strategies developed based on SWOT analysis. The author [30] selects a strategy for the university based on Fuzzy AHP.

In [5], a model for evaluating and selecting enterprise strategies based on a modification of the classical quantitative strategic planning matrix is developed, with fuzzy multi-criteria evaluation methods being used to achieve the set goals (Fuzzy AHP for calculating the importance of analysis directions and evaluation criteria, and Fuzzy SAW for determining fuzzy integral evaluations of strategic alternatives according to these directions and overall). In addition to traditional criteria for evaluating strategic alternatives, it is proposed to consider the potential ability to achieve defined strategic goals. Strategic alternatives are ranked based on the defuzzified values of the obtained integral fuzzy evaluations.

For selecting a company’s marketing strategy, a Mamdani fuzzy inference system is applied in [27], while the fuzzy analytic network process (FANP) is used in the study [22], and VIKOR and Fuzzy AHP are applied in work [36]. To select an enterprise management strategy to ensure its financial stability, the problem of diagnosing bankruptcy was being solved using methods of fuzzy sets [29] and fuzzy logic [35].

However, despite the growing number of publications in the field of strategic planning using the theory of fuzzy sets and fuzzy logic, there are issues related to improving the existing methodological approaches to evaluating and selecting strategies for their implementation at the company.

The aim and tasks of the research

The article aims to analyse the current state of research on the problems of evaluation and selection of strategies in the strategic process and develop an approach to their stratification based on the Fuzzy Extension of Simplified Best-Worst Method (F-SBWM), superposition of the built fuzzy evaluation matrices and application of the developed productive rules to identify strategic alternatives belonging to the corresponding hierarchical groups.

Results

The problem of evaluating strategies and making other strategic choices is an essential element of strategic planning at the enterprise, as the cost of miscalculations at this stage can be extremely high. It is considered that choosing from alternative strategy options is the least structured of all the decisions made by managers.

As G. Day notes in [10], "an unsuccessful choice of strategic direction is very costly for the company: its limited financial resources are scattered, valuable time is wasted, and managers neglect other (promising) opportunities, as they try to compensate for the losses caused by the failed option". In the worst case, choosing the "wrong" strategy can even lead to the destruction of the organisation and bankruptcy of the enterprise. In the words of Professors W. Glueck and L. Jauch, evaluating a strategy is a process through which strategists determine the extent to which a strategy can achieve its goals [17].

It should be noted that the process of evaluating strategies in current conditions requires significant improvement of traditional (classical) methodological approaches and the development of new methods and tools, which is related to several reasons and trends, including:

1) a sharp increase in uncertainty, instability, dynamics, and turbulence in the operating environment of enterprises;

2) the increasing complexity of forecasting the future and the need to use the scenario approach and other modern predictive methods, and the need not just to predict or plan the company's activities but to make precise, thorough, multivariate current and future forecasting in constantly changing complex conditions;

3) reduction of the time interval of "reliable" forecasting and, accordingly, planning due to changes, events, and phenomena that bring elements of chaos, spontaneity, imbalance and disorder into the activities of organisations;

4) a large number of factors, parameters, variables, and criteria that need to be applied in the evaluation process;

5) the use of cutting-edge information technologies, expert systems, and strategic decision support systems, rapid, practical innovations that radically change the traditional paradigm of strategic management;

6) the focus of modern companies on constantly increasing the speed of bringing products to market, with a simultaneous trend of reducing product life cycles and their rapid replacement;

7) the transformation of methods, rules, and conditions of conducting business in each country and, accordingly, the intensification of competition, which necessitates constant monitoring of sales markets, and competitors' activities, studying their strategic behaviour, and modelling future development parameters.

It should be noted that the evaluation of the strategy can be carried out both at the stage of selecting strategies for implementation at the enterprise and when exercising control over the execution in case of necessary adjustments depending on the change in the influence of external factors or changes in internal factors. Accordingly, four main approaches are applied in the field of strategy evaluation (strategic alternatives) in strategic management [2]:

– goal-centred approach, in which two implementations are possible: a) retrospective (and current) assessment of the degree of achievement of pre-defined strategic goals; b) the use of a tool that allows assessing, through expert methods, the potential ability to achieve these strategic goals in the future, i.e., to obtain relevant predictive estimates of the future "performance" of strategies;

– the comparative approach compares the company, its strategy, and the effectiveness of its activities with similar companies;

– the improvement approach assesses how the strategy evolves and improves over time;

– the normative approach does not compare the developed strategy with a single, defined, theoretically ideal strategy (which does not exist), but as R. Rumelt claims, "instead, it assesses whether the developed strategy has characteristics typically associated with successful, effective strategies. This only points to general factors associated with success in the chosen field of activity and does not yet explain the differences in productivity between firms" [41].

From the analysis of the above approaches to evaluating strategies (strategic alternatives), two approaches – the goal-centred (which allows assessing the potential ability to achieve goals) and the normative approach can be applied to evaluate the long-term advantages of the strategy and strategic choice (Fig. 1).

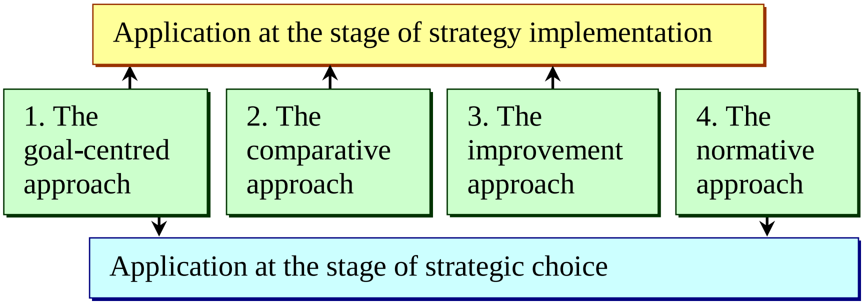

Fig. 1. Application of methodological approaches to strategy evaluation at the stages of the strategic process

It should be noted that the normative approach focuses on critical factors that affect the future situation and relies on a specific type of rational logic for conducting the evaluation. Goal-centred approach with retrospective evaluation of the degree of its achievement, comparative and improvement approaches are more focused on measuring business efficiency, strategy performance, which is being implemented, and which can be directly observed and are essential for operational reasons. In this study, the emphasis will be on evaluating strategic alternatives to select them for implementation in the enterprise.

Let us consider some meaningful relationships and statements of fuzzy set theory that will be necessary when addressing the tasks of this study.

In this paper, a triangular representation of a fuzzy number will be used $\tilde{A} = (a_1; a_2; a_3)$ (Fig. 2) with corresponding membership function (1).

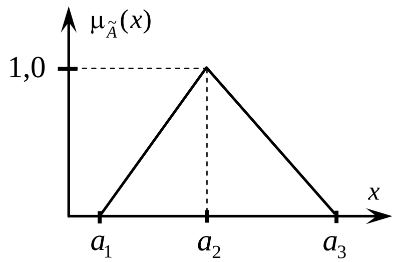

Fig. 2. Graphical representation of a fuzzy number with a triangular membership function

$$\mu_{\tilde{A}}(x) = \begin{cases} 0, \ x < a_1; \\ \dfrac{x - a_1}{a_2 - a_1}, \ x \in [a_1; a_2]; \\ \dfrac{x - a_3}{a_2 - a_3}, \ x \in [a_2; a_3]; \\ 0, \ x > a_3. \end{cases} \tag{1}$$

Note that if $\tilde{A} = (a_1; a_2; a_3)$ and $\tilde{B} = (b_1; b_2; b_3)$ – fuzzy numbers, then:

$$\tilde{A} \oplus \tilde{B} = (a_1; a_2; a_3) \oplus (b_1; b_2; b_3) = (a_1 + b_1; a_2 + b_2; a_3 + b_3), \tag{2}$$

$$\tilde{A}(-)\tilde{B} = (a_1; a_2; a_3)(-)(b_1; b_2; b_3) = (a_1 - b_3; a_2 - b_2; a_3 - b_1), \tag{3}$$

$$\tilde{A} \otimes \tilde{B} = (a_1; a_2; a_3) \otimes (b_1; b_2; b_3) = (a_1 \times b_1; a_2 \times b_2; a_3 \times b_3), \tag{4}$$

$$\tilde{A}(\div)\tilde{B} = (a_1; a_2; a_3)(\div)(b_1; b_2; b_3) = (a_1 / b_3; a_2 / b_2; a_3 / b_1), \tag{5}$$

$$c \times \tilde{A} = c \times (a_1;\, a_2;\, a_3) = (ca_1;\, ca_2;\, ca_3),\ c \geq 0,\ \ c - const, \tag{6}$$

$$c \times \tilde{A} = c \times (a_1;\, a_2;\, a_3) = (ca_3;\, ca_2;\, ca_1),\ c < 0,\ \ c - const. \tag{7}$$

If $\tilde{A}_i = (a_{1i};\, a_{2i};\, a_{3i})$, $i = \overline{1,\ n}$, then

$$\bigoplus_{i=1}^{n} \tilde{A}_i = \bigoplus_{i=1}^{n} (a_{1i};\, a_{2i};\, a_{3i}) = \left(\sum_{i=1}^{n} a_{1i};\, \sum_{i=1}^{n} a_{2i};\, \sum_{i=1}^{n} a_{3i} \right). \tag{8}$$

By [33], the COA (Center of Area) method (9) is used for the defuzzification of a fuzzy triangular number $\tilde{A} = (a_1;\, a_2;\, a_3)$:

$$\tilde{A}^{def} = \frac{(a_3 - a_1) + (a_2 - a_1)}{3} + a_1. \tag{9}$$

To implement this model, the author proposes a methodological approach based on the fuzzy set theory [45], the main stages of which are shown in Fig. 3.

At **stage 1**, the enterprise and strategic analysts thoroughly diagnose the it and its environment using appropriate tools (EFE and IFE matrices, ETOM method, PEST analysis, SWOT analysis, competitive analysis methods, etc.).

Stage 2 – formation of a working group of experts with professional knowledge, experience and authority. Including external experts with relevant competencies in the problem area and qualifications is also advisable.

Stage 3 is a crucial part of the strategic process because it enables the creation of a list of strategic options utilising traditional planning tools (correlation SWOT analysis, portfolio analysis matrices – Ansoff, IEM, BCG, GE-McKinsey, SPACE), and their modification based on fuzzy methodology. As G. Day notes, “... the best strategic choice is made when decision-makers are looking for and discussing several alternatives at the same time. Diversity gives managers a basis for comparison and boosts creativity by offering combinations of different strategies” [10].

We denote the strategic alternatives obtained for evaluation $s = \{s_1;\, s_2;\, ...;\, s_n\}$, where n – their number.

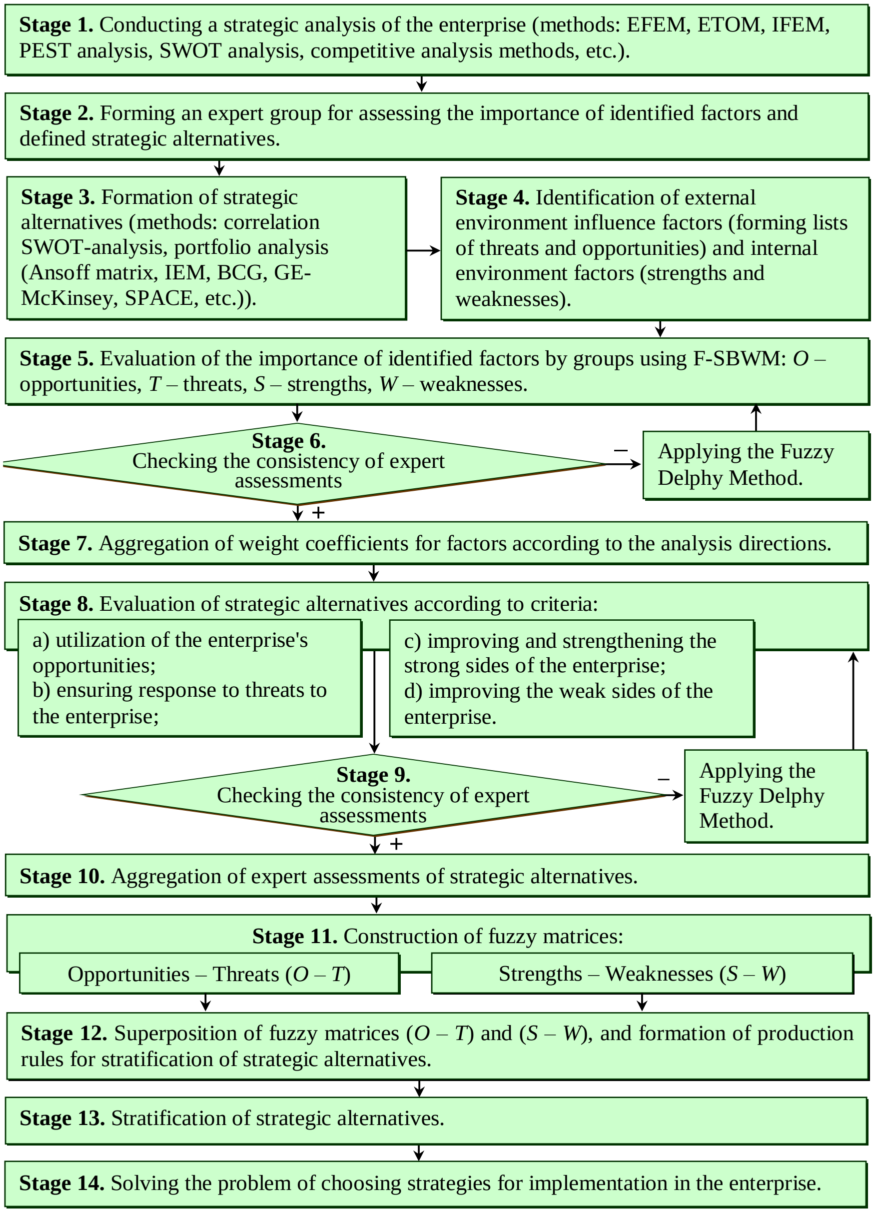

Fig. 3. Stages of stratification of strategic alternatives for the enterprise

During implementation of **Stage 4**, it is supposed to identify the criteria for evaluating the formed strategic alternatives. This is one of the most challenging moments in the analysis procedure and the choice of a strategy for implementation since the choice of a system of evaluation criteria depends on many factors, in particular, on the sectoral affiliation of the enterprise, the level of competition in the industry, the size and competitive position of the enterprise, etc. As G. Day [10] notes, "the debate over which alternatives to choose will only be productive when the alternatives are compared in terms of the strategic pillars that underlie shareholder value creation."

In the literature, there is a serious controversy on the requirements or criteria for evaluating strategies. In particular, G. Day [10] suggests checking each strategic alternative using the following tests:

– test 1: How attractive is the market opportunity?

– test 2: How sustainable is the competitive advantage?

– test 3: What are the prospects for successful implementation?

– test 4: Are the risks acceptable?

– test 5: Will the forecast financial results be achieved and increase shareholder value?

D. Hussey [24], based on practical experience, identified several questions, the answers to which can make it possible to check whether there are elementary errors in the strategy:

- is the strategy identified and clearly stated?
- has it considered competitors and the industry structure?
- does it match the realities of the market?
- is the geographical scope appropriate?
- is it consistent with environmental forces?
- are the levels of risk acceptable?
- does it enhance shareholder value?
- does it match corporate competence and resources?
- does it match the company culture?
- does it have an appropriate time horizon?
- does the plan have internal consistency?

The authors [43] suggest considering the following criteria for choosing a strategy:

1) *Compliance with the environment*. The strategy must comply with the conditions of competition, market opportunities and threats, and other aspects of the external environment. At the same time, the

strategy should also consider the company's strengths and weaknesses, its competence, and competitive opportunities. A strategy must match the internal and external environments to achieve the desired results.

2) *Competitive advantage*. The strategy must provide a sustainable competitive advantage. The greater the competitive advantage the strategy provides, the higher the efficiency and return.

3) *Efficiency*. The better strategy choice is confirmed by improving two parameters – profitability and strengthening the competitive and market position.

According to the views of Ph. Kotler and his colleagues [28], in order to solve various problems, a strategy must meet five basic requirements:

– integration (the strategy should include all areas and activities of the company);

– awareness (the person making a strategic decision must act consciously and intentionally);

– action orientation;

– methodicity (third parties must understand the strategy);

– its goal is not only to solve complex tasks but also to achieve long-term success.

R. Rumelt [41] proposed a system of criteria for evaluating strategies, which contains the following requirements:

– consistency: the strategy must not present mutually inconsistent goals and policies;

– consonance: the strategy must represent an adaptive response to the external environment and to the critical changes occurring within it;

– advantage: the strategy must provide for the creation and/or maintenance of a competitive advantage in the selected area of activity;

– feasibility: the strategy must neither overtax available resources nor create unsolvable sub problems.

The authors [31] proposes that during strategic decision-making, strategic alternatives should be analysed through four interconnected lenses: financial, market, competitive advantage, and operating model. G. Johnson, K. Scholes and R. Whittington [26] propose three universal evaluation criteria, each of which is decomposed into a series of questions through decomposition:

1. Suitability – can be assessed by the degree of its correspondence to the needs identified during the strategic analysis. Such a suitability

test is sometimes viewed as a test for adequacy to external environmental factors and organisational resources, as well as for consistency with organisational goals:

a) the strategy should solve a strategic problem or implement the opportunities identified during the strategic analysis;

b) the strategy must correspond to the goals of the organisation, both financial and non-financial performance indicators of the organisation;

c) the strategy must correspond to the state and requirements of the environment. It is checked to what extent the strategy is related to the requirements of the main subjects of the environment, to what extent the factors of market dynamics and the dynamics of the development of the product life cycle are taken into account, whether the implementation of the strategy will lead to the emergence of new competitive advantages, etc.;

d) the strategy should be based on appropriate organisational resources and capabilities and consider their potential in using external opportunities. In this case, it is evaluated to what extent the chosen strategy is related to other strategies, whether the strategy corresponds to the capabilities of the staff, whether the existing structure enables the successful implementation of the strategy, whether the strategy implementation program is verified, etc.

2. Feasibility of the proposed strategy – involves analysing the strategy in terms of how well it works in practice and how difficult it is to implement. In the evaluation process, it is necessary to answer the following questions:

a) are there enough resources to implement this strategy?

b) can the company achieve the required level of operational indicators, for example, in terms of quality or level of service provision? Will a strategy aimed at reducing costs lead to such negative consequences as a lack of experienced management personnel and qualified employees, an outdated technological process or product;

c) how will competitors react, and how will the organisation respond to their actions?

3. The acceptability of the proposed strategy is an assessment of the potential perception by stakeholders of the expected results of the implementation of this strategy, such as risk, profit, reward, ethics, and the impact of the relations of the parties. The following questions are offered for such a test:

a) what will be the financial efficiency of the company? What is the ratio of costs and benefits from the activity? Is there an unacceptable risk to the company's overall liquidity or capital structure?

b) is there a risk of unacceptable deterioration of the company's relations with its stakeholders? Will the proposed strategy alienate employees, shareholders, existing customers, or government entities?

c) what will be the impact of the proposed strategy on internal systems and processes? Even if the strategy seems feasible, will it not be a source of additional stress for the company's employees?

The three mentioned above strategies evaluation criteria are a set of primary tools for making strategic choices. They encourage managers to openly discuss the implications of proposed strategies and even assess the degree of risk and uncertainty associated with them. These criteria make it possible to assess the acceptability of the strategy for stakeholders. However, the developed strategy may only be helpful if the organisation creates a mechanism for its implementation. This is a separate big problem, which includes building adequate strategies of organisational structures, financing functional strategies, selecting managers with leadership qualities, and creating a corporate culture that enables all employees to reveal their qualities better.

According to S. Abraham [1], regardless of the process used to generate strategic alternatives, each resulting alternative must be rigorously evaluated in terms of its ability to meet four criteria:

1. Mutual exclusivity: doing any one alternative would preclude doing any other.

2. Success: it must be feasible and have a good probability of success.

3. Completeness: it must take into account all the key strategic issues.

4. Internal consistency: it must make sense on its own as a strategic decision for the entire firm and not contradict key goals, policies, and strategies currently being pursued by the firm or its units.

Other criteria can be used besides the above: complete coverage of all critical aspects of the activity, degree of risk, etc.

In this study, the criteria of the classic quantitative strategic planning matrix (Quantitative Strategic Planning Matrix – QSPM) [9] are used to make a strategic choice. It should be noted that in it, the assessment of the priority of strategic alternatives is carried out in two directions: external – how effectively the company's strategies use existing opportunities and minimise the possible negative consequences of threats generated by the external environment, and internal – determining the level of “strategy influence” on improving the internal state of the enterprise or its strategic business units, i.e. to what extent this strategy allows to “strengthen” its strengths and improve its weaknesses [5].

In accordance with this, factors of the external environment that significantly affect the enterprise are determined – favourable opportunities $F^O = \{F_1^O; F_2^O; ...; F_{m^O}^O\}$ and threats $F^T = \{F_1^T; F_2^T; ...; F_{m^T}^T\}$, and essential factors of the internal environment – strengths $F^S = \{F_1^S; F_2^S; ...; F_{m^S}^S\}$ and weaknesses $F^W = \{F_1^W; F_2^W; ...; F_{m^W}^W\}$, moreover $m^O; m^T; m^S; m^W$ – the number of factors identified by the directions of analysis *O*, *T*, *S*, *W*, respectively.

For example, for a domestic enterprise operating in the regional market to produce and sell food products, the identified lists of these factors are given in the Tables 1 and 2.

Table 1

CRITICAL INTERNAL SUCCESS FACTORS OF THE ENTERPRISE

	List of critical internal success factors of the enterprise
Strengths	F_1^S – availability of raw materials and availability of resources; F_2^S – high level of management; F_3^S – high level of business reputation; F_4^S – a wide range of products; F_5^S – modern production technologies; F_6^S – powerful advertising support; F_7^S – compliance of the company's products with standards and environmental regulations; F_8^S – high-quality products.
Weaknesses	F_1^W – a depreciation of fixed assets; F_2^W – insufficiently high qualification of personnel; F_3^W – little experience in the market; F_4^W – the level of marketing is not high enough; F_5^W – low consumer commitment; F_6^W – low level of strategic flexibility; F_7^W – the unstable financial condition of the company; F_8^W – insufficient funds for the implementation of innovative projects.

Table 2

CRITICAL EXTERNAL FACTORS INFLUENCING THE ENTERPRISE

	List of critical external success factors of the enterprise
Opportunities	F_1^O – consumer attachment to domestic food products; F_2^O – availability of raw material suppliers; F_3^O – development of unique production technologies; F_4^O – expansion of the sales network; F_5^O – access to international markets; F_6^O – introduction of stricter requirements for product quality control.
Threats	F_1^T – strengthening and intensifying the level of competition; F_2^T – decline in the purchasing power of buyers; F_3^T – a price increase of products; F_4^T – capacity building by competitors; F_5^T – increase in the inflation rate; F_6^T – dependence of raw material prices on natural conditions.

Stage 5. To evaluate the importance of the identified factors by groups: *O* – opportunities, *T* – threats, *S* – strengths, *W* – weaknesses, we will use the Fuzzy Extension of the Simplified Best-Worst Method (Fuzzy SBWM) [3, 11]. BWM was proposed by J. Rezaei [39, 40] for multi-criteria decision-making problems based on pairwise comparisons. In [20] and [21] this method was extended for the theory of fuzzy sets mainly using triangular fuzzy numbers and in [19] – for group decision-making.

The illustration of its application for a set of factors in the general case is provided $F = \{F_1; F_2; ...; F_m\}$. It should be noted that the Fuzzy SBWM procedure involves the use of two approaches: the "best" approach and the "worst" approach, the results of which are combined to determine the integral values of the importance of the studied factors (Fig. 4).

Step 1. Determination of the most important ("best") and least important ("worst") factors for each direction of analysis should be carried out based on reaching a consensus by a group of experts. In the general case they are denoted as follows: F_{best} and F_{worst}.

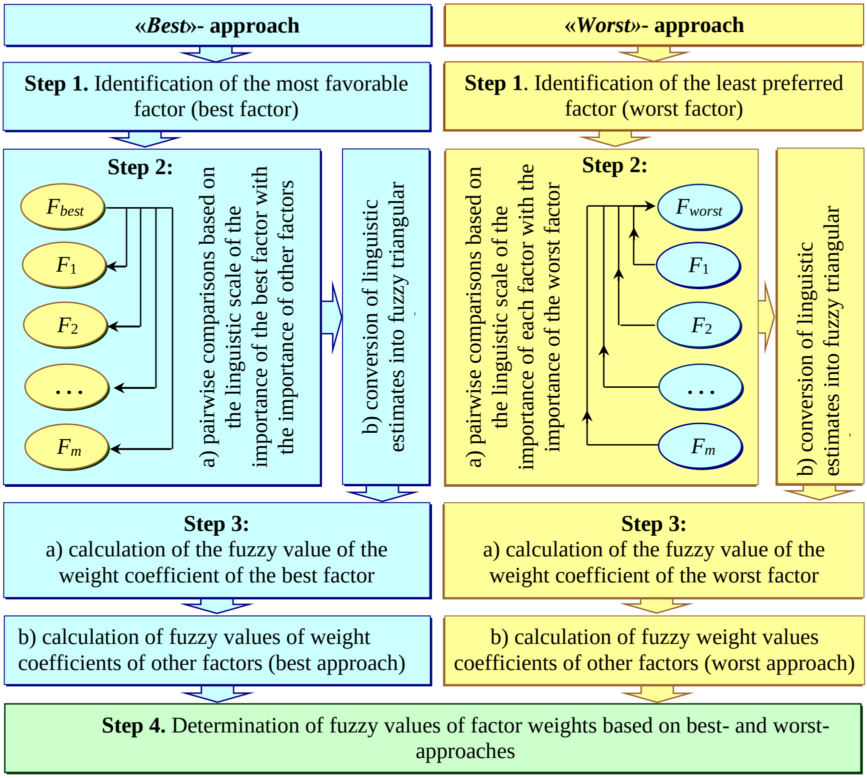

Fig. 4. Scheme of application of the F-SBWM method for determining importance weight coefficients of SWOT factors

Step 2. The first consideration is the “best” approach, which is proceeded with the following steps:

a) linguistic evaluation by each of K experts of the importance (priority) of the “best” factor compared to each of the other factors using the terms listed in the Table 3. This will result in linguistic assessments L_{jk}^{best} ($j=\overline{1,\ m}$, $k=\overline{1,\ K}$);

b) transfer of received grades L_{jk}^{best} into the corresponding fuzzy triangular numbers (Fig. 5) according to the scale of the Table 3 in the form: $\tilde{a}_{jk}^{best}=(\alpha_{jk}^{best};\ \beta_{jk}^{best};\ \gamma_{jk}^{best})$, $j=\overline{1,\ m}$, $k=\overline{1,\ K}$.

Table 3

LINGUISTIC TERMS FOR ASSESSING THE IMPORTANCE OF FACTORS AND CORRESPONDING FUZZY NUMBERS IN THE TRIANGULAR FORM [39]

Linguistic terms for evaluating the importance of factors	Marking	Fuzzy form
Equally	EI	(1; 1; 1)
Weakly	WI	(1; 2; 3)
Moderate	MI	(2; 3; 4)
Moderate plus	MP	(3; 4; 5)
Strong	SI	(4; 5; 6)
Strong plus	SP	(5; 6; 7)
Very strong	VS	(6; 7; 8)
Extreme	EX	(7; 8; 9)

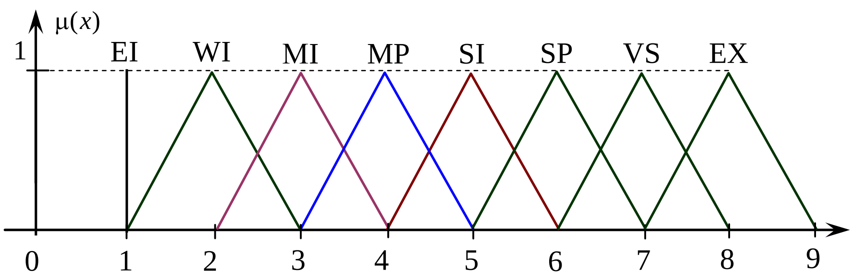

Fig. 5. Membership functions for linguistic terms [39]

The “worst” approach in **step 2** is carried out by the way:

a) linguistic evaluation by each of K experts of the importance (priority) of each of the factors compared to the least important factor (worst factor) using the terms listed in the Table 3 (result: L_{jk}^{worst}, $j=\overline{1,\ m}$; $k=\overline{1,\ K}$) and

b) transfer of received grades L_{jk}^{worst} into corresponding fuzzy triangular numbers according to the scale of the Table 3 in the form $\tilde{a}_{jk}^{worst}=(\alpha_{jk}^{worst};\ \beta_{jk}^{worst};\ \gamma_{jk}^{worst})$, $j=\overline{1,\ m}$, $k=\overline{1,\ K}$.

Step 3 calculates the fuzzy importance values of each factor of the "best" approach in the form $\tilde{w}_{jk}^{best} = (x_{jk}^{best}; y_{jk}^{best}; z_{jk}^{best})$, $j = \overline{1, m}$, $k = \overline{1, K}$.

To do this:

a) the importance (priority) of the "best" factor $\tilde{w}_{Bk}^{best}$ is first calculated using equation (10):

$$\left(\bigoplus_{j=1}^{m} \frac{1}{\tilde{a}_{jk}^{best}} \right) \otimes \tilde{w}_{Bk}^{best} = 1, \; k = \overline{1, K}. \tag{10}$$

From here

$$\tilde{w}_{Bk}^{best} = \frac{1}{\bigoplus_{j=1}^{m} \frac{1}{\tilde{a}_{jk}^{best}}} =$$

$$= \frac{1}{\frac{1}{(\alpha_{1k}^{best}; \beta_{1k}^{best}; \gamma_{1k}^{best})} \oplus \frac{1}{(\alpha_{2k}^{best}; \beta_{2k}^{best}; \gamma_{2k}^{best})} \oplus \ldots \oplus \frac{1}{(\alpha_{mk}^{best}; \beta_{mk}^{best}; \gamma_{mk}^{best})}} =$$

$$= \frac{1}{\left(\frac{1}{\gamma_{1k}^{best}}; \frac{1}{\beta_{1k}^{best}}; \frac{1}{\alpha_{1k}^{best}} \right) \oplus \left(\frac{1}{\gamma_{2k}^{best}}; \frac{1}{\beta_{2k}^{best}}; \frac{1}{\alpha_{2k}^{best}} \right) \oplus \ldots \oplus \left(\frac{1}{\gamma_{mk}^{best}}; \frac{1}{\beta_{mk}^{best}}; \frac{1}{\alpha_{mk}^{best}} \right)} =$$

$$= \frac{1}{\left(\sum_{j=1}^{m} \frac{1}{\gamma_{jk}^{best}}; \sum_{j=1}^{m} \frac{1}{\beta_{jk}^{best}}; \sum_{j=1}^{m} \frac{1}{\alpha_{jk}^{best}} \right)} = \left(\frac{1}{\sum_{j=1}^{m} \frac{1}{\alpha_{jk}^{best}}}; \frac{1}{\sum_{j=1}^{m} \frac{1}{\beta_{jk}^{best}}}; \frac{1}{\sum_{j=1}^{m} \frac{1}{\gamma_{jk}^{best}}} \right) =$$

$$= (x_{Bk}^{best}; y_{Bk}^{best}; z_{Bk}^{best}), \; k = \overline{1, K}. \tag{11}$$

b) further, since ratios must be satisfied

$$\tilde{w}_{Bk}^{best} (-) \tilde{a}_{jk}^{best} \otimes \tilde{w}_{jk}^{best} = 0, \tag{12}$$

then for arbitrary $j=\overline{1,\ m}$

$$w_{jk}^{best}=\frac{\tilde{w}_{Bk}}{\tilde{a}_{jk}^{best}}=\frac{(x_{Bk}^{best};y_{Bk}^{best};z_{Bk}^{best})}{(\alpha_{jk}^{best};\ \beta_{jk}^{best};\ \gamma_{jk}^{best})}=$$

$$=\left(\frac{x_{Bk}^{best}}{\gamma_{jk}^{best}};\frac{y_{Bk}^{best}}{\beta_{jk}^{best}};\frac{z_{Bk}^{best}}{\alpha_{jk}^{best}}\right)=(x_{jk}^{best};y_{jk}^{best};z_{jk}^{best}). \qquad (13)$$

For the "worst" approach in **step 3** the fuzzy importance values of each factor in the form $\tilde{w}_{jk}^{worst}=(x_{jk}^{worst};y_{jk}^{worst};z_{jk}^{worst})$, $j=\overline{1,\ m}$, $k=\overline{1,\ K}$, are calculated. For this:

a) first, the importance $\tilde{w}_{Wk}^{worst}$ of the "worst" factor is calculated from the equation:

$$\left(\bigoplus_{j=1}^{m}\tilde{a}_{jk}^{worst}\right)\otimes\tilde{w}_{Wk}^{worst}=1,\ k=\overline{1,\ K}. \qquad (14)$$

So,

$$\tilde{w}_{Wk}^{worst}=\frac{1}{\bigoplus_{j=1}^{m}\tilde{a}_{jk}^{worst}}=$$

$$=\frac{1}{(\alpha_{1k}^{worst};\beta_{1k}^{worst};\gamma_{1k}^{worst})\oplus(\alpha_{2k}^{worst};\beta_{2k}^{worst};\gamma_{2k}^{worst})\oplus...\oplus(\alpha_{mk}^{worst};\beta_{mk}^{worst};\gamma_{mk}^{worst})}=$$

$$=\frac{1}{\left(\sum_{j=1}^{m}\alpha_{jk}^{worst};\ \sum_{j=1}^{m}\beta_{jk}^{worst};\sum_{j=1}^{m}\gamma_{jk}^{worst}\right)}=\left(\frac{1}{\sum_{j=1}^{m}\gamma_{jk}^{worst}};\ \frac{1}{\sum_{j=1}^{m}\beta_{jk}^{worst}};\frac{1}{\sum_{j=1}^{m}\alpha_{jk}^{worst}}\right)=$$

$$=(x_{Wk}^{worst};y_{Wk}^{worst};z_{Wk}^{worst}),\ k=\overline{1,\ K}. \qquad (15)$$

b) further, by substituting the weighting factor of the least important factor (15) into equation (16), it is possible to calculate the weighting factors of other factors (17):

$$\tilde{w}_{jk}^{worst}(-)\tilde{a}_{jk}^{worst} \otimes \tilde{w}_{Wk}^{worst} = 0, \text{ for arbitrary } j = \overline{1, m}. \quad (16)$$

$$\tilde{w}_{jk}^{worst} = \tilde{a}_{jk}^{worst} \otimes \tilde{w}_{Wk}^{worst} = (\alpha_{jk}^{worst}; \beta_{jk}^{worst}; \gamma_{jk}^{worst}) \otimes (x_{Wk}^{worst}; y_{Wk}^{worst}; z_{Wk}^{worst}) =$$
$$= (\alpha_{jk}^{worst} x_{Wk}^{worst}; \beta_{jk}^{worst} y_{Wk}^{worst}; \gamma_{jk}^{worst} z_{Wk}^{worst}) = (x_{jk}^{worst}; y_{jk}^{worst}; z_{jk}^{worst}). \quad (17)$$

Step 4. Fuzzy values of factor weighting coefficients are calculated as the arithmetic mean of fuzzy values of weighting coefficients obtained based on the best and worst approaches:

$$\tilde{w}_{jk} = \frac{1}{2}(\tilde{w}_{jk}^{best} + \tilde{w}_{jk}^{worst}) = \frac{1}{2}((x_{jk}^{best}; y_{jk}^{best}; z_{jk}^{best}) \oplus (x_{jk}^{worst}; y_{jk}^{worst}; z_{jk}^{worst})) =$$
$$= \left(\frac{1}{2}(x_{jk}^{best} + x_{jk}^{worst});\ \frac{1}{2}(y_{jk}^{best} + y_{jk}^{worst});\ \frac{1}{2}(z_{jk}^{best} + z_{jk}^{worst})\right) =$$
$$= (x_{jk}; y_{jk}; z_{jk}). \quad (18)$$

To check the consistency of the evaluations of each expert, the coefficient CR_k can be used, which is calculated from the ratio:

$$CR_k = def \left(\bigoplus_{j=1}^{m} (\tilde{w}_{jk}^{best}(-)\tilde{w}_{jk}^{worst})^2 \right), \quad (19)$$

or the total deviation coefficient according to formula [3]:

$$TD_k = def \left(\bigoplus_{j=1}^{m} \left(\left(\tilde{a}_{jk}^{best}(-)\frac{\tilde{w}_{Bk}^{best}}{\tilde{w}_{jk}} \right)^2 \oplus \left(\tilde{a}_{jk}^{worst}(-)\frac{\tilde{w}_{jk}}{\tilde{w}_{Wk}^{worst}} \right)^2 \right) \right). \quad (20)$$

If the values of the calculated coefficients are significant enough, experts need to revise their estimates of superiority in pairwise comparisons to reach an acceptable range for these coefficients.

The weighting coefficients of the factors by directions are denoted, that are calculated based on the estimates of each expert *O*, *T*, *S*, *W* in accordance:

$$\tilde{w}^O_{jk} = (x^O_{jk}; y^O_{jk}; z^O_{jk}),\ \tilde{w}^T_{jk} = (x^T_{jk}; y^T_{jk}; z^T_{jk}),$$
$$\tilde{w}^S_{jk} = (x^S_{jk}; y^S_{jk}; z^S_{jk}),\ \tilde{w}^W_{jk} = (x^W_{jk}; y^W_{jk}; z^W_{jk}).$$

At **stage 6,** the group consistency of experts' assessments is checked based on the calculation of concordance coefficients for each area of analysis. In the case of a significant difference between these estimates, the fuzzy Delphi method [7] can be applied.

Stage 7. In the case of satisfactory consistency of experts' assessments, the aggregation of factor weights is carried out according to the following formulas:

$$\tilde{w}^O_j = \frac{1}{K}\bigoplus_{k=1}^{K}\tilde{w}^O_{jk} = \frac{1}{K}\bigoplus_{k=1}^{K}(x^O_{jk}; y^O_{jk}; z^O_{jk}) = (x^O_j; y^O_j; z^O_j),\quad j=\overline{1, m^O}; \tag{21}$$

$$\tilde{w}^T_j = \frac{1}{K}\bigoplus_{k=1}^{K}\tilde{w}^T_{jk} = \frac{1}{K}\bigoplus_{k=1}^{K}(x^T_{jk}; y^T_{jk}; z^T_{jk}) = (x^T_j; y^T_j; z^T_j),\quad j=\overline{1, m^T}; \tag{22}$$

$$\tilde{w}^S_j = \frac{1}{K}\bigoplus_{k=1}^{K}\tilde{w}^S_{jk} = \frac{1}{K}\bigoplus_{k=1}^{K}(x^S_{jk}; y^S_{jk}; z^S_{jk}) = (x^S_j; y^S_j; z^S_j),\quad j=\overline{1, m^S}; \tag{23}$$

$$\tilde{w}^W_j = \frac{1}{K}\bigoplus_{k=1}^{K}\tilde{w}^W_{jk} = \frac{1}{K}\bigoplus_{k=1}^{K}(x^W_{jk}; y^W_{jk}; z^W_{jk}) = (x^W_j; y^W_j; z^W_j),\quad j=\overline{1, m^W}. \tag{24}$$

For further application of the received values of the weighting coefficients of the factors by directions *O*, *T*, *S*, *W* the defuzzified by formula (9) values $(\tilde{w}^O_j)^{def}$, $(\tilde{w}^T_j)^{def}$, $(\tilde{w}^S_j)^{def}$, $(\tilde{w}^W_j)^{def}$ can be used.

At **stage 8**, the strategic alternatives determined at stage 3 are evaluated s_i, $i=\overline{1, n}$, according to the criteria, which are SWOT factors:

a) to what extent it enables the enterprise to use opportunities (F^O_1; F^O_2; ...; $F^O_{m^O}$) generated by the external environment;

b) to what extent it makes it possible to respond to threats and reduce their impact (F^T_1; F^T_2; ...; $F^T_{m^T}$) on the enterprise;

c) to what extent it contributes to the improvement and further consolidation of existing strengths (F^S_1; F^S_2; ...; $F^S_{m^S}$) for the enterprise;

d) to what extent it enables the elimination of weaknesses (F_1^W; F_2^W; ...; $F_{m^w}^W$) for the enterprise.

For evaluating the level of strategic alternatives s_i, $i=\overline{1,n}$, according to SWOT criteria, the following set of terms is used: $TS = \{$Extremely Low (EL), Very Low (VL); Low (L); Medium (M); High (H); Very High (VH), Extremely High (EH)$\}$.

Fuzzy numbers give the semantics of terms on the interval $[0; 6]$ (Fig. 6) with corresponding membership functions and fuzzy numbers in triangular representation: EL: $(0; 0; 1)$; VL: $(0; 1; 2)$; L: $(1; 2; 3)$; M: $(2; 3; 4)$; H: $(3; 4; 5)$; VH: $(4; 5; 6)$; EH: $(5; 6; 6)$.

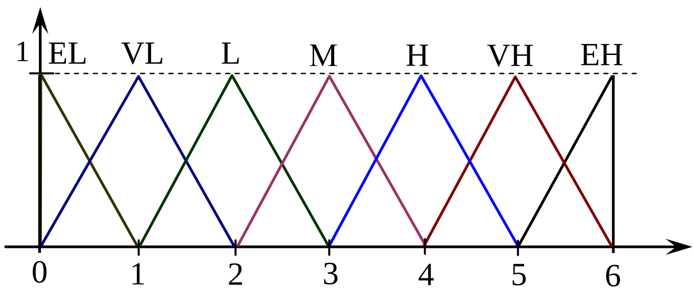

Fig. 6. Membership functions of the terms of assessment the level of strategic alternatives

So, L_{ijk}^O, L_{ijk}^T, L_{ijk}^S, L_{ijk}^W are the linguistic evaluations by the k-th expert of the i-th strategic alternative according to the j-factor of the corresponding direction of analysis.

Estimates are transformed using a triangular form of representation:

$$L_{ijk}^O \to \tilde{O}_{ijk} = (O_{ijk}^{\alpha}; O_{ijk}^{\beta}; O_{ijk}^{\gamma});$$

$$L_{ijk}^T \to \tilde{T}_{ijk} = (T_{ijk}^{\alpha}; T_{ijk}^{\beta}; T_{ijk}^{\gamma});$$

$$L_{ijk}^S \to \tilde{S}_{ijk} = (S_{ijk}^{\alpha}; S_{ijk}^{\beta}; S_{ijk}^{\gamma});$$

$$L_{ijk}^W \to \tilde{W}_{ijk} = (W_{ijk}^{\alpha}; W_{ijk}^{\beta}; W_{ijk}^{\gamma}).$$

Stage 9 checks the group consistency of expert evaluations of strategic alternatives based on calculating concordance coefficients for each line of analysis. If necessary, as in stage 6, the procedure of the Fuzzy Delphi method can be applied.

Stage 10. Aggregation of the obtained fuzzy estimates of experts is carried out according to the following formulas:

$$\tilde{O}_{ij} = \frac{1}{K}\bigoplus_{k=1}^{K}\tilde{O}_{ijk} = \left(\frac{1}{K}\sum_{k=1}^{K}O_{ijk}^{\alpha};\frac{1}{K}\sum_{k=1}^{K}O_{ijk}^{\beta};\frac{1}{K}\sum_{k=1}^{K}O_{ijk}^{\gamma}\right); \quad (25)$$

$$\tilde{T}_{ij} = \frac{1}{K}\bigoplus_{k=1}^{K}\tilde{T}_{ijk} = \left(\frac{1}{K}\sum_{k=1}^{K}T_{ijk}^{\alpha};\frac{1}{K}\sum_{k=1}^{K}T_{ijk}^{\beta};\frac{1}{K}\sum_{k=1}^{K}T_{ijk}^{\gamma}\right); \quad (26)$$

$$\tilde{S}_{ij} = \frac{1}{K}\bigoplus_{k=1}^{K}\tilde{S}_{ijk} = \left(\frac{1}{K}\sum_{k=1}^{K}S_{ijk}^{\alpha};\frac{1}{K}\sum_{k=1}^{K}S_{ijk}^{\beta};\frac{1}{K}\sum_{k=1}^{K}S_{ijk}^{\gamma}\right); \quad (27)$$

$$\tilde{W}_{ij} = \frac{1}{K}\bigoplus_{k=1}^{K}\tilde{W}_{ijk} = \left(\frac{1}{K}\sum_{k=1}^{K}W_{ijk}^{\alpha};\frac{1}{K}\sum_{k=1}^{K}W_{ijk}^{\beta};\frac{1}{K}\sum_{k=1}^{K}W_{ijk}^{\gamma}\right). \quad (28)$$

Next, using the Fuzzy SAW method, the integral values of strategic alternatives for each direction of analysis are calculated:

$$\tilde{O}_{i} = \bigoplus_{j=1}^{m^O}\tilde{w}_j^O \otimes \tilde{O}_{ij} = (O_i^{\alpha};O_i^{\beta};O_i^{\gamma}); \quad (29)$$

$$\tilde{T}_{i} = \bigoplus_{j=1}^{m^T}\tilde{w}_j^T \otimes \tilde{T}_{ij} = (T_i^{\alpha};T_i^{\beta};T_i^{\gamma}). \quad (30)$$

$$\tilde{S}_{i} = \bigoplus_{j=1}^{m^S}\tilde{w}_j^S \otimes \tilde{S}_{ij} = (S_i^{\alpha};S_i^{\beta};S_i^{\gamma}); \quad (31)$$

$$\tilde{W}_{i} = \bigoplus_{j=1}^{m^W}\tilde{w}_j^W \otimes \tilde{W}_{ij} = (W_i^{\alpha};W_i^{\beta};W_i^{\gamma}). \quad (32)$$

Stage 11. All strategic alternatives are positioned on the matrices according to the criteria *O* – *T* and *S* – *W* (Fig. 7). To consider different levels of uncertainty ("refinement of the obtained fuzzy estimates”), it is possible to use the α-section of a fuzzy number [33]. Note that if a given fuzzy number $\tilde{u} = (a, b, c)$, its α-section is determined as follows $\tilde{u}_\alpha = (a(1-\alpha) + \alpha b,\ b,\ c(1-\alpha) + \alpha b))$.

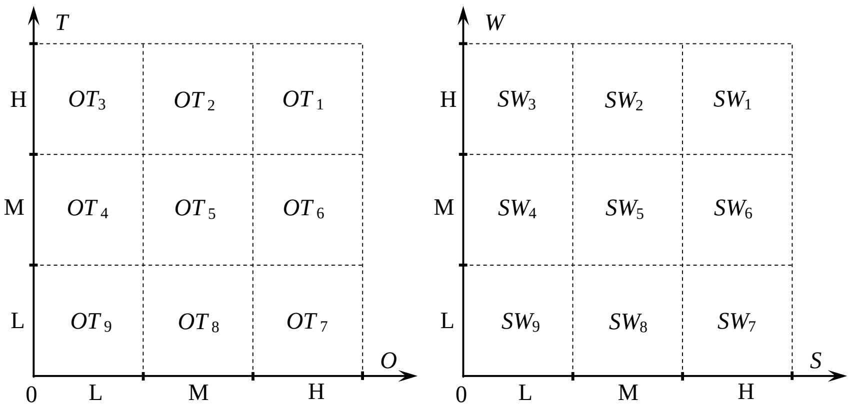

Fig. 7. Fuzzy matrixes for the evaluation of strategic alternatives

Fig. 8 shows an example of the construction of fuzzy evaluation matrices [6] of strategic alternatives according to the generalized criteria $O - T$ and $S - W$.

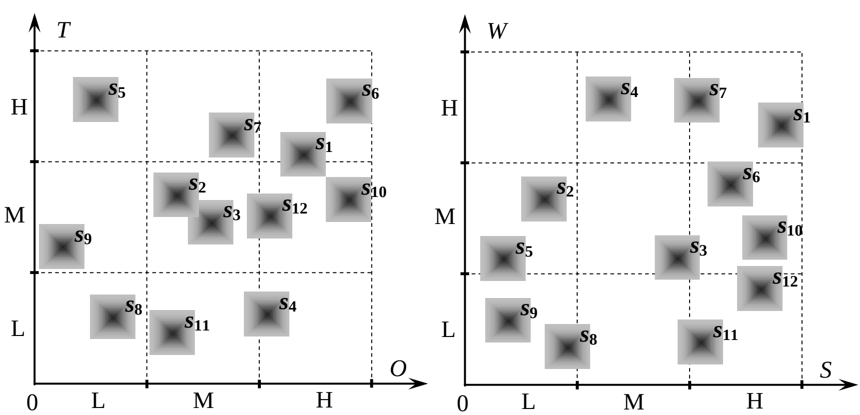

Fig. 8. An example of constructing fuzzy matrices for evaluating strategic alternatives according to the $O - T$ and $S - W$ criteria

Stage 12. The superposition of fuzzy matrices (*O* – *T*) and (*S* – *W*) is carried out by "superimposing" one matrix on another and considering possible combinations of "placements" of strategic recommendations in them. Further, experts should be involved in forming production rules for stratifying strategic alternatives, who should develop the conditions for belonging strategic alternatives to a particular stratum (Str_1, Str_2, ..., Str_p). An example of expert construction of such production rules is given below:

$$
\begin{aligned}
& if\ s_i \in OT_1\ and\ s_i \in SW_1 \\
& then\ s_i \in Str_1; \\
& if\ (s_i \in OT_1\ and\ s_i \in SW_2)\ or\ (s_i \in OT_2\ and\ s_i \in SW_1)\ or \\
& \quad (s_i \in OT_1\ and\ s_i \in SW_6)\ or (s_i \in OT_6\ and\ s_i \in SW_1) \\
& then\ s_i \in Str_2; \\
& if\ (s_i \in OT_2\ and\ s_i \in SW_6)\ or\ (s_i \in OT_6\ and\ s_i \in SW_2)\ or \\
& \quad (s_i \in OT_2\ and\ s_i \in SW_5)\ or (s_i \in OT_5\ and\ s_i \in SW_2)\ or \\
& \quad (s_i \in OT_1\ and\ s_i \in SW_5)\ or (s_i \in OT_5\ and\ s_i \in SW_1) \\
& then\ s_i \in Str_3; \\
& if\ (s_i \in OT_1\ and\ s_i \in SW_3)\ or\ (s_i \in OT_3\ and\ s_i \in SW_1)\ or \\
& \quad (s_i \in OT_1\ and\ s_i \in SW_7)\ or (s_i \in OT_7\ and\ s_i \in SW_1) \\
& then\ s_i \in Str_4; \\
& if\ (s_i \in OT_1\ and\ s_i \in SW_4)\ or\ (s_i \in OT_4\ and\ s_i \in SW_1)\ or \\
& \quad (s_i \in OT_1\ and\ s_i \in SW_8)\ or (s_i \in OT_8\ and\ s_i \in SW_1)\ or \\
& \quad (s_i \in OT_2\ and\ s_i \in SW_3)\ or (s_i \in OT_3\ and\ s_i \in SW_2)\ or \\
& \quad (s_i \in OT_6\ and\ s_i \in SW_7)\ or (s_i \in OT_7\ and\ s_i \in SW_6)\ or \\
& \qquad\qquad\qquad (s_i \in OT_5\ and\ s_i \in SW_5) \\
& then\ s_i \in Str_5; \\
& if\ (s_i \in OT_2\ and\ s_i \in SW_4)\ or\ (s_i \in OT_4\ and\ s_i \in SW_2)\ or \\
& \quad (s_i \in OT_6\ and\ s_i \in SW_8)\ or (s_i \in OT_8\ and\ s_i \in SW_6)\ or
\end{aligned}
$$

$$
\begin{aligned}
&(s_i \in OT_5 \ \ and \ \ s_i \in SW_3)\ or\,(s_i \in OT_3 \ \ and \ \ s_i \in SW_5)\ or\\
&(s_i \in OT_5 \ \ and \ \ s_i \in SW_7)\ or\,(s_i \in OT_7 \ \ and \ \ s_i \in SW_5)\,or\\
&(s_i \in OT_1 \ \ and \ \ s_i \in SW_9)\ or\ (s_i \in OT_9 \ \ and \ \ s_i \in SW_1)\\
&then \ \ s_i \in Str_6;\\
&if\ \ (s_i \in OT_5 \ and \ s_i \in SW_4)\ \ or\ \ (s_i \in OT_4 \ \ and \ s_i \in SW_5)\ \ or\\
&(s_i \in OT_5 \ \ and \ \ s_i \in SW_8)\ or\,(s_i \in OT_8 \ \ and \ \ s_i \in SW_5)\ or\\
&(s_i \in OT_2 \ \ and \ \ s_i \in SW_9)\ or\,(s_i \in OT_9 \ \ and \ \ s_i \in SW_2)\ or\\
&(s_i \in OT_6 \ \ and \ \ s_i \in SW_9)\ or\,(s_i \in OT_9 \ \ and \ \ s_i \in SW_6)\\
&then \ \ s_i \in Str_7;\\
&if\ \ (s_i \in OT_3 \ and \ s_i \in SW_4)\ \ or\ \ (s_i \in OT_4 \ \ and \ s_i \in SW_3)\ \ or\\
&(s_i \in OT_7 \ \ and \ \ s_i \in SW_8)\ or\,(s_i \in OT_8 \ \ and \ \ s_i \in SW_7)\ or\\
&(s_i \in OT_5 \ \ and \ \ s_i \in SW_9)\ or\,(s_i \in OT_9 \ \ and \ \ s_i \in SW_5)\\
&then \ \ s_i \in Str_8;\\
&if\ \ (s_i \in OT_3 \ and \ s_i \in SW_9)\ \ or\ \ (s_i \in OT_9 \ \ and \ s_i \in SW_3)\ \ or\\
&(s_i \in OT_7 \ \ and \ \ s_i \in SW_9)\ or\,(s_i \in OT_9 \ \ and \ \ s_i \in SW_7)\ or\\
&(s_i \in OT_4 \ \ and \ \ s_i \in SW_8)\ or\,(s_i \in OT_8 \ \ and \ \ s_i \in SW_4)\\
&then \ \ s_i \in Str_9;\\
&if\ \ (s_i \in OT_4 \ and \ s_i \in SW_9)\ \ or\ \ (s_i \in OT_9 \ \ and \ s_i \in SW_4)\ \ or\\
&(s_i \in OT_8 \ \ and \ \ s_i \in SW_9)\ or\,(s_i \in OT_9 \ \ and \ \ s_i \in SW_8)\\
&then \ \ s_i \in Str_{10};\\
&if\ s_i \in OT_9 \ \ and \ \ s_i \in SW_9\\
&then \ \ s_i \in Str_{11}\,.
\end{aligned}
$$

Regarding the implementation of this stage, next comments should be considered:

1) when constructing production rules, the importance of each direction can be taken into account, which can be determined, for example, using the fuzzy SMART method, Fuzzy AHP or Fuzzy SBWM;

2) the given production rules can be written using the obtained membership functions of fuzzy estimates of strategic alternatives, and the stratification process can be easily automated;

3) the number of strata can be determined depending on the task (select the best strategic alternative, the most important and other alternatives, etc.).

Stage 13. Stratification of alternatives is carried out based on the application of developed production rules. In particular, for the case shown in Fig. 8, applying the above production rules, we get 8 strata: $Str_1 : \{ s_1 \}$; $Str_2 : \{ s_6, s_7 \}$; $Str_3 : \{ s_{10} \}$; $Str_4 : \{ s_3, s_4, s_{12} \}$; $Str_5 :$ $\{ s_2 \}$; $Str_6 : \{ s_5, s_{11} \}$; $Str_7 : \{ s_9 \}$; $Str_8 : \{ s_8 \}$.

Note that the Fuzzy SAW method can be used for stratification (and ranking) of strategic alternatives based on the obtained fuzzy integral values $\tilde{O}_i$, $\tilde{T}_i$, $\tilde{S}_i$ and $\tilde{W}_i$ if the weighting coefficients of the generalized "criteria" are determined. Indeed, if $\tilde{w}^O$, $\tilde{w}^T$, $\tilde{w}^S$ and $\tilde{w}^W$ are their respective fuzzy weighting coefficients, then the fuzzy evaluation of the "priority" of the i-th ($i = \overline{1, n}$) strategic alternative is based on the formula:

$$\tilde{P}(s_i) = \tilde{w}^O \otimes \tilde{O}_i \oplus \tilde{w}^T \otimes \tilde{T}_i \oplus \tilde{w}^S \otimes \tilde{S}_i \oplus \tilde{w}^W \otimes \tilde{W}_i . \quad (33)$$

This approach can be used to verify the results obtained by the basic model or, if necessary, to rank strategic alternatives.

At **stage 14**, a strategy is selected for implementation at the enterprise, or a group of preferable alternatives is selected for consideration by top management.

Let us make a few remarks about the validity of the proposed model, which is ensured by the use of verification procedures:

1) reaching a consensus by the expert group regarding the selection of the best and worst factors for each direction of analysis;

2) consistency of individual opinions of experts;

3) consistency of group assessments of experts in the best and worst approaches for each direction of analysis;

4) coherence of experts when evaluating strategic alternatives for each direction of analysis.

The framework has been developed in the Excel software application to implement the methodical approach, which contains the following main blocks (Fig. 9) and provides the possibility of simulation modelling depending on the input estimates of experts.

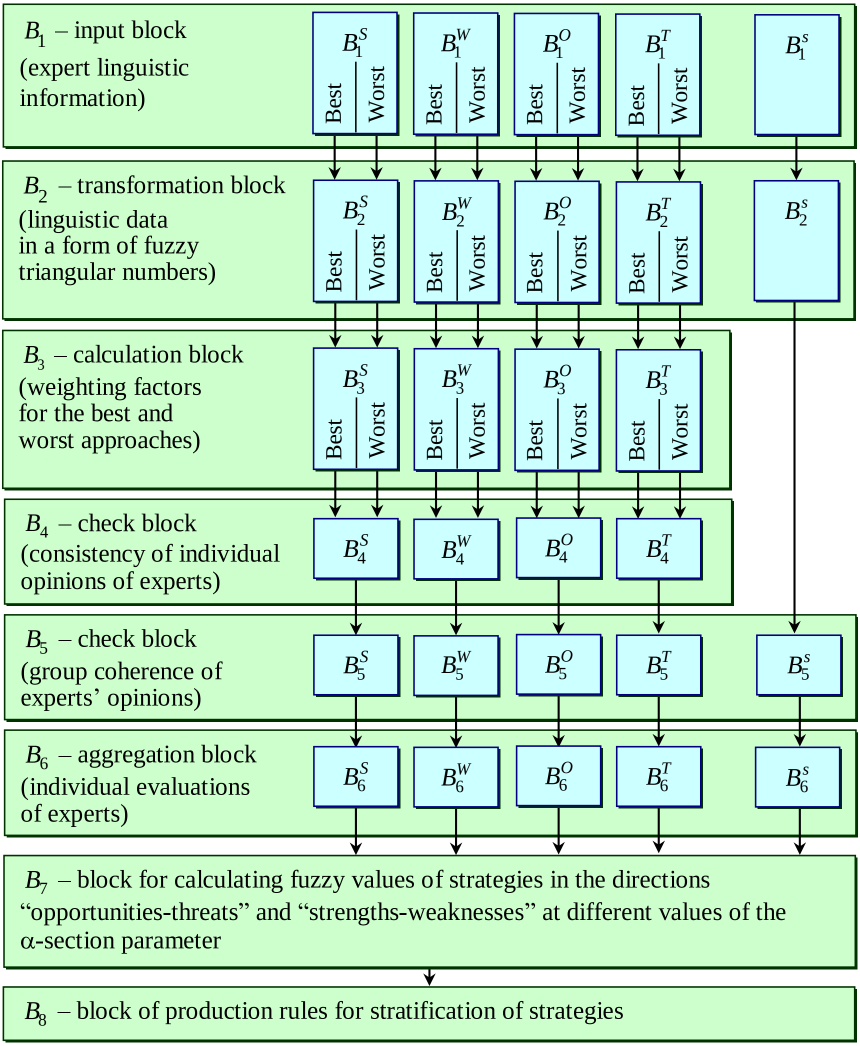

Fig. 9. Basic blocks of the framework for stratification of strategic alternatives of the enterprise

Conclusions and discussion

The need to improve existing and develop new methodological approaches to strategic choice in the strategic planning of an enterprise is due to the ever-increasing turbulence, complexity, instability, uncertainty and ambiguity of the environment for its functioning since an unsuccessful choice of a strategic direction is costly for the company and, in the worst case, can lead to its bankruptcy. Problematic aspects of this process are the formation of a system of criteria for evaluating strategic alternatives, the fuzziness of expert assessments and, accordingly, the need to use fuzzy multi-criteria analysis tools to select strategies for implementation. This study uses the criteria of the classical quantitative matrix of strategic planning (SWOT-factors), to determine the weighting factors of which the Fuzzy Extension of the Simplified Best-Worst Method is applied. Model is based on expert linguistic assessments for certain term sets (8-level – to determine the importance of SWOT factors and 7-level – to evaluate strategic alternatives) with their subsequent transformation into fuzzy numbers with triangular membership functions.

The second problem is proposed to be solved with the help of the Fuzzy SAW method (to determine fuzzy integral estimates of strategic alternatives in these areas) and fuzzy matrices "O – T" and "S – W", in which developed strategic alternatives are positioned. Stratification of strategies for strategic choice is carried out based on the superposition of fuzzy matrices and the application of production rules of Mamdani fuzzy inference system developed by experts for the obtained integral fuzzy estimates of strategic alternatives.

In order to facilitate calculations according to this approach, a framework has been developed in the Excel software application, which can be the basis for creating appropriate support systems for making strategic management decisions to identify the list of preferable strategic alternatives.

Further research on the topic of the article can be aimed at improving individual stages of this methodological approach, in particular at:

– formation of a list of criteria for evaluating strategic alternatives, taking into account their focus on achieving strategic goals;

– complex application of several calculation schemes for assessing weighting factors of evaluation criteria based on fuzzy methods of multi-criteria analysis (Fuzzy AHP, Fuzzy SMART);

– optimization of parameters of the Mamdani fuzzy inference system on real data;

– development of a strategic decision-making support system based on the proposed framework using Fuzzy Logic Toolbox, Fuzzy Control Design Toolbox, fuzzyTECH, etc.

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