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## STRATEGIC DIAGNOSTICS IN THE SYSTEM OF CONTROLLING THE FINANCIAL RESULTS OF THE ENTERPRISE

**Purpose.** To create a mathematical model and approaches for the formation of optimal management actions on the basis of strategic diagnostics data and to use them to form an effective algorithm of strategic diagnostics in the system of controlling the financial results of the enterprise.

**Methodology.** General and special methods of cognition were used during the study. The scientific economic approach to the implementation of the method of scientific abstraction was used to substantiate the relevance of the topic, purpose and tasks of the study, analysis of the impact of the use of strategic controlling systems on the financial condition of the enterprise. The method of analysis and synthesis and the method of induction and deduction were used to develop an algorithm for strategic controlling of the financial activity of the enterprise. The method of economic modeling was used for a formalized description and strategic forecast of the effectiveness of the strategies selected according to the controlling data. The method of comparison was used to analyze the pace of financial results and forecast the results of the extractive industry and the development of quarries by region.

**Findings.** The mathematical model and approaches have been developed using the entropy method and the time series method for comparative analysis of variants of complex application of management solutions for the formation of optimal management actions based on strategic diagnostic data. An algorithm of strategic diagnostics in the system of controlling the financial results of the enterprise was created. The proposed vector criteria, their rate of change detected during the controlling, and their threshold values become an indicator that the current financial and production condition of the enterprise requires decisions to neutralize risks and improve the financial condition of the enterprise.

**Originality.** The proposed mathematical model and approaches were first used to analyze the directions of strategic diagnostics in the system of controlling the activities of the enterprise. For the first time, a system of vector criteria for determining the need for management decisions to improve the financial condition of the enterprise has been proposed. The algorithm of realization of strategic controlling of financial activity of the enterprise is introduced.

**Practical value.** The developed algorithm and mathematical apparatus can be used both for scientific purposes and in practical work by the management of enterprises of various industries. The effectiveness of the developed mathematical methods and the proposed algorithm is tested on forecasting the activities of mining enterprises and quarry development for Kyiv, Mykolaiv and Odesa regions of Ukraine.

**Keywords:** *strategic diagnostics, controlling, financial results, mathematical model, prognostication*

**Introduction.** The crisis situation in Ukraine requires the development and application of new effective methods of systematic control of financial performance of the enterprise. Strategic diagnostics and forecasting using controlling data should help management to accurately assess the results of each activity and the trend of their integrated evaluation, weigh each of the signals of both external and internal influences and form the right actions to neutralize risks and threats at an early stage, and identify an effective strategy.

Not only the efficiency of the enterprise but also the guarantee of its survival in modern extremely difficult economic conditions depends on the relevance of determining the company's strategy and systematic application of optimal management decisions based on correct methodological principles and reliable and timely results of systematic control of financial activities.

The use of systematic strategic financial controlling, primarily through the use of the latest methods, algorithms and information tools becomes an integral part of management and the key to the formation of sustainable development of the enterprise.

It is strategic controlling that forms the basis for making effective management decisions by enterprise management to avoid risks and threats. Therefore, systemic strategic financial

controlling today is actually becoming a separate area of financial work related to the management of not only financial and economic activities of the enterprise, but also with defining management actions for all activities of the enterprise in the strategic perspective.

**Literature review.** The issue of diagnostics in the system of controlling the financial results of the enterprise is in the field of attention of scientists. Thus, Reta, et al. [1] used Fishburn's Rule to minimize information entropy in determining a generalized performance indicator. Konsek-Ciechońska [2] studied the features of the use of universal controlling tools for small businesses. Kaplina [3] proposed tools for information support of financial diagnostics. Berdar [4] pointed out that financial controlling should be carried out in the relationship between the components of the overall management system of the enterprise. Sukhanova [5] formed a method of controlling on the basis of existing functional management subsystems for strategic development. Savchuk [6] and Vasechko [7] studied the effects of the crisis on the method for controlling financial results and forming a strategic forecast. Cherevko, et al. [8] defined the system of financial control as an instrument of financial and economic security of the enterprise. Lemishovskij [9] formulated the conceptual basis of financial controlling. Makarenko [10] proposed a system of cost-oriented controlling using the criterion of economic added value. Tarasiuk, et al. [11] points out that strategic management is not possible with-

out consistent and effective analysis and forecasting and offers a set of tools for this. Klychova, et al. [12] points to the correlation between the existence of an effective system of financial controlling and the competitiveness of the enterprise. Shemayeva, et al. [13] proposes a model of cross-optimization of financial and material flows. Akimova, et al. [14] points out the difficulties of strategic forecasting of financial activities of enterprises and suggests the use of benchmarking. Levytska, et al. [15] proposed a model of profit factor analysis that uses direct costing. Pavlova, et al. [16] proposed a method for predicting bankruptcy on the basis of controlling financial results.

**Unsolved aspects of the problem.** Analytical review of literature sources indicates the need for the formation of effective diagnostic methods in the system of controlling financial results, aimed at forming a strategy of the enterprise. There is a search for reliable tools for diagnosing and forecasting the financial activities of the enterprise in crisis conditions. However, the approaches proposed by colleagues are debatable or have some limitations on use. Unfortunately, the available methods of strategic diagnostics and decision-making, mathematical models of existing support and decision-making systems aimed at controlling financial results using strategic diagnostic approaches do not provide results of sufficient reliability.

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**Methods.** General and special methods of cognition were used during the research. The scientific economic approach to the implementation of the method of scientific abstraction was used to substantiate the relevance of the topic, purpose and tasks of the study, analysis of the impact of the use of strategic controlling systems on the financial condition of the enterprise. The method of analysis and synthesis and the method of induction and deduction were used to develop an algorithm for strategic controlling of financial activities of the enterprise. The method of economic modeling was used for a formalized description and strategic forecast of the effectiveness of selected strategies based on controlling data. The method of comparison was used to analyze the pace of financial results and forecast the performance of extractive industries and quarry development by region.

**Results.** The analysis showed a correlation between the company's use of support and decision-making, which, based on data monitoring of financial results using strategic diagnostic approaches, allows finding the necessary management decisions to ensure effective performance and practical results – the formation of appropriate financial stability, solvency, profitability (Table 1). Enterprises that use expert approaches rather than support and decision-making systems have a lower level of these financial indicators.

When forming the methods and models on which the strategic diagnosis should be based, the following should be taken into account:

1. Strategic diagnostics should be based not only on the analysis of financial results of the enterprise but on the complex analysis with research on external factors of influence. According to the results of the analysis, the available financial results only in accordance with the level of external challenges and comparative analysis with the rate of change of indicators of homogeneous enterprises can be interpreted as successful or unsuccessful.

2. The use of a set of data that includes both rational numbers and probable and fuzzy parameters leads to certain difficulties in mathematical formalization and relative error of the analysis results. The relevant result will not be guaranteed without the use of mathematical approaches that unify different scales for measuring the parameters.

3. Management decisions made on the basis of strategic diagnostics in the system of controlling the financial results of

the enterprise should take into account the systematic analysis of the whole set of economic indicators – both those that characterize the quality of production management, in particular, production costs, fixed assets, and others and those indicators that characterize the quality of financial resource management.

Therefore, it was proposed to use an entropy mathematical model in the structure of the algorithm for the implementation of strategic controlling of financial activities of the enterprise (Fig. 1) to assess the effectiveness of management decisions of a strategic nature.

Based on the approaches detailed in the articles of Bazaluk, et al. [17], Nitsenko, et al. [18], Kotenko, et al. [19] and Nazarova, et al. [20] an entropic approach to the analysis of deviations from the basic state of the enterprise was formed for the implementation of strategic diagnostics and forecasting the results of certain management decisions in their complex

$$\mathcal{O}(Q_1, Q_2) = \left\| \| Q_{bs} - Q_1 Q_2 \|_W \right\| = \left\| \hat{Q}_{bs} - \text{vec}(Q_1) \text{ve}(Q_2)^T \right\|_W = \min;$$

$$\{ \text{vec}(Q_1^{opt}) = \sigma_1^2 U(:1); \quad f_i^f \rightarrow \text{opt} \text{vec}(Q_2^{opt}) = \sigma_2^2 V(:1); \\ f_i^f \rightarrow \text{opt};$$

$$Q_{bs} \in \nabla m \times n;$$

$$m = m_1 m_2;$$

$$n = n_1 n_2;$$

$$Q_1 \in \nabla m_1 \times n_1 \quad \text{and} \quad Q_2 \in \nabla m_2 \times n_2,$$

where  $Q_{bs}$  is a set of business strategies (so-called “basic” option) before the moment of decision-making (bifurcation point) conditioned by the achievement of critical values of the relevant parameters. It is a “set” – because it is a complex solution for a group of business strategies, which includes strategies for their individual types  $Q_j$  (Fig. 1), the conditions of which are:  $Q_j \in Q_{bs}$ ;  $Q_j = \emptyset$ ;  $Q_1, Q_2$  are competitive options for business solutions to neutralize risks and threats, from which the best option is chosen;  $m$  is an indicator for each type of strategy;  $m_1, m_2$  are the indicators for the type of strategies of the first and second competitive options for management actions of the enterprise;  $n$  is the number of types of strategies;  $n_1, n_2$  are the number of types of strategies for the first and second competitive options for management actions of the enterprise;  $f_i^f$  is a local set of parameters for  $i = 1 - m(n)$ ;  $W$  is the general matrix (vector) of parameters;  $T$  is the symbol of transposition of vectors by the method proposed by [17].

Since the indicators  $m_1, m_2$  for the type of strategies of the first and second competitive options for management actions of the enterprise  $Q_1, Q_2$  are homogeneous, their comparison is correct regardless of the specific measurement scales.

The limitation of comparison by pairs of variants is introduced because in case of increase in the number of variants by using one-stage comparison, the required reserves of computer resources and calculation time will increase exponentially.

The developed mathematical model is the main part of the block “Estimation of efficiency of a choice of a set of strategic administrative decisions” of the developed algorithm of realization of strategic controlling of financial activity of the enterprise (Fig. 1). This unit is designed to find the best set of management decisions using strategic diagnostics of the enterprise.

A study on a representative group of 27 companies using a systematic approach found out that the strategic assessment of purely financial activities of the company does not provide management with sufficient grounds for the implementation of appropriate management decisions.

For example, a decrease in the investment activity of the enterprise or other financial indicators of the enterprise, in

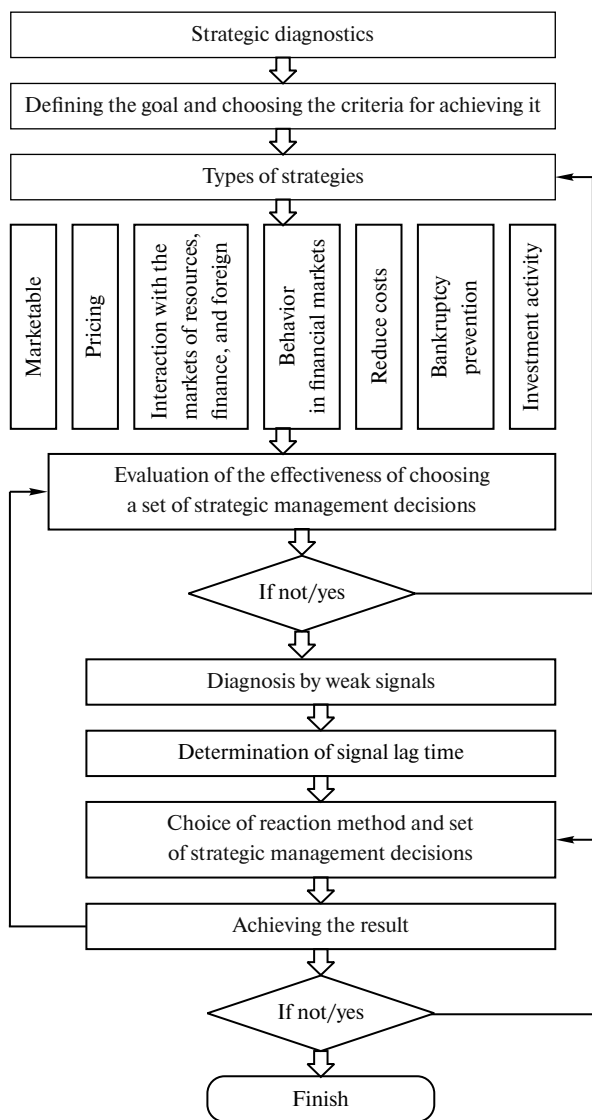


Fig. 1. Algorithm for implementing strategic controlling of financial activities of the enterprise

certain circumstances of sectoral or general economic nature may be justified in terms of maintaining the enterprise in a crisis.

Therefore, controlling the activities of the enterprise using a systematic approach, in our opinion, should, in addition to financial indicators, provide managers with a comparative analysis of the company's position at the market.

As an indicator for comparative analysis of the position of a particular enterprise at the market, it is proposed to use the coefficient of competitiveness of the company (hereinafter abbreviated – CC) – Table 2. The rationale for this is that this indicator shows the position of the studied enterprise relative to a group of other homogeneous enterprises.

This indicator relatively shows the need and effectiveness of certain management actions at the level of a country, region or industry.

The study used the indicators shown in Table 2. The dynamics of changes in the relative values of these indicators with the use of strategic controlling indicates a certain lag in time, which is necessary for the effect of the implementation of controlling to become noticeable.

Table 2 uses the indices – 1 – the first quarter after the introduction of strategic controlling,  $i = 1, 2, 3, \dots$  – the number of the quarter after the introduction of strategic controlling at the enterprise.

The vector of the criterion of financial position (hereinafter – FP) was calculated by the formula

$$\overline{FP} = \sum \overline{a}_n \overline{k}_n,$$

where  $\overline{a}_n$  is a weight vector of the corresponding coefficients;  $\overline{k}_n$  is the vectors of relative indicators of autonomy; solvency; liquidity; efficiency of working capital use. The use of a vector rather than a scalar approach is due to the fact that the criteria are described by matrices if changes in the parameters are dynamic.

The vector of the coefficient of competitiveness was calculated by the formula

$$\overline{CC} = \sum \overline{b}_m \overline{k}_m,$$

where  $\overline{b}_m$  is a weight vector of the corresponding indicators;  $\overline{k}_m$  is the vectors of production efficiency indicators (EP); financial position (FP); efficiency of production activity (EO); product quality (Qt) (Table 1).

Vector  $\overline{EO}$  depends on the relative share of production costs per unit of output; relative rate of return; relative indicator of profitability of goods and relative indicator of labor productivity.

Limit values of the specified vector criteria for acceptance of complex effective administrative decisions for carrying out strategic diagnostics in the system of control of financial re-

Table 1

Analysis of the impact of the availability of strategic controlling systems and information support with the controlling unit on the financial condition of the enterprise

Name of Company	Strategic controlling system	Availability of information support system with controlling unit	Characteristics of financial condition
DP "Eksperymentalnyi mekhanichnyi zavod No.45"	The functions of controlling are combined with the functions of structural units (planning and economic department and finance)	There is no integrated information system with a controlling unit	The company is solvent, insufficiently profitable
DP "Ukrinterenerho"	Controlling functions are performed by employees of various structural units	There is no integrated information system with a controlling unit	The company is solvent, profitable
KP "NVK "Iskra"	Controlling functions are performed by employees of various structural units	There is an integrated information system with a controlling unit	Financially stable, solvent, profitable
TOV "SmartMeritaim Hrup"	Controlling functions are performed by employees of various structural units	There is an integrated information system with a controlling unit	Financially stable, solvent, profitable
TOV "MP "EnerhoMash"	Controlling functions are performed by employees of various structural units	There is an integrated information system with a controlling unit	Financially stable, solvent, profitable

Dynamics of change in relative indicators of the enterprise with the use of strategic controlling

Relative indicators	The weight of the relevant indicator, $a_n$	Quarter					
		1	2	3	4	5	6
Efficiency of production activities ( $EP_1/EP_j$ )	0.15	1	1	1.05	1.06	1.07	1.07
Financial position ( $FP_1/FP_j$ )	0.29	1	1.05	1.07	1.15	1.25	1.32
Efficiency of production activities ( $EO_1/EO_j$ )	0.23	1	~1	~1	~1	~1.01	~1.01
Production quality ( $Qt_1/Qt_i$ )	0.33	1	1	1	1	1.01	1.01
Value of results for use and without the use of strategic diagnostics	–	1	1.01	1.02	1.03	1.04	1.05
Coefficient of competitiveness ( $CC_1/CC_i$ )	–	1	1	1.01	1.03	1.07	1.11

sults of activity of the enterprise should be accepted expertly.

These threshold values of the criteria are not constant over time and are adjusted by comparative analysis with similar enterprises.

The next stage of forming a strategic forecast to identify areas of strategic diagnosis in the system of controlling the financial performance of a particular enterprise is forecasting for the industry to which the company belongs, and the administrative region where the company is located.

An integral part of this stage is a comparative analysis of the results of forecasting and identifying trends in the indicators of the studied enterprise in relation to the group of related enterprises for the region where the enterprise is located and the industry to which it belongs.

For practical testing of this approach using the time series method, a forecast was made for the extractive industry and quarrying in Kyiv, Mykolaiv and Odesa regions of Ukraine while analyzing the results of the implementation of systemic strategic controlling activities at the enterprises of these regions. This study was based on the use of government statistics according to regions.

Kyiv, Mykolaiv and Odesa regions of Ukraine were chosen because they are characterized by a relatively smaller number of enterprises related to the extractive industry and quarrying than in the leading regions of this industry, which reduces the relative forecasting error.

For Kyiv region analytical equation for the forecast is

$$y = -13.227x^3 + 200.27x^2 - 646.25x + 1154.5.$$

For Mykolaiv area the analytical equation for the forecast is

$$y = 0.6021x^4 - 7.2456x^3 + 3.0903x^2 + 293.23x - 46.418.$$

For Odesa region the equation has the form

$$y = 2.0655x^2 - 2.2798x + 46.389.$$

The proposed method allows not only analyzing the comparative state of mining and quarrying, their financial results by region but also identifying correlations between the share of enterprises in these areas where systemic strategic controlling is implemented, with varying degrees of effectiveness, (respectively, ~ 58; ~ 32; ~ 17 %) and the results of their activities.

A formalized indicator for comparing the activities of mining enterprises and quarrying is the importance of the pace of dynamics of financial results of enterprises in the industry by region.

For comparison, the linearization of these financial results for the period 2020–2022 was carried out.

The slope ratios (i.e. growth rates) of linearized forecasts of financial results from the sale of extractive industry products and quarry development in Kyiv, Mykolaiv, Odesa regions are 157.45; 89.8; 18.85 respectively.

That is, the growth rate of financial results from the sale of mining products and quarrying in Kyiv region is 8.35 more than the corresponding figure in Odesa region. This, to some

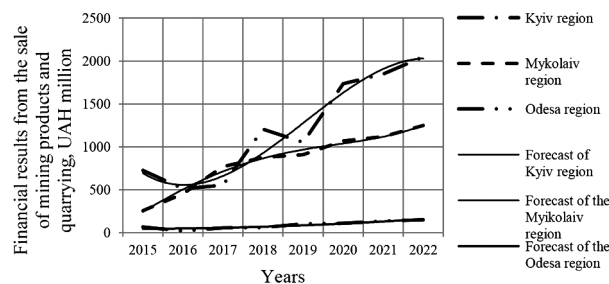


Fig. 2. Financial results from sales of products and forecast data of the extractive industry and quarrying by regions of Ukraine, UAH million

extent, characterizes the effectiveness of the implementation of strategic diagnostics in the system of controlling the financial performance of enterprises in the industry in these regions.

**Conclusions.** A mathematical model and approaches using the entropy method and the time series method were created to compare options for integrated application of management decisions for the formation of optimal management actions on the basis of strategic diagnostic data.

These mathematical models are part of the unit for evaluating the effectiveness of the choice of a set of strategic management decisions of the proposed algorithm of strategic diagnostics in the system of controlling the financial results of the enterprise.

The proposed vector criteria, their rate of change detected during the controlling, and their threshold values become an indicator that the current financial and production condition of the enterprise requires decisions to neutralize risks and improve the financial condition of the enterprise.

The study on the dynamics of changes in the relative performance of enterprises indicated a certain lag in time between the use of system controlling and the first results of its implementation.

Practical testing of the proposed approach allowed making a forecast for the extractive industry and quarry development for Kyiv, Mykolaiv and Odesa regions of Ukraine. The results are formalized in the form of polynomial equations for each region.

Further interval linearization of polynomials allowed establishing the pace of change in financial results and establishing a connection between them and the introduction of systematic strategic controlling of activities at enterprises of the extractive industry of these regions. This allows us to conclude that it is necessary to modernize the system of financial management of extractive industries and the development of quarries in Odesa region.

The results of the introduction of systemic strategic controlling activities at the enterprises of the extractive industry are supported by a selective analysis of the impact of the introduction of strategic controlling and information support systems with the controlling unit on the financial condition of enterprises in other industries.

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## Стратегічна діагностика в системі контролю фінансових результатів діяльності підприємства

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**Мета.** Створити математичну модель і підходи для формування оптимальних управлінських дій на базі даних стратегічної діагностики та за їх використання сформувати ефективний алгоритм стратегічної діагностики в системі контролю фінансових результатів діяльності підприємства.

**Методика.** Під час проведення дослідження були застосовані загальні та спеціальні методи пізнання. Науковий економічний підхід за реалізації методу наукової абстракції було застосовано для обґрунтування актуальності теми, мети й завдань дослідження, аналізу впливу використання систем стратегічного контролю на фінансовий стан підприємства. Метод аналізу й синтезу та метод індукції й дедукції застосовано для розробки алгоритму стратегічного контролю фінансової діяльності підприємства. Метод економічного моделювання – для формалізованого опису та стратегічного прогнозу ефективності обраних за даними контролю стратегій. Метод порівняння – для аналізу темпів фінансових результатів і прогнозування результатів діяльності підприємств добувної промисловості й розроблення кар'єрів за областями.

**Результати.** Розроблена математична модель і підходи з використанням методу ентропії та методу часових рядів для порівняльного аналізу варіантів комплексного застосування менеджментом рішень для формування оптимальних управлінських дій на основі даних стратегічної діагностики. Створено алгоритм стратегічної діагностики в системі контролю фінансових результатів діяльності підприємства. Запропоновані векторні критерії, темпи зміни яких, виявлені під час проведення контролю, та їх граничні значення стають індикатором того, що наявний фінансовий і виробничий стан підприємства потребує прийняття рішень задля нейтралізації ризиків і покращення фінансового стану підприємства.

**Наукова новизна.** Запропоновані математична модель і підходи вперше використані для аналізу напрямів стратегічної діагностики в системі контролю діяльності підприємства. Уперше запропонована система векторних критеріїв для визначення необхідності прийняття управлінських рішень для покращення фінансового стану підприємства. Упроваджено алгоритм реалізації стратегічного контролю фінансової діяльності підприємства.

**Практична значимість.** Розроблений алгоритм і математичний апарат може бути використаний як у наукових цілях, так і у практичній роботі менеджментом підприємств різних галузей. Результативність розроблених математичних методів і запропонованого алгоритму перевірена на прогнозуванні діяльності підприємств добувної промисловості та розробки кар'єрів для Київської, Миколаївської та Одеської областей України.

**Ключові слова:** стратегічна діагностика, контроль, фінансові результати, математична модель, прогнозування

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