

Leading Strategic Planning and Management of a Holding Based on Informational and Cognitive Technologies

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Abstract This paper develops the methodology of a leading strategic planning and management of a holding using the automated system-cognitive analysis (the ASC-analysis) as a theoretical base. This methodology considers the holding as a complex, multiparametric and nonlinear system. The relevance of the research is due to the special role of holdings and other corporate integrated structures both in Russia as a whole and in the Krasnodar region. Despite obvious system advantages, such holdings face a wide range of problems related to management efficiency or ensuring their sustainable functioning.

Our proposed methodology offers ways to solve these problems and can be successfully applied in holdings and other corporate integrated structures of various regions, volumes, and areas of activity which determines the relevance of the research topic. The research scientific novelty of the paper is the development of conceptual and theoretical and methodological provisions aimed at managing the development of holdings. Our results and their relevance and significance are represented by the methodology developed in the outcome of this research that may be successfully used by holdings and other corporate integrated structures and would significantly improve the quality of their management.

Keywords: *strategic planning, management, holding, information, leadership, cognitive technologies*

1 Introduction

The main aim of this paper is to create a methodology for strategic planning and management of holdings as complex multiparametric dynamic nonlinear systems. In order to achieve the goal by decomposing it, a number of tasks that are stages of achieving the goal have been set and solved.

The relevance of the research is due to the special role of holdings and other holdings both in Russia as a whole and in the Krasnodar region. Despite the obvious system advantages, holdings face a wide range of problems related to management efficiency, ensuring their sustainable functioning, etc. The proposed methodology offers ways to solve these problems and can be successfully applied in holdings and other holdings of various regions, volumes and areas of activity, which determines the relevance of the study. The research direction corresponds to the strategy of the Russian Federation.

Various aspects of management in economics were revealed in the works of Berzon (2004), Ansoff (2007), Bochkarev and Kondrat'ev (2008), Bepaxotny (2010), Vinslav (1997), Vinslav et al. (1998), Baklazhenko (2003), Xiczkov et al. (2003), Keller et al. (1996), Kashanina (1999), Shitkina (2001), and others.

From these scientists' works we may understand that considering their economic nature, holdings are complex multiparametric nonlinear dynamic systems, which include dozens, and sometimes hundreds of enterprises of various volumes and activities. These features of the holding as an object of management create methodological, mathematical, technological and technical problems in the development of the whole holding management system. Strategic planning and management of such systems at the level of modern requirements seem impossible without a clear methodology and the use of adequate mathematical methods for identifying knowledge about the object of management, forecasting and decision support.

All these circumstances justify the relevance of developing a methodology for strategic planning and management of holdings based on informational and cognitive technologies, as a single complex multiparametric

nonlinear system. This study is dedicated to the formulation and solution of these issues, which makes it relevant.

2. Methodology and methods

The problem is the discrepancy between the actual and the desired (goals), i.e. the contradiction between them. Holdings, as an object of management, are complex multiparametric nonlinear dynamic systems. This imposes strict requirements on the methodology, mathematical models, technologies and tools for managing them, namely, they must: work effectively with large data of high dimensions in conditions of incomplete and noisy information; correctly and comparably quantify heterogeneous factors measured in different types of scales and different units of measurement; directly in the management cycle, provide adaptation and re-synthesis of the model based on the information about previous management results.

The methods for solving the problem revealed in this study are based on the works of Orlov et al. (2015), Orlov et al. (2016), Lucenko et al. (2017), Lojko et al. (2018), Takhumova et al. (2018b), Takhumova et al. (2018b), Polozhentseva et al. (2019), or Lojko et al. (2019). The solution of the problem is the achievement of the research goal and it consists in solving the following tasks, which are the stages of achieving the goal:

- Task 1. Statement of the problem to be solved and development of a methodology for its solution at the conceptual level;
- Task 2. Cognitive-target structuring and formalization of the subject area;
- Task 3. Synthesis and verification of the system-cognitive model of the holding;
- Task 4. Studying the holding company by examining its system-cognitive model in order to obtain the knowledge about the holding needed to solve the problem;
- Task 5. Solution of the problem: solving the problems of forecasting and decision support (management) for the holding by applying updated and renewed knowledge about it.

The following five methods were used to solve these tasks (see below explained for each consecutive method in detail).

The method for solving the 1st task

- statement of the problem of strategic planning and management of holdings;
- substantiation of the requirements for the mathematical method and the model of holding management;
- description of the traditional approach and its disadvantages, which make it unsuitable for solving this problem;
- selection of the method corresponding to the reasonable requirements;
- development of a mathematical method and principles for creating a model that meets reasonable requirements.

The method for solving the 2nd task

When applying cognitive-target structuring, the developers of the holding model determine what they have to consider as factors affecting the management object, and what as the results of their actions. In this case, the factors considered internal and external economic indicators of enterprises of the holding, and the impact of factors: future status of this holding, both targeted and unwanted, characterized by the resulting economic performance of its activities.

When formalizing the subject area, we first develop classification and descriptive scales and gradations that allow encoding events described in the empirical source data, and then the source data is encoded using the developed classification and descriptive scales and gradations, as a result of which the source databases are normalized and converted into a training sample.

The method for solving the 3rd task

This system-cognitive model consists of 3 statistical and 7 system-cognitive models that differ in particular knowledge criteria, as well as two additive integral criteria, mathematical models of automated cognitive clustering, automated cognitive SWOT analysis, reliability criteria for models that are invariant with respect to the sample size, a fuzzy multiclass generalization of the van Riesbergen's F-measure, and other mathematical models developed by the authors (2014, 2015, 2016, 2017, 2018, 2019).

Below, we briefly consider the synthesis of system-cognitive models and particular knowledge criteria, as well as multiparametric typization.

The mathematical model of the ASC-analysis and the Eidos system is based on system fuzzy interval mathematics (Orlov and Lutsenko 2014) and provides comparable processing of large volumes of fragmented and noisy interdependent data presented in various types of scales (nominal, ordinal, and numeric) and various units of measurement (Orlov and Lutsenko 2014). The essence of the mathematical model of the ASC-analysis is as follows. The absolute frequency matrix is calculated directly from empirical data (Table 1).

Table 1. Absolute frequency Matrix

		Classes					Sum
		I	..	j	..	W	
Values of factors	I	N_{11}		N_{1j}		N_{1W}	
	...						
	i	N_{i1}		N_{ij}		N_{iW}	$N_{i\Sigma} = \sum_{j=1}^W N_{ij}$
	...						
	M	N_{M1}		N_{Mj}		N_{MW}	
Total quantity attributes by class				$N_{\Sigma j} = \sum_{i=1}^M N_{ij}$			$N_{\Sigma\Sigma} = \sum_{i=1}^W \sum_{j=1}^M N_{ij}$
Total number of objects in the training selection by class				$N_{\Sigma j}$			$N_{\Sigma\Sigma} = \sum_{j=1}^W N_{\Sigma j}$

Source: Own results

The matrix of conditional and unconditional percentage distributions is calculated on the basis of Table 1 (Table 2). Please note that the ASC-analysis and the Eidos use two methods for calculating matrices of conditional and unconditional percentage distributions: i) Method 1: the total number of attributes by class is used as the standard; and ii) Method 2: the total number of objects in the training selection by class is used as the result.

Table 2. Matrix of conditional and unconditional percentage distributions

		Classes					Unconditional probability of the sign
		I	..	j	..	W	
Value of the factors	I	P_{11}		P_{1j}		P_{1W}	
	..						
	i	P_{i1}		$P_{ij} = \frac{N_{ij}}{N_{\Sigma j}}$		P_{iW}	$P_{i\Sigma} = \frac{N_{i\Sigma}}{N_{\Sigma\Sigma}}$
	...						
	M	P_{M1}		P_{Mj}		P_{MW}	
Unconditional probability of the class				$P_{\Sigma j}$			

Source: Own results

Then, on the basis of Table 2, using the particular criteria given in Table 3, we can calculate the matrices of system-cognitive models (see Table 4).

Table 3. Various analytical forms of particular knowledge criteria

The model and a criterion	Criterion expression	
	via relative frequencies	via absolute frequencies
ABS or absolute frequency matrix	---	N_{ij}
PRC1 , a matrix of conditional and unconditional percent distributions, which uses $N_{\Sigma j}$ as the total number of objects in the training sample by class	---	$P_{ij} = \frac{N_{ij}}{N_{\Sigma j}}$
PRC2 , a matrix of conditional and unconditional percent distributions, which uses $N_{\Sigma j}$ as the total number of objects in the training sample by class	---	$P_{ij} = \frac{N_{ij}}{N_{\Sigma j}}$
INF1 , a special criterion: the amount of knowledge according to A. Harkevich, the 1st version of the probability calculation: N_j – the total number of features for the j-th class. The probability that if an object of the j-th class has a trait, it is the i-th trait	$I_{ij} = \Psi \times \log_2 \frac{P_{ij}}{P_i}$	$I_{ij} = \Psi \times \log_2 \frac{N_{ij} N}{N_i N_j}$
INF2 , a special criterion: the amount of knowledge according to A. Harkevich, the 2nd version of the probability calculation: N_j – the total number of objects in the j-th class. The probability that if an object of the j-th class is presented, it will have the i-th attribute detected.	$I_{ij} = \Psi \times \log_2 \frac{P_{ij}}{P_i}$	$I_{ij} = \Psi \times \log_2 \frac{N_{ij} N}{N_i N_j}$
INF3 , special criterion: Chi-square : differences between actual and theoretically expected absolute frequencies	---	$I_{ij} = N_{ij} - \frac{N_i N_j}{N}$
INF4 , special criterion: ROI - Return On Investment, 1st variant of probability calculation: N_j -total number of features for the j-th class	$I_{ij} = \frac{P_{ij}}{P_i} - 1 = \frac{P_{ij} - P_i}{P_i}$	$I_{ij} = \frac{N_{ij} N}{N_i N_j} - 1$
INF5 , special criterion: ROI - Return On Investment, 2nd variant of probability calculation: N_j -total number of objects in the j-th class	$I_{ij} = \frac{P_{ij}}{P_i} - 1 = \frac{P_{ij} - P_i}{P_i}$	$I_{ij} = \frac{N_{ij} N}{N_i N_j} - 1$
INF6 , special criterion: the difference between conditional and unconditional probabilities, 1st variant of probability calculation: N_j – the total number of features for the j-th class	$I_{ij} = P_{ij} - P_i$	$I_{ij} = \frac{N_{ij}}{N_j} - \frac{N_i}{N}$
INF7 , special criterion: the difference between conditional and unconditional probabilities, 2nd variant of probability calculation: N_j – the total number of objects in the j-th class	$I_{ij} = P_{ij} - P_i$	$I_{ij} = \frac{N_{ij}}{N_j} - \frac{N_i}{N}$

Source: Own results

The symbols for Table 3 stand for as the following:

i – value of the last parameter;

j – the value of the future parameter;

 N_{ij} – the number of appearance of the j-th value of the future parameter when the i-th value of the last parameter;

M – the total number of past values of all parameters;

W – the total number of values of all future options;

 N_i – the number of appearance of the i-th value of the last parameter for the whole sample;

 N_j – the number of appearance of the j-th value of the future parameter for the whole sample;

N – the number of appearance of the j-th value of the future parameter when the i-th value of the last parameter for the whole sample;

 I_{ij} – criterion of knowledge; Ψ – selection coefficient;

 P_i is the unconditional relative frequency of the meeting of the i-th value of the last parameter in the training set;

 P_{ij} -conditional relative frequency of appearance of the i-th value of the past parameter with the j-th value of the future parameter.

Table 4. Matrix of the system-cognitive model

		Classes				Significance of factors	
		I	..	j	..		W
Values of factors	I	I_{11}		I_{1j}		I_{1W}	$\sigma_{1\Sigma} = \sqrt{\frac{1}{W-1} \sum_{j=1}^W (I_{1j} - \bar{I}_1)^2}$
	..						
	i	I_{i1}		I_{ij}		I_{iW}	$\sigma_{i\Sigma} = \sqrt{\frac{1}{W-1} \sum_{j=1}^W (I_{ij} - \bar{I}_i)^2}$
	..						
	M	I_{M1}		I_{Mj}		I_{MW}	$\sigma_{M\Sigma} = \sqrt{\frac{1}{W-1} \sum_{j=1}^W (I_{Mj} - \bar{I}_M)^2}$
Degree of reduction of the class		$\sigma_{\Sigma 1}$		$\sigma_{\Sigma j}$		$\sigma_{\Sigma W}$	$H = \sqrt{\frac{1}{(W \cdot M - 1)} \sum_{j=1}^W \sum_{i=1}^M (I_{ij} - \bar{I})^2}$

Source: Own results

The integral criteria and solution of system identification and decision-making problems go like this. The system's identification task is finding the degree of similarity (and difference) of a particular object with generalized images of the classes corresponding to certain future states of the holding and its member enterprises. The models shown in table 4 is the amount of information in each value of an internal indicator of any of the holding companies about the onset of various future states of the holding and its member companies. However, the holding companies are described by a large number of values of various internal indicators. Therefore, it is natural to assume that the state of the holding belongs to those classes that these values of indicators contain a greater total amount of information about their membership.

A function of particular criteria that has a certain numerical value, which is its own for each class and reflects the degree of belonging of the holding state to this class, is called an *integral criterion*.

As a result, it turns out that some certain state of the holding belongs to different classes and does not belong to different classes in some degree.

Integral criteria are used in solving both the identification or forecasting problem and the decision-making problem. Currently, the system of "Eidos" uses two additive integral criteria: i) sum of knowledge; and ii) resonance of knowledge.

The 1st integral criterion called "Sum of knowledge" is the total amount of knowledge contained in the features of an object about its similarity/difference with each of the classes. The integral criterion is an additive function of particular knowledge criteria. In the expression, parentheses denote the scalar product. In coordinate form, this expression looks like:

$$I_j = (\bar{I}_{ij}, \bar{L}_i), \quad I_j = \sum_{i=1}^M I_{ij} L_i, \quad (1)$$

where M is the number of gradations of descriptive scales (attributes);

$\bar{I}_{ij} = \{I_{ij}\}$ – the state vector of the j–th class;

$\bar{L}_i = \{L_i\}$ – the state vector of the recognized object, which includes all types of factors that characterize the object itself, controlling influences, and the environment (locator array), i.e.:

$$\bar{L}_i = \begin{cases} 1, & \text{if } i\text{-th factor works;} \\ n, & \text{where: } n > 0, \text{ if } i\text{-th factor works with } n \text{ validity;} \\ 0, & \text{if } i\text{-th factor does not work.} \end{cases} \quad (2)$$

The 2nd integral criterion "Semantic resonance of knowledge" is a normalized total amount of knowledge contained in the features of an object about its similarity/difference with each of the classes.

The integral criterion is an additive function of particular knowledge criteria and has the form:

$$I_j = \frac{1}{\sigma_j \sigma_l M} \sum_{i=1}^M (I_{ij} - \bar{I}_j) (L_i - \bar{L}), \quad (3)$$

The method for solving the 4th task is as follows. When solving the 4th task, a number of research problems were classified, set, and then solved; in particular:

- typological analysis of the state of the simulated holding and factors affecting it;
- generalizing and detailed study of classes depending on their system of determination and values of factors, by the system of classes determined by them;
- SWOT analysis of factor classes and values;
- cluster-constructive analysis of classes and values of factors, construction of dendrograms of cognitive agglomerative clustering;
- analysis of the impact of factors and their values on the holding company;
- analysis of the degree of determinism of the future state of the holding due to their factors.

The method for solving the 5th task is as follows. Firstly, we develop the classification of forecasting and decision-making tasks; then we proceed with their formulation, and after that we solve these tasks using one the most reliable of the created system-cognitive models.

However, in the ASC-analysis we have developed an advanced decision-making algorithm, that includes not only SWOT analysis, but also forecasting, as well as the results of cluster-constructive analysis of classes by their determination system and the values of factors by the strength and direction of their influence on the behavior of the management object.

Step 1. We set management goals, i.e. we define one or more target states of the management object. In physical terms, target states are usually the quantity and quality of products, and in value terms it is the profit and profitability of its production and sale.

Step 2. We carry out cognitive-target structuring for the models; we determine one the most reliable of them (by using van Riesbergen's F-criterion and the L1 and L2 criteria by Prof Lutsenko).

Step 3. If the target state is the same, then go to step 5.

Step 4. Otherwise, we evaluate the correctness of the set goals by comparing the system of determination of target states by the method of cognitive clustering or simply the similarity matrix, i.e. we determine whether the target states are compatible, i.e. achievable simultaneously, by the factors that determine them, or they are mutually exclusive (alternative) and cannot be achieved simultaneously.

Step 5. We solve the problem of decision support in a simplified version using automated cognitive SWOT analysis of the target states.

Step 6. We evaluate the technological and financial possibilities of applying the recommended values of factors in step 5 in practice.

Step 7. If such a possibility exists for all the values of factors, then we accept them for implementation in practice and exit the decision-making algorithm.

Step 8. If it is not possible, we exclude those factors (that for some reason can not be applied) from the system of values of factors and go to step 9.

Step 9. We predict the results of applying in practice, for a reduced system of values of factors in which there are only those that have a real opportunity to be applied.

Step 10. Does the reduced system of factor values lead to the achievement of target states?

Step 11. We replace the recommended in step 5, but deleted in step 8 values of the factors with other factors that have similar effects on the control object, but can be used. These replacement factor values are selected using the results of a cognitive cluster-design analysis of factor values, or simply a similarity matrix.

Step 12. We predict the results of practical application of the system of factor values formed in step 11.

Step 13. If the predicted result of applying in practice the system of factor values formed at step 12 leads to the transition of the control object to the target states, we accept this system of factor values for implementation in practice and exit the decision-making algorithm. If the forecast shows that the target state is not reached when using this system of factor values, then the management problem has no solution in this model and the transition to step 2 is made for the re-synthesis (qualitative change) of the model with new source data and an expanded system of factor values.

We exit from the decision-making algorithm.

3. Results

The main result and its scientific and applied significance is that the methodology developed as an outcome of the research can be applied to strategic planning and management of holdings, which will significantly improve the quality of their management. To obtain this main result, all the tasks were solved, and the following results were achieved:

The principles of creating a model that implements the proposed mathematical method include the method of numerical calculations, i.e. data structures and the algorithms for their processing.

The result of solving the 2nd task: Classification and descriptive scales and gradations and a training sample.

The result of solving the 3rd task: A system-cognitive model of the holding company, which includes 3 statistical and 7 system-cognitive models, as well as an assessment of their reliability.

The result of solving the 4th task: New and updated knowledge about the holding that can be used to solve forecasting and management problems, presented in a variety of tabular and graphical forms that reflect the dynamics of the modeling object under the influence of various factors.

The result of solving the 5th problem: The results of forecasting and making control decisions, available in screen, table and graphical output forms.

4. Discussions

The results obtained have a scientific novelty, which provides certain advantages over the traditional approach. Novelty and advantages of solving the 1st problem: the system-cognitive models of the holding company can take into account tens of thousands of future states of the management object, hundreds of thousands of values of factors, millions of examples of observations of the behavior of the management object under the influence of factors reflected in the training sample.

Based on empirical data on the behavior of the control object, new knowledge about the behavior of the management object under the influence of various factors is identified and clarified. This knowledge is reflected in the system-cognitive models of the controlled object. These models may be used to solve the problems of studying a complex multiparametric dynamic nonlinear modeling object by examining its model, as well as on the basis of knowledge about the control object reflected in the model - the problems of forecasting and supporting management's decision-making. It is planned to develop a model of a specific object of control that meets previously justified requirements by applying the system information theory. The study considers a holding company as an object of management. The process of developing a model of a specific controlled object is implemented in two stages when solving the 2nd and 3rd problems.

5. Conclusions

Overall, the article proposes to develop the methodology of holding management with the method proposed by the authors. The relevance of the research is due to the special role of holdings and other corporate integrated structures both in Russia as a whole and in the Krasnodar region, in particular. Despite obvious system advantages, holdings face a wide range of problems related to management efficiency, ensuring their sustainable functioning, as well as other serious issues.

Our results help to develop the useful and practical theoretical and methodological provisions designed for the effective management of holdings. This paper devises the novel methodology intended for the holdings and other corporate integrated structures both in Russia and abroad. These results might be of a particular interest for the managers, policy makers and relevant stakeholders.

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