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DESIGN OF VERBAL MODELS FOR FORMING AN OPTIMAL STRATEGY FOR SUSTAINABLE DEVELOPMENT OF SERVICE ENTERPRISES IN THE CONDITIONS OF A CRISIS

Introduction. *The presence of a strategy and a strategic plan, necessary for determining the direction of the enterprise development and for making informed decisions, allows enterprise to achieve its goals with confidence and, at the same time, to respond flexibly to changes in the external environment, especially in times of crisis.*

Problem Statement. *The formation of sustainable development strategies requires sufficient consultancy costs and technologies that are designed for being used by large enterprises with professionals having relevant expertise. However, most of all, during the crisis, small and medium-sized enterprises of the service sector suffer from it, which prevents them from using such consulting and technologies.*

Purpose. *The development of a verbal model for shaping an optimal strategy for sustainable development of small and medium-sized enterprises of the service sector in times of crisis to find, to evaluate, and to support effective management decisions.*

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Materials and Methods. *Methods of formal logic, qualitative methods of verbal analysis, methods of discrete mathematics, and benchmarking method.*

Results. *A verbal model has been developed for classifying the current state of enterprises on the basis of qualitative methods. The model is adapted for the possibility of its use in the presence of an arbitrary set of criteria and their values. A model has been developed for the automatically finding the optimal path (strategy) from a certain alternative (the current state of the enterprise) to an alternative that is guaranteed to belong either to the next better class (short-term strategy), or to the best class (long-term strategy).*

Conclusions. *The verbal model allows us to describe and to classify the states of small and medium-sized enterprises of the service sector in any branch of business and automatically produces optimal strategies for their sustainable development. The criteria for optimal strategy may be the time and cost of achieving the required state of enterprise.*

Keywords: verbal analysis, optimal strategy, and decision support system.

The modern business environment defines its own rules of conduct for enterprises in the competitive market. Market practice demonstrates new modern methods, tools, and approaches to the management of organizations, which allow enterprises to form advantages among competitors and, accordingly, to raise their competitiveness. In this case, the presence of a strategy, a strategic plan, necessary for determining the direction of the enterprise development, making informed decisions, comes to the fore. Without a strategy, a company lacks a well-designed plan of action which helps it adapt quickly and easily to the changing external environment and without which it is difficult to achieve the desired goals and objectives. A strategy allows the enterprise to achieve its goals with confidence and, at the same time, to respond flexibly to changes in the external environment. This is most evident in times of crisis. A prime example of such a situation is the COVID19 pandemic, which has had serious economic consequences worldwide, especially for small and medium-sized enterprises (SMEs) in the service sector. In particular, statistics show that 33% of such small enterprises in Ukraine have lost between 50% and 75% of their income, and 7% are considering closing down [1]. In such a situation, service SMEs, which do not have enough qualified specialists or do not have them at all, need consulting on making effective management decisions. This is particularly relevant in such a specific area as building a sustainable enterprise development strategy in a crisis.

There is a substantial number of publications in this field.

Thus, the paper [2] discusses theoretical and practical examples of how to achieve and maintain SME business efficiency by implementing optimal and cohesive management models. The basis for increasing efficiency is the optimization of SME business processes. The disadvantage is that this approach requires quite a long time, significant funds and qualified specialists.

The paper [3] proposes theoretical provisions and methodological recommendations on the formation of a logistics approach to the development strategy of service companies to make managerial decisions in conditions of economic instability. Based on the assessment of quantitative parameters of micro-, macro- and internal environment of the company, the company's business profile and general development strategy are determined. The strategy is based on identification of optimal logistic, marketing, production, financial and human resources strategies for an individual strategic area of business. The research is theoretical and uses quantitative methods. The disadvantages include the fact that the results of the study are designed for sufficiently large enterprises with corresponding human resources.

The subject of the paper [4] is a set of theoretical and methodological aspects of development strategy formed for objects (country, region, industry, enterprise) on the basis of life cycle theory in conditions of uncertainty of the external environment. The methodology involves a certain

sequence of studying the life cycle of a product in retrospect and at the current moment, then modeling and developing options for implementing short-term and long-term strategies. The results of the study are intended to substantiate the methodology of strategic planning in the context of environmental uncertainty, taking into account the life cycle theory. The combination of strategic management with life cycle theory will improve the objectivity and effectiveness of management decisions. Taking into account the li-fe cycles of an organization in strategic planning allows choosing an effective strategy. The disadvantages are the following: the proposed methodology uses quantitative methods and is designed for large production enterprises that have the sufficient human resources and funds for research.

In the paper [5], a methodology based on multi-criteria optimization is described and applied to a case study of the industrial supply chain. It is also stated that life cycle assessment is an important tool in mapping enterprise strategy. It is emphasized that improving sustainability reporting by identifying sources of uncertainty in life cycle methodologies as well as supply chain analytics has the greatest impact on defining business strategies. The proposed methodology addresses supply chain design and planning and therefore the definition of business strategy in relation to environmental protection strategies. This is important for large industrial enterprises, but is not decisive for SMEs.

The work [6] investigates topical issues of formation of sustainable development methodology. The main factors of sustainable development are analyzed. The economic tools to ensure sustainable development of enterprises at different levels of management are considered. Particular attention is paid to scientific and applied aspects of sustainable development, such as public-private partnership, professional and emotional competence of civil servants and information space of innovative business processes of industrial enterprises. The scientific-applied aspects of credit support in the financing of investment activities of enterprises, marketing research of new media and technological development of the process of implementation of banking products are also considered. The disadvantage is that the proposed economic instruments are designed for sufficiently large enterprises with sufficient human resources and funds.

In [7], research has been conducted into the sustainability of retail trade. It is highlighted that, increasingly, retailers are facing major sustainability challenges, such as pressure from resource constraints, fierce competition, changing customer needs and evolving technology. It is suggested that adopting best practices through manager training is the key to achieving sustainability for retailers. The disadvantage is that this approach requires the creation or acquisition of sufficient training material and the availability or selection of adequate staff willing to be trained for a certain period of time.

The paper [8] addresses the fundamental problem of corporate sustainability in terms of transforming trade-offs through win-win management strategies aimed at value creation. A combination of four identified management strategies with three ESG ("ecological, social and governance") sustainability criteria in the form of a matrix of 12 blocks is proposed as a tool for strategic management of corporate sustainability. The disadvantage is that the results of the study are based on quantitative methods and are designed for large enterprises with a large number of staff and stakeholders.

In [9], as a strategy for the development of power supply companies, it is proposed to carry out their organizational changes on the basis of optimization of information management support using the Petri nets. The disadvantage is that this approach requires a detailed description of business processes, i.e. quite a long time, significant funds and qualified specialists.

All this allows us to argue that the formation of sustainable development strategies:

- requires sufficient consultancy costs;

- use technologies based on mathematical models and quantitative methods that are designed for use in large enterprises with specialists with relevant expertise.

In other words, there is currently no adequate, sufficiently simple and accessible consultancy tool to enable SMEs to formulate an optimal strategy for their sustainable development.

If we turn to the world practice, such problems are solved by creating consulting zones for entrepreneurs. For example, in the USA, there is a company American Small Business Development Centers (SBDC) [10], which provides SMEs with free business consulting on business planning and many other topics. If we take Ukraine, the Ministry of Digital Transformation is dealing with this problem, and at the end of 2019 it started the creation of consulting zones for entrepreneurs on the model of SBDC.

However, this program, like its prototype, the SBDC, is designed mainly for off-line counselling (with on-line counselling available only by appointment and strictly during office hours) [11].

Therefore, it is relevant to develop a verbal model (VM) of the optimal strategy for sustainable development of service enterprises in times of crisis for SME consulting in a non-stop on-line mode. This will enable the management of such enterprises to make effective management decisions with minimal loss of time and money.

The application of economic and mathematical methods in management and marketing is often limited. In many cases, this is due to the lack of statistical and other information in small and medium-sized enterprises, as well as to the lack of specialists in such enterprises with necessary qualifications. It is especially noteworthy that in a crisis situation it is not possible to apply statistical data that are obtained under normal conditions. In such a situation, expert judgement is the only means of solving such problems [12]. The advantages of expert evaluations include ease of application for forecasting almost any situation, including under conditions of incomplete information. In particular, the EFQM model [13], which helps organizations to manage change and improve productivity, contains about 160 criteria, divided into 9 groups, the vast majority of which are qualitative.

The aim of the study is to develop a VM for shaping an optimal strategy for sustainable development of service SMEs in times of crisis to find, evaluate and support effective management decisions.

In order to achieve the objective, the following tasks need to be carried out:

- develop a verbal model for classifying the current state of service SMEs based on qualitative methods;
- adapt the verbal model for classifying the current state of SMEs, which has been chosen as the basis of the VM, so that it can be used with an arbitrary set of criteria and their values;
- develop a model for automatically finding the optimal path (strategy) from a given alternative (current state of the enterprise) to an alternative that is guaranteed to belong either to the next best class — short-term strategy, or to the tops class — long-term strategy.

In quantitative methods used to build decision support systems (DSS), an implicit assumption is made that a person measures some quantitative parameter once [14]. The resulting value is the only one that reflects the decision maker's (DM) preference. However, psychological research [15], as well as practical experience of applying these methods, allow us to question the validity of this assumption.

As we know, DM is not an accurate measuring device that does not allow for inaccuracy in quantitative measurements [14]. Psychophysics provides quantitative evidence of human inaccuracy in measuring physical parameters (weight, length, and so on). As a consequence, the direct assignment of quantitative criterion weights is always carried out with errors [16]. The need to account for errors in quantitative measurements is rightly pointed out in [17]. In psychological ex-

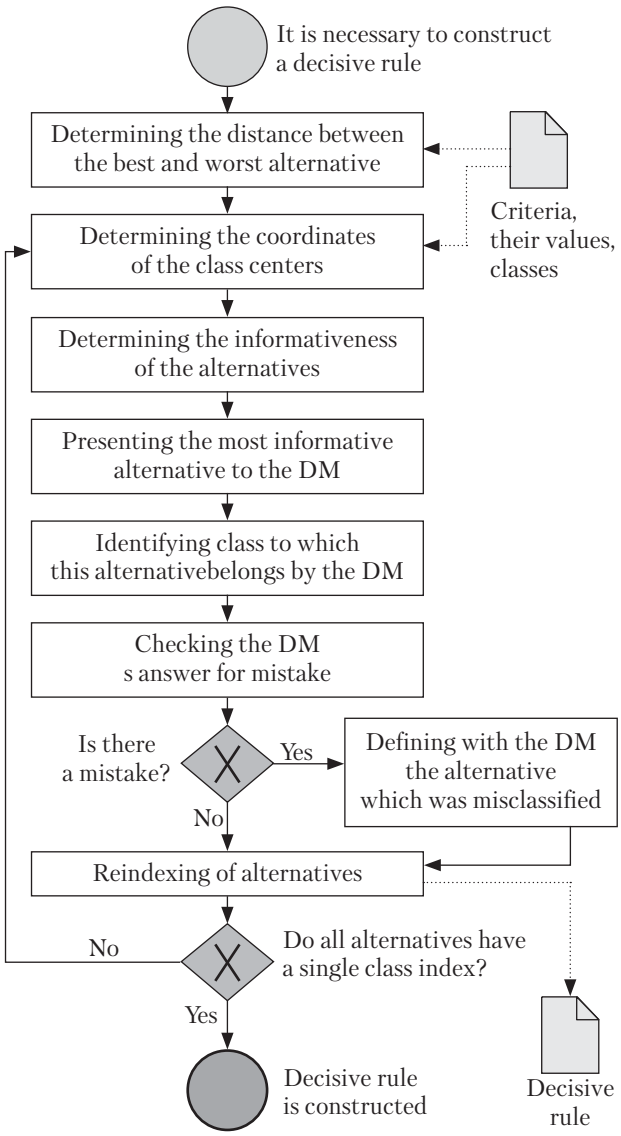

Fig. 1. Procedure for constructing a decisive rule

periments [15] it was shown that human "heuristics and biases" lead to significant errors in the information obtained (for example, in quantitative assessment of event probabilities).

Therefore, the development of the proposed model is based on the use of qualitative information — expert knowledge obtained from experts in terms of their subject area. The expert is the DM, who is the main source of data for the VM. ORCLASS (ORdinary CLASSification of options) [15] from the set of verbal decision analysis methods is chosen as the method. This converts quantitative criterion scales into verbal ordinal scales. For example, quantitative thermometer scales are converted by the DM (expert doctor) into an ordinal temperature scale:

— "low";
— "normal";
— "elevated";
— "high".

The ORCLASS method is based on three concepts: alternative, criterion (and its values) and class — having the following meaning:

- alternatives: data sets (research results). For the model under development, these are sets of SME indicator values;
- criteria: the set of characteristics that distinguish the alternatives from one another. For the model being developed, it is a set of SME indicators;
- criterion values: the set of all possible values for all criteria, ordered from best to worst for each criterion. For the model under development, these are the values of the SME indicators;
- classes: having their own unique features, ordered (from best to worst) parts of a common list of all possible alternatives. For the model being developed, this is one of the possible states of an SME.

The concepts described are defined with the use of benchmarking techniques [18], based on the performance of leaders in the business sector in which the SME is operating.

Table 1. **Fragment of the Decisive Rule**

Number of the alternative	Criteria values						Class
	C1	C2	C3	C4	C5	C6	
1	1	1	1	1	1	1	1
2	1	1	1	1	1	2	1
			...				
7815	3	3	3	3	3	5	3
7816	3	3	3	3	4	1	2
			...				
15624	5	5	5	5	5	4	5
15625	5	5	5	5	5	5	5

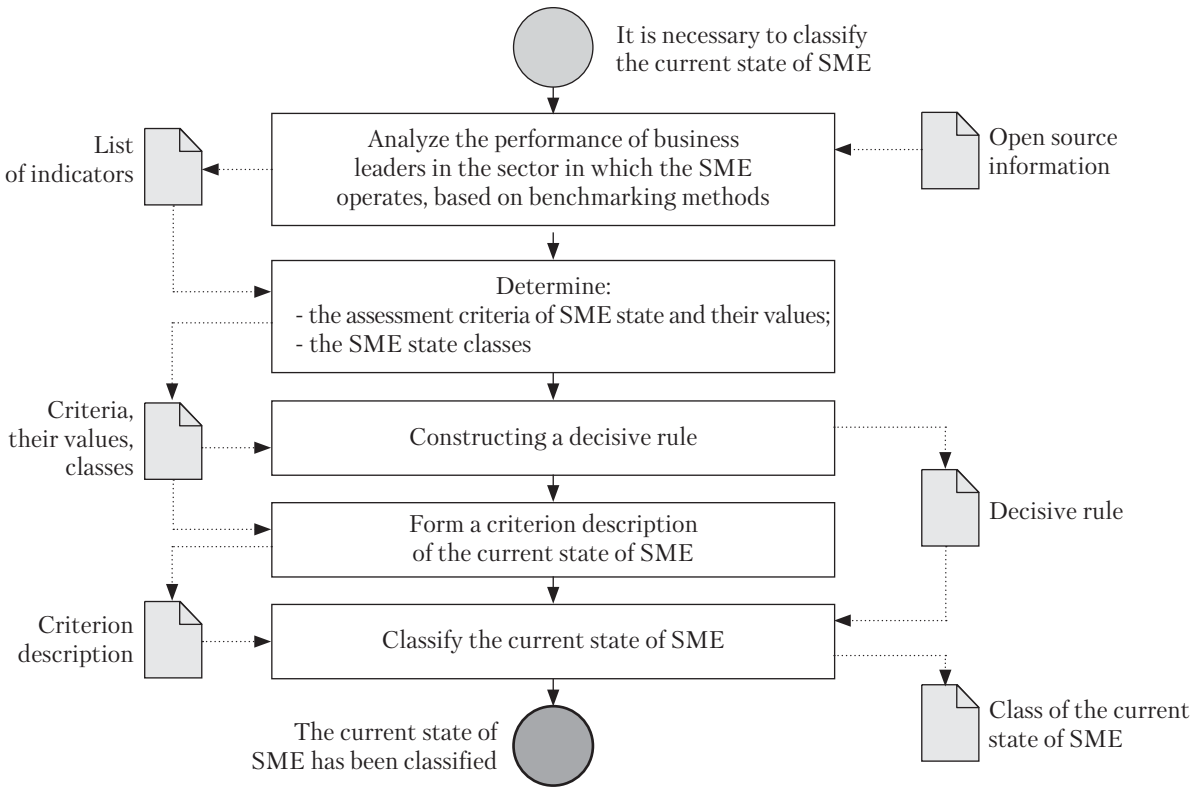

Fig. 2. Verbal model of the ORCLASS method for classifying the current state of SMEs

The basic principles of verbal decision analysis are formulated as follows

- the use of definitions and formulations to describe the problem and the wording of the assessment of options in a way that is natural to the decision-maker, their advisers and active groups, without any conversion of such verbal formulations into quantitative values;
- the construction of a decisive rule (Fig. 1) based on logical, qualitative transformations of verbal variables while respecting the psychological and mathematical correctness of these transformations.

The decisive rule for the model being developed is a table containing all possible alternatives arranged in lexicographical order from the best (having the best values of all SMEs indicators) to the worst (having the worst values of all SMEs indicators) alternative, each of which is assigned a class to which it belongs.

A fragment of the decisive rule for 6 criteria with 5 values (total $5^6 = 15625$ alternatives) and 5 classes is shown in Table 1.

In contrast to ORCLASS, we can assume that the probability of assigning an alternative to a certain class is a constant, independent of the alternative and determined only by the number of partition classes.

The optimal path is searched in the space of all hypothetically possible SME states, as the path with the shortest distance from the current state to the boundary state of the next best class.

1. Development of VM for of the current state of service SMEs based on qualitative methods

A verbal model of the ORCLASS method for classifying the current state of SMEs is presented in Fig. 2.

The model presented in Figure 2, the DSS for classifying the current state of the enterprise, contains the following procedure:

1) based on publicly available information on the performance of business leaders in the industry in which the SME operates, benchmarking techniques are used to determine a list of indicators that can be used to assess the performance of businesses in the industry;

2) based on the identified list of indicators, the criteria, their values and the SME state classes are defined.

Examples of criteria: *state of management, existing policies and strategies, state of human resources, state of partnerships and resources, state of processes, attitude to customers, attitude to society, main results of activities*, etc.

Example values for the *process state* criterion (from best to worst): *all SME processes are described, most SME processes are described, main SME processes are described, some SME processes are described, SME processes are not described*.

Examples of classes (from best to worst): *"Stable development"; "Developmental tendency"; "Equilibrium"; "Stagnation tendency"; "Stagnation"*. As practice shows, a breakdown into 5 classes is sufficient;

3) Based on the list of criteria, their values and classes of SME states, a decisive rule is developed according to the procedure shown in Figure 1. A certain SME state belongs to a certain class: from the best (class I) to the worst. The subdivision of all possible alternatives of the SME state into classes is made on the basis of expert evaluations. Each class has its own set of criterion values, i.e. alternatives;

4) Based on the list of criteria and their values, a criterion description of the current state of the SME is formed, i.e. SME managers determine the current value for each criterion on the basis of the available data;

5) The resulting criterion description (set of criterion values) of the current SME state is compared with the complete set of all possible SME states, i.e. with a decisive rule in the form of a table. In this table, a row is determined which coincides with the set of criterion values from the criterion description and the corresponding value of the SME state class.

The model developed makes it possible:

- For any set of process indicators and their values, to rank (to arrange into predetermined classes) according to the "better-worse" principle a certain number of alternatives (sets of SME process indicator values), i.e. to build a decisive rule;
- to use the decisive rule to unambiguously identify which class any of the alternatives in the DSS input belongs to.

Due to the peculiarities of the procedure for constructing a decisive rule, namely the need to calculate the informativeness of an alternative relative to a particular class, the number of criteria and their values is currently limited. Practice has shown that when there are 4 criteria with 5 values each, the resulting values of the informativeness of the alternative are incorrect when divided into 5 classes. An alternative that differs from the best by one criterion by one value is more informative than an alternative that has average values for all criteria.

This required an appropriate adaptation of the existing procedure for constructing a decision rule for an arbitrary number of criteria and their values.

2. Adaptation of VM for the classification of the current state of service SMEs

Formally the classification (distribution) of alternatives into k classes corresponds to a polynomial (multinomial) distribution in which the event A_i is expressed by assigning (classifying) an alternative to *i-th* class ($i = 1, ..., k$). These events are mutually exclusive, because an alternative can belong to only one class. Let us denote by $p_i \geq 0$ the probability of event A_i, ξ_i is the number of alternatives belonging to *i-th* class, $P(\xi_1 = n_1, ...,$

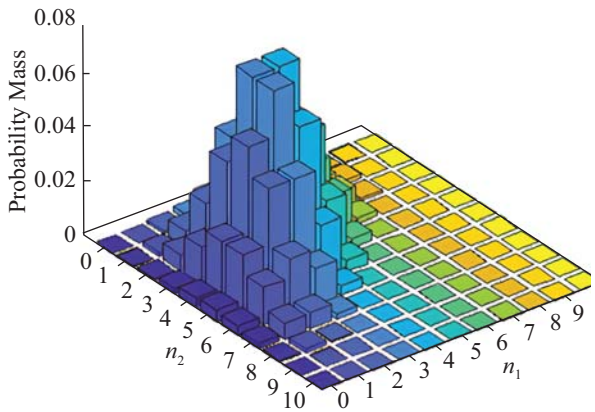

Fig. 3. Visualization of the trinomial distribution with Probability Mass values of the probability function $P(\xi_1 = n_1, \xi_2 = n_2, \xi_3 = n_3)$, for all possible combinations of n_1 and n_2 occurrences of corresponding events

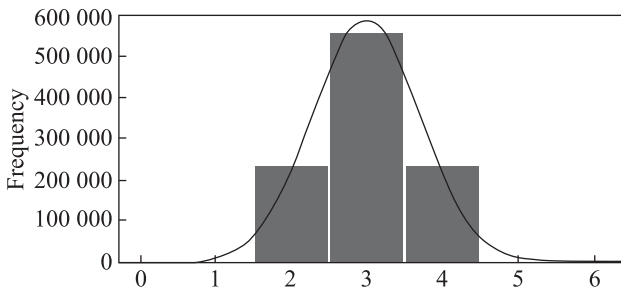

Fig. 4. Histogram with values of numbers (frequencies) of alternatives in classes 1, 2, 3, 4, 5 and normal distribution curve

$\xi_k = n_k$) is the probability that the event A_i occurs n_i times ($i = 1, ..., k$). Then

$$P = (\xi_1 = n_1, ..., \xi_k = n_k) = \\ = \frac{n!}{n_1! \times ... n_k!} p_1^{n_1} \times ... \times p_k^{n_k}, \quad (1)$$

$$\sum_{i=1}^{k} p_i = 1, \quad (2)$$

$$\sum_{i=1}^{k} n_i = n, \quad (3)$$

where n is the number of all hypothetically possible alternatives.

Visualizing the probability function $P(\xi_1 = n_1, \xi_2 = n_2, \xi_3 = n_3)$ by formulae (1)—(3) with $p_1 = p_2 = p_3 = 1/3$ and $n = 10$ by means of MATLAB [18] is shown in Fig. 3.

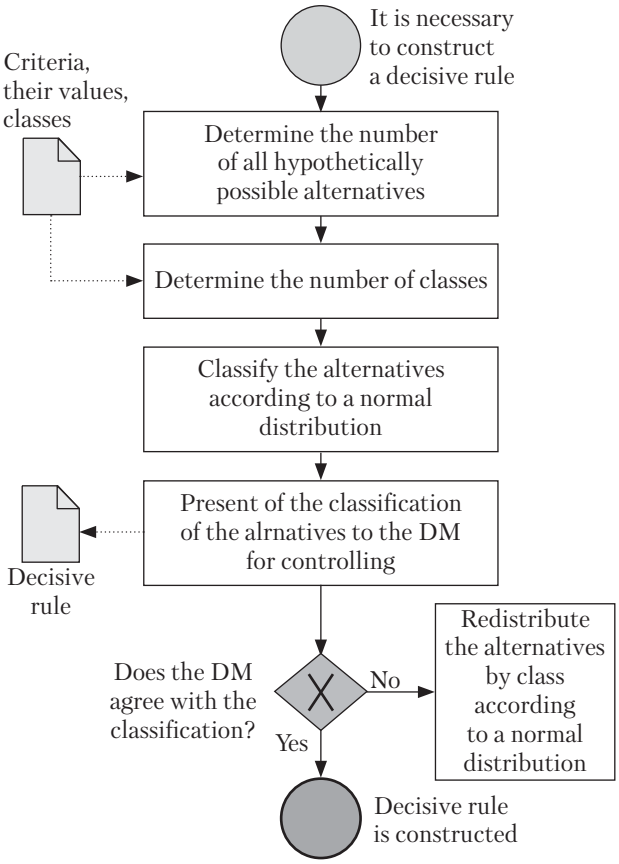

Fig. 5. Adapted procedure for building a decisive rule

Fig. 3 shows that for a fixed value of one variable, the other two variables are distributed in a binomial law.

The binomial distribution is known to approximate the normal distribution for large values of n. Therefore, the classification result of all hypothetically possible states of service SMEs should also approximate the corresponding normal distribution.

For example, let 1,036,800 alternatives be allocated to the 5 classes as follows:

- in grades 1 (best) and 5 (worst), 5.558 alternatives each;
- in grade 3 (middle), 556.638 alternatives;
- grades 2 and 4 have 234.523 alternatives each.

This distribution then corresponds to a normal distribution (Fig. 4).

This is the basis of the proposed adapted decisive rule procedure (Fig. 5).

Fig. 6. K_m criterion scale

The adapted procedure shown in Fig. 5 contains the following order of operations:

- define the number of all hypothetically possible alternatives as the product of the lengths of the criterion scales;
- determine the number of classes based on the DM's response;
- distribute the alternatives into classes according to a normal distribution, as the minimum possible deviation of the numbers (frequencies) of alternatives in the classes from the normal distribution curve (Fig. 4);
- present the distribution of alternatives to the DM for monitoring, with upper and lower class boundaries;
- In the case of disagreement with the distribution presented by the DM, reallocate the boundary alternatives, taking into account the DM's opinion, while remaining within the normal distribution (Fig. 4).

Thus, the adapted procedure is based on the result that the classical algorithm for building a decisive rule seeks to achieve: matching the classification to a normal distribution. This constructs a pattern that the decision maker can modify by reallocating alternatives across classes, staying within the normal distribution.

3. Development of a model for automatically finding the optimal path (strategy)

Formally there is a set of $K = \{K_m\}_{m=1}^{M}$ criteria for assessing the state of SMEs. Each criterion K_m has a set of values, which will be formally denoted in the same way as the criterion itself: $K_m = \{k_{m,n}\}_{n=1}^{N(m)}$, where $N(m)$ is the number of criterion values K_m. The set of K_m values is ordered from best to worst. In other words, a ratio $R_m = \{(k_{m,i}, k_{m,j})\ K_m\ K_m | k_{m,i} > k_{m,j}$ (better) at $i < j\}$ of linear order (scale) is given: $k_{m,1}$ is the best value, $k_{m,N(m)}$ is the worst value. An illustration of the scale of criterion K_m is shown in Fig. 6.

If there is a formal description of the criteria, we can define the set $A = K_1 \times K_2 \times ... \times K_M$ of all hypothetically possible states of an SME. The best SME state is $a^{best} = (k_{1,1}, k_{2,1}, ..., k_{M,1})$, the worst is $a^{worst} = (k_{1,N(1)}, k_{2,N(2)}, ..., k_{M,N(M)})$. Often, to shorten the entry, only the number of value on the criterion scale is given: $a^{best} = (1, 1, ..., 1)$, $a^{worst} = (N(1), N(2), ..., N(M))$.

The criteria scales define a dominance relation R on the set A. A state $a_i = (a_{i,1}, a_{i,2}, ..., a_{i,M})$ is better than $a_j = (a_{j,1}, a_{j,2}, ..., a_{j,M})$ if $a_{i,m} \geq a_{j,m}$ for all $m = 1, ..., M$ and there exists such m_0 that $a_{i,m0} > a_{j,m0}$.

The set A is divided into non-overlapping subsets (classes of SME states):

$$A = \bigcup_{t=1}^{T} A_t, \qquad (4)$$

where $A_i \cap A_j = \varnothing$ at $i \neq j$ and $A_i > A_j$ (better) when $i < j$.

Partitioning (4) must satisfy two conditions:

a) if $a_i > a_j$ and $a_j \in A_t$, then $a_i \in A_s$ at $t < s$, in other words the best state should not fall into the worst class;

b) if $a_i > a_j$ and $a_i \in A_t$, then $a_j \notin A_s$ at $s < t$, in other words, the worst state should not fall into the best class.

The lower boundary of class A_t is the set $A_t^{low} \subset A_t$, whose elements pass to the worse class when any of their components deteriorates: $a_i = (a_{i,1}, ..., a_{i,m}=k_{m,n}, ..., a_{i,M}) \in A_t^{low}$, if $(a_{i,1}, ..., k_{m,n+1}, ..., a_{i,M}) \in A_{t+1}$ for any $m = 1, ..., M$. The upper bound of class A_t is the set $A_t^{high} \subset A_t$, whose elements pass to the best class when any of their components is improved: $a_i = (a_{i,1}, ..., a_{i,m} = k_{m,n}, ..., a_{i,M}) \in A_t^{high}$, если $(a_{i,1}, ..., k_{m,n-1}, ..., a_{i,M}) \in A_{t-1}$ for any $m = 1, ..., M$.

The distance between the states a_i and a_j is the sum of the moduli of the differences of the respective components:

$$d = (a_i, a_j) = \sum_{m=1}^{M} |a_{i,m} - a_{j,m}|. \qquad (5)$$

The most distant from each other are the best a^{best} and worst a^{worst} states of the SME. From formula (5) we get:

$$\max_{a_i, a_j \in A} \{d(a_i, a_j)\} = d(a^{best}, a^{worst}) = \sum_{m=1}^{M} |1 - N(m)|. \qquad (6)$$

$N(m)$ — is the number of criterion values K_m.

Thus, the optimal transition path for an SME from its current state $a_i \in A_t$ to the best class A_{t-1} is the path in the attitude space R of dominance on the set A to the nearest element b lower bound A_{t-1}^{low}. Finding this element reduces to the following minimization problem:

$$d = (a_i, b) = \min_{a \in A_{t-1}^{low}} \{(d(a_i, a)\}. \qquad (7)$$

For example, for the set $K = \{K_1, K_2\}$, where $K_1 = \{k_{1,n}\}_{n=1}^{5}$ и $K_2 = \{k_{2,n}\}_{n=1}^{4}$, the set $A = K_1 \times K_2$ with best state $a^{best} = (1, 1)$ and the worst $a^{worst} = (5, 4)$,distant from each other by distance 7 (see formula (6)), can be divided into classes A_1 и A_2, such that $A_1^{low} = \{(1,4), (2.3), (3.2), (4.1)\}$ and $A_2^{high} = \{(2.4), (3.3), (4.2), (5.1)\}$. The relation R of dominance on the set A is shown in Fig. 7.

Let $(5.2) \in A_2$ be the current state of the SME. Then the search for the optimal way of SME transition to the best class A_1 is reduced by formula (7) to the problem $\min_{a \in A_1^{low}} \{d((5.2), a)\}$. This problem has two solutions: $b_1 = (3.2)$ and $b_2 = (4.1)$. The final choice may depend on both the time and the cost of moving from the current state of the SME to the states b_1 and b_2.

4. Shaping the final VM of the optimal strategy for sustainable development of service SMEs in crisis

Based on the research results, we carry out the final formation of the VM, which is shown in Fig. 8.

The developed VM (Fig. 8) describes the following procedure:

- consolidate information on leaders in a given business area, based on benchmarking techniques;
- based on the consolidated information, generate a list of classes, qualitative criteria and their values in definitions that are natural to the DM, their advisers and active groups in the given business area;
- based on the list of classes, qualitative criteria and their values, develop a decision rule according to an adapted decisive rule procedure;
- based on the list of qualitative criteria and their values, form a criterion description of the current state of SMEs, i.e. to define a list of values for all criteria;
- using the decisive rule and a criterion description of the current state of the SME, determine the class to which this state belongs, based on the decisive rule, as a result of an adapted procedure for constructing the decisive rule;
- choose the optimality criterion (time/cost) and type of strategy (short/long term);
- based on the chosen optimality criterion and type of strategy, generate an optimal SME sustainability strategy according to an automatic optimal pathfinder model (strategy).

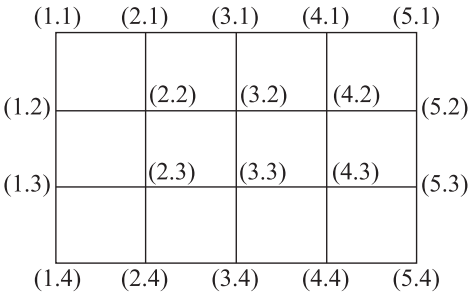

Fig. 7. Ratio R of dominance on the set A

The formation of an optimal strategy in VM consists of 3 steps (Fig. 9):

Step 1: Information preparation for SME performance assessment. The performance of leaders in a given business sector is analyzed and the values of the qualitative criteria describing their state, the values of the criteria that are ordered from best to worst, and the name of the classes to which that state may belong, are determined.

The current state of an SME is defined as a set of criterion values that describe the performance of leaders in a given business sector — a criterion description is formed.

Step 2: Classification of the current state of SMEs. According to the developed decisive rule, the current state of SMEs is automatically classified in relation to the indicators of the business leaders.

Step 3: Determining the optimal SME development strategy. An optimal list of criteria is automatically determined, whose values and to what extent they need to be improved (strategy)

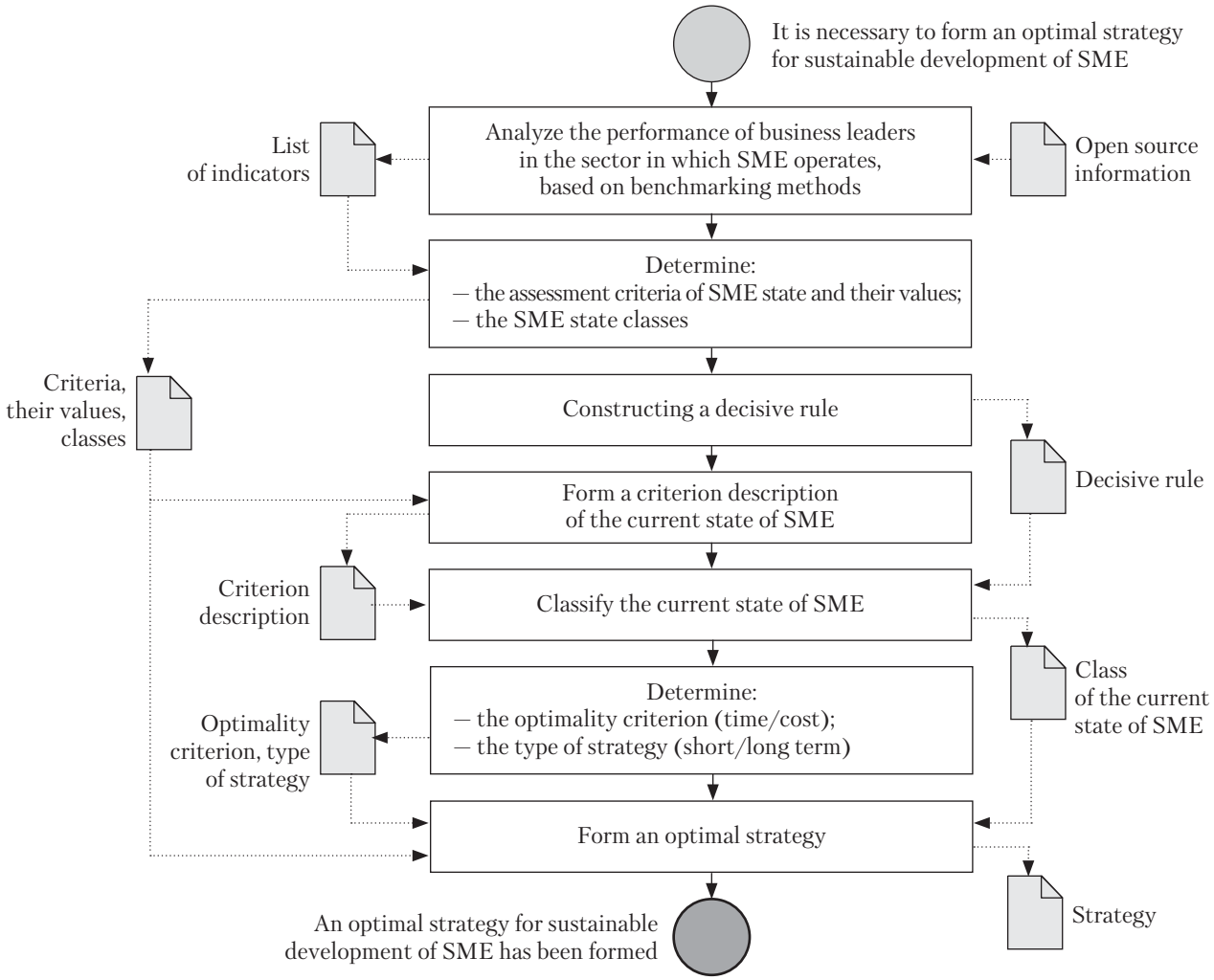

Fig. 8. Verbal model for forming an optimal strategy for sustainable development of service SMEs in the conditions of a crisis

in order for the SME to be able to move up the class. The strategy can be either short-term (promotion to the next "best" class) or long-term (promotion to the "best" class). Optimization of a set of criteria can be both in terms of time and cost to achieve the objective.

The result to be achieved with the developed VM is an automatically generated optimal service SME development strategy, which will be based on proven methods. Namely, methods of formal logic, qualitative methods of verbal analysis (in particular ORCLASS) and methods of discrete mathematics (in particular graph theory).

5. Discussion on the results

The hypothesis underlying the research is that all the prerequisites are in place to develop an online automated consultancy for the formation of an optimal strategy for the sustainable development of enterprises.

Such prerequisites are:

- the global practice of such off-line consultancy, which, for example in Ukraine, is recognized as relevant at state level, especially for SMEs without adequate resources;
- the EFQM model for classifying the state of management of companies on the basis of qua-

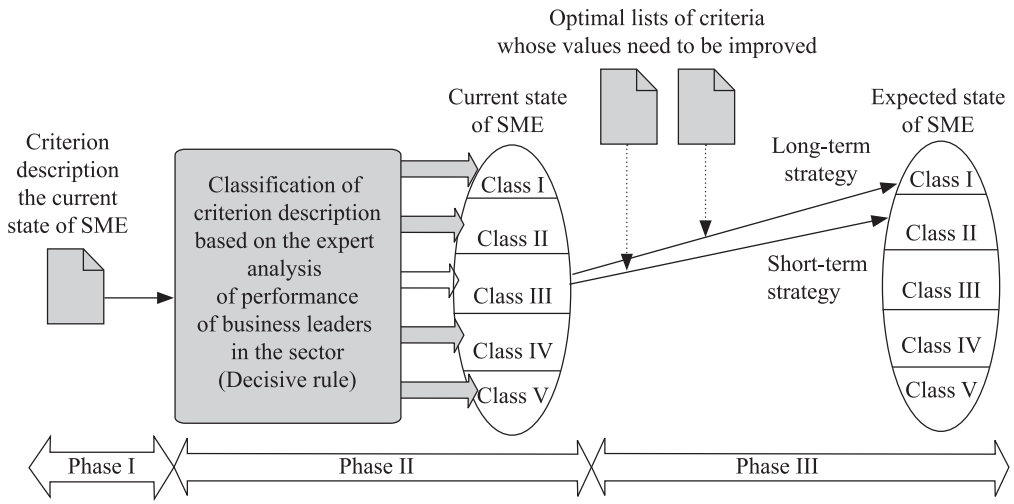

Fig. 9. Stages of optimal strategy formation in VMs

litative criteria, which has been used in practice since 1992;

- the ORCLASS verbal method for allocating alternatives to ordered classes, the first mention of its use dates back to 1982;
- the need for a strategy that is a competitive advantage and allows for easy adaptation to changing external conditions, including a crisis.

Each of the prerequisites has its own disadvantages:

- off-line consultancy requires time and human resources diverted from the core business;
- the EFQM model only states the current state of enterprise management, without offering any recommendations for improvement;
- the ORCLASS verbal method effectively allocates alternatives for a fairly small number of criteria and their values;
- enterprise strategy formation is a rather informal brainstorming process which often, in the case of SMEs, lacks the necessary level of experts.

In fact, the aim and objectives of the study were to remedy these shortcomings:

- VM allows moving consultancy from off-line to on-line 24/7;
- the developed VM automatically generates the optimal (in terms of time or cost) path to improve the current state of the enterprise;
- the procedure for assigning alternatives to classes is adapted for an arbitrary number of criteria and their values;
- The developed VM formalizes the process of shaping the enterprise's strategy).

The effectiveness of the proposed VM can be assessed in terms of the time it takes both to construct an ordinal classification and to form a strategy.

When constructing an ordinal classification in the ORCLASS method, the DM is presented with the alternatives selected for the direct classification, and its responses are continuously monitored for consistency. If inconsistencies are found, it is necessary to go back to the point of inconsistency, correct it and continue the classification from the same place. This takes quite a lot of time. For example, according to the data from [20], it took 12 hours of net time of expert's work (7 working days in total) to develop an ordinal classification of 2304 alternatives in 7 classes. The development of an ordinal classification of about 20,000 alternatives in 14 classes required 60 hours of net expert time (about 20 working days in total).

In the developed VM, constructing an ordinal classification of 1,036,800 alternatives into 5 classes took one working day. This is due to the fact

that in the proposed approach, the DM is excluded from the process of developing the ordinal classification. In other words, a source of error is eliminated.

With the current approach to consultancy services, strategy formation can take anywhere from a few days to months.

In the developed VM, it takes almost no time at all to form a strategy (a fraction of a second, depending on the speed of the computer), but it can take several hours to enter a description of the current state of the company, depending on the number of criteria.

Verbal models are generally adequate [14]:

- for unstructured tasks, which includes strategy formation;
- for the human information processing system that is the DM;
- in terms of logic (the best condition does not fall into the worst class, the worst condition does not fall into the best class);
- in terms of using the experts: these are experienced people and the adequacy of their criteria has been tested by experience, time and recognized in a particular field.

The VM is not sensitive to small changes in criterion values. Changing the value of any criterion by one unit on the scale does not result in a change of class for most alternatives. For borderline alternatives, it is possible to move to an adjacent class.

Practical results obtained in the course of VM development have confirmed the hypothesis that it is possible to develop on-line automated consulting for the formation of an optimal strategy for sustainable development of enterprises. At the same time, the VM is not sufficiently detailed to become a method. It is the first step towards the creation of information technology (software product). The lack of detailed elaboration and practical implementation at a specific enterprise can be considered shortcomings, but they were not the purpose of the study and can be the basis for its development.

The advantages of the developed model over similar scientific and technical products are the following:

- ease of use — definitions that are natural to the DM, their advisers and active groups are used to describe the state of SMEs, without converting such verbal formulations into quantitative values;
- automatic formation of an optimal sustainable development strategy for service SMEs based on quality expert data and proven scientific methods, which enable such enterprises to avoid spending money on suitably qualified specialists;
- the versatility of the verbal model for any business area of service SMEs through the use of qualitative criteria to describe the state of the enterprise.

As a software product, the VM can be executed as a web application (open access site), electronic link to which will be available to potential users both in Ukraine and abroad. On such a website, the user with the program prompts:

a) conducts information preparation for obtaining consultancy — introducing the meaning of the qualitative criteria describing its condition and their meaning and the name of the classes in which this condition may belong.

b) then enters the current values of the criteria — the criterion description of the state of the enterprise;

c) is then given the name of the class to which the current state of the enterprise belongs;

d) then receives recommendations as to which values of which criteria need to be improved and to what extent in order for the enterprise to "move up" to the next best class — short-term strategy, or to the tops class — long-term enterprise development strategy;

Once the changes have been implemented according to the formed strategy — points b), c) and d) are repeated with the necessary frequency until the company's objectives have been achieved.

The website, as an information and analytical system, should have a well-developed advisory and supportive environment for informing the assessment of a service SME and shaping its sustainable development strategy.

If necessary, monetization of the product can be implemented as follows: information prepara-

tion and definition (classification) of the current state of the company is free of charge, and strategy formation for a fee.

Limitations of the study include:

- applying only qualitative criteria when describing the subject area;
- the availability of up-to-date information on the cost of tasks, which will allow for changing the values of the criteria and their execution times for optimality calculations;

A shortcoming of the study is the generality of the recommendations for the application of a normal distribution of alternatives across classes. A remedy is to make such recommendations more specific and requires additional research.

The development of this research lies in solving the problem of path minimization on a graph when searching for an optimal strategy for high dimensional problems. This is due to mathematical and methodological difficulties due to the lack of a general approach to solving such problems.

Conclusions

1. Based on the ORCLASS verbal decision analysis method, a verbal model for classifying the current state of service SMEs has been developed. The model allows us to describe and to classify the states of SMEs in any business area. This is achieved by using the definitions that are natural to the DM, their advisors and active groups, without converting such verbal formulations into quantitative values.

2. The basis for the adaptation is the hypothesis that the probability of assigning an alternative to a certain class is a constant, independent of the alternative and determined only by the number of partition classes. The adapted procedure is based on the result sought by the classical algorithm for constructing a decisive rule: the correspondence of the classification to the normal distribution. This constructs a pattern that the decision maker can modify by reallocating alternatives into classes while remaining within the normal distribution.

3. The optimal path is searched in the space of all hypothetically possible SME states, as the path with the shortest distance from the current state to the boundary state of the next best class. This automatically produces optimal strategies for the sustainable development of enterprises. The optimality of the strategy can be both in terms of time and cost to achieve the required state of the enterprise.

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РОЗРОБКА ВЕРБАЛЬНОЇ МОДЕЛІ ФОРМУВАННЯ ОПТИМАЛЬНОЇ СТРАТЕГІЇ СТАЛОГО РОЗВИТКУ СЕРВІСНИХ ПІДПРИЄМСТВ В УМОВАХ КРИЗИ

Вступ. Наявність стратегії, стратегічного плану, необхідного для визначення напрямку розвитку підприємства, прийняття обґрунтованих рішень дозволяє підприємству впевнено досягати поставлених цілей, й водночас гнучко реагувати на зміни зовнішнього середовища, особливо в умовах кризи.

Проблематика. Формування стратегій сталого розвитку вимагає достатніх витрат на консалтинг та використовує технології, які розраховано на застосування на великих підприємствах, що мають фахівців відповідної кваліфікації. Але найбільше в умовах кризи потерпають малі та середні підприємства сфери надання сервісних послуг, які не в змозі використовувати такий консалтинг та технології.

Мета. Розробка вербальної моделі формування оптимальної стратегії сталого розвитку малих та середніх підприємств сфери надання сервісних послуг в умовах кризи для пошуку, оцінки та підтримки прийняття ефективних управлінських рішень.

Матеріали й методи. Методи формальної логіки, якісні методи вербального аналізу, методи дискретної математики, метод бенчмаркинга.

Результати. Розроблено вербальну модель класифікації поточного стану підприємств на основі якісних методів. Модель адаптовано для можливості її використання за наявності довільного набору критеріїв та їхніх значень. Розроблено модель автоматичного пошуку оптимального шляху (стратегії) від певної альтернативи (поточного стану підприємства) до альтернативи, яка гарантовано належить або наступному кращому класу — короткострокова стратегія, або найкращому класу — довгострокова стратегія.

Висновки. Вербальна модель дозволяє описувати та класифікувати стан малих та середніх підприємств сфери надання сервісних послуг у будь-якій галузі бізнесу та автоматично отримувати оптимальні стратегії їхнього сталого розвитку. Критеріями оптимальності стратегії можуть бути час та вартість досягнення необхідного стану підприємства.

Ключові слова: вербальний аналіз, оптимальна стратегія, система підтримки прийняття рішень.