“Management and modelling of the industrial enterprise’s crisis situations”

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MANAGEMENT AND MODELLING OF THE INDUSTRIAL ENTERPRISE'S CRISIS SITUATIONS

Abstract

In conditions of national economy's unstable development, the primary task of the enterprise internal management is to timely assess and predict the effects of external fluctuations on the state of the enterprise and to develop effective management decisions. The article aims to develop the methodological approach, which, based on a set of models for recognizing an artificial crisis or localizing a natural crisis, allows the crisis management of an enterprise considering its resource capabilities and stage of the life cycle as the interaction of system-forming spheres of life, namely production, financial, and labor. The practical value of the approach consists in developing a system of econometric and cognitive modeling models that allows developing a set of managerial decisions that are adaptive to external and internal fluctuations for localizing a natural crisis or recognizing an artificial crisis. The methodological approach was implemented at Ukrainian industrial enterprises. As the results of the study, several different scenarios of solutions for crisis management of the enterprise were obtained.

Keywords methodological approach, enterprises, sphere of activity, cycle of development, point of crisis, cognitive model, impulse, management decision

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INTRODUCTION

The contemporary state of the Ukrainian economy combines the contradictory processes of forming the transforming and competitive market structures, economic relations, and interests that lead to the emergence of crisis phenomena. In the conditions of world market non-stationary development and the national economic downturn, the majority of national economic entities were in crisis.

So, for 2010–2018, the largest number of unprofitable industrial enterprises was recorded in 2010 and amounted to 41% of the total number of enterprises in the country's economy. The period 2011–2014 was also characterized by high percentage of unprofitable enterprises; on average, every third business entity was unprofitable. Since 2015, the country has developed a positive trend for the gradual reduction of unprofitable industrial enterprises. So, in 2018, their number amounted to 24.8%, which is 39% less than in 2010. The share of unprofitable enterprises in January-June 2019 amounted to 24.9%. This trend is associated with an increase in production in some industrial sectors; in particular, improvements were noted in coke production (growth of 9.8%). However, although there are successes in mechanical engineering (growth by 0.4%), they are insignificant.

In many cases, the activities of industrial enterprises remain unsatisfactory, because their management cannot adapt its management style to new business conditions, which does not allow timely using

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the adequate methods in crisis management. As a result, there is a real need to develop and apply new approaches and tools to manage the enterprises under specific conditions, particularly in crisis. In crisis management, a management strategy should play a decisive role, in which main attention should be paid to the problems, directions, and ways of getting out of the crisis, which is connected with the search and elimination of the reasons. To do this, a permanent analysis of the enterprise's external and internal environment is necessary to identify the factors that affect these environments and, based on assessing the enterprise's real and potential capabilities, to determine the causes of the crisis.

In this regard, the analysis of the main trends and factors of industrial enterprises development, including machine-building ones, in the conditions of their functioning in an unstable external environment, becomes increasingly relevant. There is an urgent need for crisis management of machine-building enterprises based on forming the achievable scenarios of their further development that are adaptive to fluctuation changes. Overcoming the crisis will allow to continue the life activity of the enterprise, to ensure its revival at the same or higher level of organization and efficiency. Violation of cyclicality (non-exit from a crisis) leads to the cessation of its activity as a business entity.

1. LITERATURE REVIEW

The study of approaches to crisis management of an industrial enterprise is today an urgent research problem. In order to eliminate or avoid crisis situations at the enterprise, domestic and foreign scientists suggest using various approaches based on the need to adapt the enterprises to the effects of the internal and external environment, the need to understand the priority impact of the external environment and the formation of enterprise's crisis management system.

Currently, there are various approaches to interpreting and understanding the definition of crisis, as well as assessing its impact on the enterprise's activity. So, according to Deloitte (2018), crises can have devastating consequences for enterprise's financial performance, employee morale, sales, and reputation. In order to maintain the current state of enterprises' operation, it is necessary to prioritize the identification and prevention of crises, as well as to manage them, to show their full range of competencies in the conditions of extreme crisis elimination, to involve management and board members in preparing the crisis plan and in crisis modelling. Scientists believe that it is necessary to start managing the crises before they occur. The authors argue that the ability to prevent a crisis can be strengthened by looking at the entire life cycle of a crisis, and not just about readiness and reaction. Crisis management should not start with a crisis. At this point, it may be too late to avoid most of the damage.

In the case of the greatest success, crisis management is a continuous activity that begins with assessing internal and external data that can signal potential changes or conflicts in the organization's environment. It is imperative to overcome any bias so that the board of directors and senior management carefully examine the risks – even those that they believe are unlikely to occur. In fact, if leaders believe there are certain types of crises that they will never face, this is probably a good place to start (Deloitte, 2018).

According to Bénaben (2016), the crisis was considered as a violation of the state of the system, which reveals the instability and discontinuity, and requires a special approach to eliminate the unwanted effects and obtain a new acceptable state of the system. Besides, he examines the concept of "crisis management" from a functional point of view. In order for crisis management to be effective, it is necessary to determine the goal, achieve the goal (given that it is not because the scheme of the response correctly describes that it will be done), and support the goal (considering also that the crisis could develop the response and it might not have the expected consequences) (Bénaben, 2016). This approach to crisis management only determines its functional structure and identifies the information flows. This functional structure is an abstract and global view of crisis management: it represents the formal and actual computerized system designed to effectively support the crisis management and to provide decision-makers with the decision-making support system.

As a representative of the Polish school of crisis management, Walecka (2016) emphasizes that a crisis in an enterprise is an extremely difficult situation, which enterprise managers need to deal with. The enterprise may take all kinds of remedial actions. Ranging from conservative measures, through moderate to very radical ones, the author had proposed steps that may aim at counteracting the effects of the past or focused on looking towards the future of the organization.

The type of actions that managers take depends on many factors discussed in the paper. These factors result from the organization's external and internal environment, the nature of the crisis, as well as the manager's personality. The paper proposes an original model of determinants of managers' behavior in a crisis (Walecka, 2016).

Because of the crisis, Tuhan-Baranovskyi (1894), Belyaev and Korotkov (2011), Cherniavskyi (2000), Hryhorieva and Mishchenko (2000) divide crises into two types: artificial one occurs as a result of human activity or inactivity in socio-economic systems, and natural one – through human activity or inactivity in the natural environment (or without its involvement through irreversible natural disasters and phenomena that are formed regardless of human activity) (Gorokhova & Sereda, 2012; Rayevnyeva, 2006; Belyaev & Korotkov, 2011; Chernyavskiy, 2000).

Some researchers believe that the effectiveness of enterprise's crisis management depends on creating the effective systems for monitoring the enterprises' activities. So, Zahurskyi and Pohorila (2018) note that the creation of a system of value-based indicators with subsequent monitoring of the enterprise's value allows us to predict and minimize the negative consequences of the crisis. Value-based indicators, as tools for financial analysis, give an idea of the level of enterprise's financial stability in crisis (Zahurskyi & Pohorila, 2018). The authors emphasize that the use of value-based indicators can be considered an innovative approach to the crisis management of enterprises. However, they, should not be considered only as tools for analyzing a crisis financial condition and enterprises' activities. To get the maximum effect from their use, they should be implemented in an integrated crisis management system, that is, in the system of strategic and operational planning, motivation, analysis, and control.

Modern researchers pay much attention to the modification of crisis management tools for the enterprise. For example, Tena-Chollet, Tixier, Dandrieux, and Slangen (2017) proposed a design methodology based on seven stages for modeling a semi-virtual learning environment for crisis management, which includes environment specification, user specification, kernel design (multi-agent system), scenario modeling, training modeling, evaluation of system participants, methods and models necessary for crisis management. They proposed a new approach to training in crisis management and proposed a set of specifications for designing a semi-virtual environment, which can then be easily applied to a real situation. They argue that based on modeling in crisis management, it is first necessary to identify the models, scenarios, unexpected events, synchronized processes, the role of leadership, procedures, decisions, consequences, indicators, factors, and specific infrastructure.

Chebashkina and Nikonova (2017) considered that the specificity of management in the sphere of entrepreneurial activity in the conditions of crisis consists in the necessity of complex decision-making at a high degree of risk and with limited funding. In order to timely prevent and overcome the crises, it is necessary to use complex methods of economic analysis and forecasting, to develop special crisis plans and programs, to distinguish between internal and external factors, and to determine the causes of the crisis. The authors propose to carry out a comprehensive analysis of all parameters and indicators that allow drawing a general picture of the enterprise in the external environment. However, they say that every crisis brings new business opportunities, with the result that it either changes or disappears. To constantly evolve, it is necessary to effectively use crisis management (Chebashkina & Nikonova, 2017).

Haida and Zaplatynskyi (2017) show that the use of innovations in crisis management is possible in two aspects: innovation as improvement activities relating to crisis management and innovations used to meet the challenges to emerge from the crisis. Based on the analysis, the authors created

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a list of possible areas of enterprises' innovation activities, the crisis of which has arisen because of natural, social, or military man-made emergencies. They analyzed the war as the source of the crisis for enterprises and the state, and showed that the state, in which military operations are going on, needs to move from conventional management to crisis management (Haida & Zaplatynskyi, 2017).

In reviewing the presented developments, it should be noted that researchers understand the necessity of crisis management in the behavior management of the enterprise, consider certain aspects and manifestations of crises. This is a good sigh, as a detailed examination of these crises on individual spheres of life helps the enterprise to get a unique, but specific knowledge about the course of the crisis processes. However, system performance does not grow.

When developing and complementing the existing approaches to crisis management of the enterprise, the proposed methodological approach differs in that it is based on a systematic approach to understanding the crisis processes based on evaluating the system-forming main spheres of the enterprise and localization of natural and artificial crisis by the stage of the enterprise's business cycle development of allows making effective management decisions on the localization of the crisis taking into the resource capabilities of the enterprise.

Management of natural and artificial crisis is significantly different, which is associated with the enterprise's resource capabilities. The study proposed that the negative stage in the enterprise's business cycle determines a natural crisis. This stage is characterized by a significant reduction in the enterprise's resources determines a natural crisis, especially financial, and, as a result, the inability of the enterprise's management to quickly respond to negative processes in the external and internal environment. In contrast to this, only the positive stage of the enterprise's business development cycle can provoke an artificial crisis. Its goal is to maintain the enterprise's sustainable development through various reengineering measures (for example, changing the enterprise's organizational structure, adjusting the contracts with suppliers, changing the production factors, etc.), which undoubtedly requires additional resources.

2. AIMS

The article aims to develop a methodological approach, which, based on the generated complex of models for recognizing an artificial crisis or localizing a natural crisis, allows the crisis management of an enterprise, taking into account its resource capabilities and stage of the life cycle.

3. RESEARCH METHODOLOGY

The studies enabled to conclude that industrial enterprises, in particular, machine-building enterprises, are greatly influenced by the uncertainty of the external environment, which is inherent in the modern stage of national economy development and which provokes an increase in the instability of all business entities' functioning. Therefore, an important task of enterprise management is to develop the effective tools, in particular, methodological approaches, to manage its development, which can enhance the enterprise's adaptive properties by increasing the efficiency of using its internal potential based on the use of a reasonable set of modern economic and mathematical methods and models. The developed methodological approach used the methods of content analysis, benchmarking, system-structural analysis, taxonomy methods, econometric impulse, and cognitive modeling. This combination of methods allows managers to analyze the dynamics of changes in processes in the current and future periods, as well as form various scenarios for the enterprise's development.

The analysis of such literature sources as Avdeyeva, Kovryga, and Makarenko (2006), Buryi and Matsekha (2006), Gorokhova and Sereda (2012), Hryhorieva and Mishchenko (2017), Rayevnyeva (2006), Gerchikova (1995) enabled to identify the main economic problems that require mathematical modeling of complex systems operation, in particular that of machine-building enterprises:

- obtaining a reliable forecast of the system's future behavior;
- identifying the reasons for a change in the system behavior;

Source: Compiled by the authors based on the study of crisis phenomena.

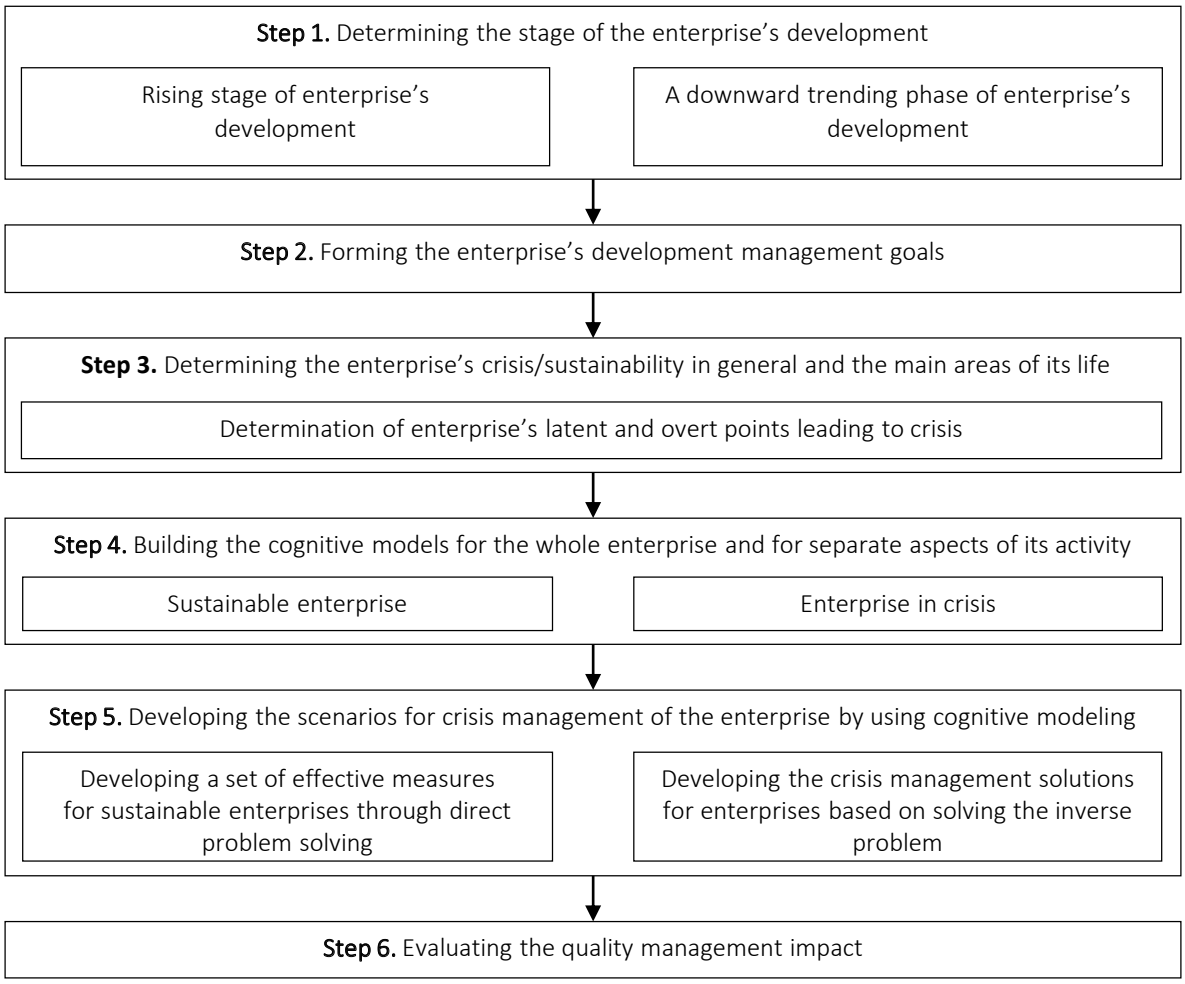

Figure 1. Methodological approach to developing the scenarios for crisis management of the enterprise

- searching for effective states of the system, which counteracts the crises;
- ensuring the system viability in various degrees of external environment aggressiveness.

The developed methodological approach to crisis management of an industrial enterprise enables to solve these problems (see Figure 1).

4. RESULTS

Let us consider in more detail the stages of the methodological approach development and the results of their implementation at the industrial enterprises of the Kharkiv region.

Step 1. Determining the stage of the enterprise's development. At this stage, it is envisaged that it is possible and necessary to make adequate management changes at the enterprise taking into account its potential and real resources.

The research is based on two types of industrial enterprises:

1) sustainable enterprise – JSC "Finprofil";
2) enterprise in crisis – JSC "Harverst."

The changes significantly depend not only on the enterprise's capacity but also on the effectiveness of its usage, i.e., on the actual resources of the enterprise, which directly depend on the stage of its

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development. Therefore, the research task is to recognize the stages of the enterprise's life cycle, namely:

1. The upstream stage of the enterprise's development is characterized by stable positive dynamics of economic activity indicators, strong competitive positions, stable financial position, investment attractiveness, significant opportunities for expansion of activities and innovative development. But the stable development of an enterprise does not in any way mean that changes to the enterprise are not needed.

As it is evident from the "golden rules of management" formulated by Peters (1982), first of all, it is necessary to change what works well because it is here that forces can be mobilized immediately. In this case, it is about permanent proactive innovative changes that should concern all spheres of the enterprise's activities.

Such changes should be oriented to the future, in fact, they are strategic, proactive, and revolutionary. Their composition should be limited by the enterprise's available resources, and they relate to certain spheres of its life activity.

2. The descending stage of the enterprise's development is characterized by low level of resource usage productivity, unsatisfactory indicators of the financial state, decrease in the volume of economic activity, chronic loss-making, which requires the introduction of sanation measures. In this case, changes should certainly be carried out, but they should be aimed at enterprise's sanation, which provides for the improvement of the enterprise state and it's getting out of the crisis or the localization of negative phenomena. Such changes should be operational and reactive, as they are associated with immediately solving the problems at a minimal cost (Bozhko, Balychev, A. Batkovskiy, & M. Batkovskiy, 2013).

Stage 2. Forming the management objectives for enterprise's development. This stage provides for the formation of the enterprise's development goals and depends on the stage of the life cycle. If the enterprise is at a descending stage of development, the purpose of managing its development is to develop a set of solutions for localizing the crisis and refracting negative trends; if the enterprise is at an ascending stage of development, the goal is to create an artificial crisis to strengthen the positive development vector of the enterprise in the future.

Stage 3. Defining the crisis/sustainability of the enterprise's development in general and the main spheres of its life activity. This stage is devoted to selecting a global direction for developing a set of management decisions for the enterprise's development by creating an artificial crisis and managing the natural crisis (Rayevnyeva & Gorokhova, 2010).

If the enterprise is at a descending stage of development, that is, it is in crisis, then when developing a set of management solutions, it is proposed to solve the inverse problem of cognitive modeling. If it is necessary for the enterprise to remain at the ascending stage of development, that is, to continue the sustainable development, it is proposed to solve the direct problem of cognitive modeling.

The content of the direct and inverse problem of cognitive modeling consists of the following:

1) the solution of the direct problem provides for the control effect (increase or decrease of the corresponding indicator) on the input factors – indices of the spheres of the enterprise's vital activity for changing the target factor – the integral indicator of the enterprise's development;

2) the solution of the inverse problem assumes the calculation in reverse order from the target factor to the input factor, that is, developing a set of management decisions on the model: "what needs to be done today to achieve the desired result in the future."

Stage 4. Building the cognitive models for the enterprise in general and its spheres of activity. This stage provides for the formation of a complex of cognitive models, which are considered as a tool for making the effective management decisions based on the building the scenarios for the enterprise's development. It is proposed to use the index for analyzing the behavior and further development of the enterprise as an integral indicator both for the enterprise as a whole and for its separate spheres of life

activity. Therefore, the criterion for the quality of managerial influences on the enterprise's development is the change in the value of the integral indicator of enterprise's development as a whole.

For quality management, it is necessary to have an objective idea of the dynamics of indicators that facilitate or hinder their circulation. All this information must be embedded in the cognitive map and model. The cognitive map reflects the functional structure of the situation in question since a change in the value of any factor in the situation leads to a range of changes in values associated with it. This spectrum of changes is called the impulse process in the cognitive map and allows obtaining forecasts for the situation development.

The formation of the cognitive map includes three main stages (Gorokhova & Sereda, 2012):

- building a hypothetical cognitive map (generating a hypothesis about the functional structure of the situation);
- verifying the cognitive map (verifying the likelihood of the hypothesis about the functional structure of the situation);
- correcting the cognitive map (functional structure) of the situation.

An example of a cognitive map on the financial sphere of life (financial, industrial, and labor) is presented in the form of an oriented sign graph (Chernyavskiy, 2000), in where the vertices of the graph are the indices for each sphere, and the arcs between the indicators are the cause-effect relationships between them.

The cognitive map of the enterprise's development as a whole is presented in the form of an oriented graph, where the integral indicators on the spheres of life activity of an industrial enterprise act as vertices.

The calculated reflection of the cognitive map is the cognitive model, the main tasks of which are:

a) formulating the task and purpose of the study;

b) collecting, systematizing, analyzing the existing statistical and qualitative information on the problems;

c) identifying the factors characterizing the problem situation;

d) highlighting the basic (main) factors that describe the nature of the problems;

e) determining the factors influencing the target factors;

f) grouping the factors into blocks (the factors that characterize this sphere of the problem and the processes in this sphere are united in one block);

g) determining the relationship between factors (determination of the relationship between the blocks of factors). This enables to determine the main directions of the influence of different blocks factors on each other;

h) determining the linkages – factors in the middle of the block: determination of influence direction between the factors; determination of the impact nature (positive or negative);

i) determining the factors' influence degree;

j) determining the relationship between the factors of different blocks.

Thus, the cognitive model is a structure of cause-effect relationships between the elements of the studied system and its environment, which reflects the views of the individual or group of individuals on the structure and functioning of the system.

In management processes, it becomes necessary to make decisions in weakly structured dynamic situations, when parameters (values of variables), laws, and patterns of situation development are described qualitatively. These are situations where the dynamics of the situation parameters is accompanied by changes in its structure, which are difficult to predict. One of the directions of cognitive methods practical application is developing a set of scenarios for modeling the trends in the development of a problematic situation based on selected control factors that are created about various plans and development forecasts. It is proposed to compile the scenarios of two types:

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1) scenarios for modeling the trends of the self-development environment;

2) scenarios for modeling the trends in the managed development of a problem situation, about changes in the characteristics of the external and internal environment.

Stage 5. Developing the scenarios for crisis management of an enterprise by using cognitive modeling. At this stage, based on the results of the constructed cognitive models, the results are analyzed by using the developed diagnostic scales for the areas of the enterprise's life for sustainable enterprises and enterprises in crisis. Based on the findings, scenarios are developed to achieve the goal of managing the enterprise's development in crisis, depending on the stage of its life cycle.

The construction of scenarios is based on two hierarchies:

1) class of enterprise: sustainable and in crisis;

2) stage of the business cycle of enterprise's development: ascending and descending.

Management decisions for crisis management of an enterprise are based on impulse impacts on the cognitive model.

The statements that underlie the complex building of crisis management scenarios for the enterprise are as follows:

1) impulse actions in the cognitive model have the content of a well-founded definition of the values of those indicators influenced by the solution of the direct and inverse problem;

2) impulse actions should correspond to resource opportunities of the enterprises according to a stage of their business cycle;

3) scenarios providing for a direct solution of the problem of cognitive modeling should contain impulsive effects on the baseline indicators in the spheres of life activity;

4) scenarios providing for the solution of the inverse problem of cognitive modeling should determine the value of the initial indicators, allowing to reach the required value of the target – the integral indicator of the enterprise's overall development.

Since the first and the second classes of enterprise are diametrically different in their resources, the following scenarios of enterprise's development management are proposed (Table 1).

When using the scenarios within a sustainable enterprise, the following objective of management is achieved: localization of crises, changing the stage of the enterprise's business cycle from descending to ascending. When using the scenarios within an enterprise in crisis, the goal of management is to support/strengthen the ascending vector of the business cycle of enterprise's development.

Table 1. Business management scenarios

Source: Compiled by the authors based a study of literary sources.

The class of enterprise	Management scenarios
Sustainable enterprises	**Scenario 1.** The general tendency of the enterprise's development and system-forming spheres of its life activity is characterized by an ascending stage of a business cycle of the enterprise's development that testifies the sufficiency of its resource base for management innovations. There is a positive or stable dynamics of the main indicators of the enterprise's activity, the revival of business activity, the strengthening of competitive positions. Management impacts are directed to the latently weak sphere of the enterprise's life activity, which has the lowest growth rates of the integral indicator
	Scenario 2. The general enterprise's development is characterized by an ascending stage of development and the availability of a sufficient resource base, but one of the spheres of its life activity is at a descending stage. Management actions should be directed to the last one
Enterprises in crisis	**Scenario 3.** It is characterized by a downward stage of enterprise's development, a lack of resource development opportunities, which is manifested in the insolvency of the enterprise, a negative dynamics in the reduction of the basic performance indicators, the decrease in the volume of products sold, and the lack of potential and available resource opportunities. Management actions should be directed to all spheres of the enterprise's life activity for a systemic crisis elimination

Based on the above scenarios (Table 1), an algorithm was developed in order to form the impulse actions, which is shown in Figure 2.

Source: Compiled by the authors based on cognitive modeling.

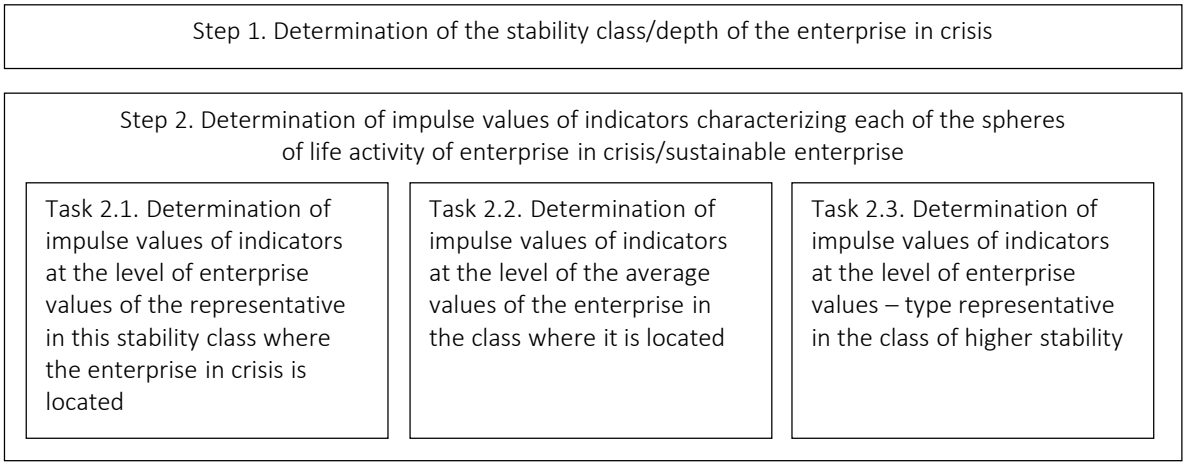

Figure 2. Algorithm for impulse actions formation

Thus, the methodological approach for crisis management of an industrial enterprise consists of the phased decision-making to localize a crisis or create the scenarios for managing the enterprise's development aimed at developing the management innovations to strengthen the positive vector of enterprise's development.

The formed managerial influences are complex, systematic, and aimed at using the full potential of modern management, developing and implementing a special strategic program at the enterprise to create conditions for supporting or forming an ascending vector of industrial enterprise's development.

Stage 6. Assessing the management impact quality. At this stage, management decisions are assessed based on cognitive modeling.

Provided that the integral indicator of the enterprise's overall development reflects the behavior of all spheres of enterprise life, it is proposed to use it as an indicator for assessing managerial influences effectiveness. The value of this indicator is normalized and varies in the range [0; 1], therefore, the criterion for the quality of managerial influences is an increase in the value of this indicator after impulse impacts on the cognitive model.

One of the main components of this methodological approach (Figure 3) is the development and implementation of the cognitive model, which aims to develop a set of crisis management scenarios for industrial enterprises, which will enable to adjust or maintain the actual development vector of an industrial enterprise in accordance with the planned one.

The implementation of the proposed methodological approach consists in developing the cognitive maps for the spheres of life activity for each type of enterprise, which is the basis for experiments aimed at implementing the scenarios for enterprise's development and testing the models for adequacy.

Scenarios of crisis management of enterprises were formed for two types of enterprises – sustainable enterprise and enterprise in crisis.

According to the results of the study, JSC "Finprofil" is at an ascending stage of development (Figure 3) in the class of normal stability, therefore, management impacts will be directed to the latently weak sphere of life activity, that is, the sphere of finance, in order to strengthen the ascending vector of this enterprise development.

As impulse values of the initial indicators for solving the direct problem of cognitive modeling, the values of the indicators of the enterprise, representing type in the class of normal stability, are established.

Table 2 presents the results of cognitive modeling for crisis management of sustainable industrial enterprise.

Thus, when solving the direct problem of cognitive modeling for sustainable enterprise JSC "Finprofil,"

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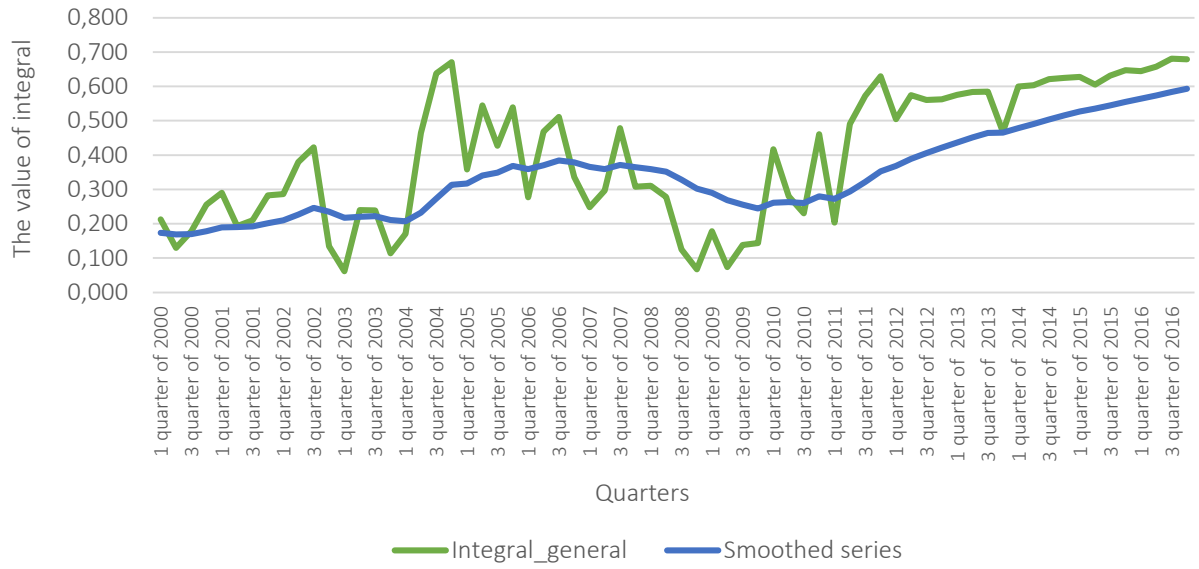

Figure 3. Initial and smoothing values of the integral indicator of the JSC "Finprofil" overall development

the best result is an increase in the integral index for the financial sector by 1.31%, provided 1.02% decrease in the debt ratio; reduce the current debt ratio by 0.85%, increase the long-term financial independence ratio by 0.6%; increase the return on equity by 0.33%; increase the coefficient of supply of reserves and costs by own circulating assets by 0.76%; increase the turnover ratio of accounts payable by 1.3%.

The results of solving the direct problem of cognitive modeling confirmed that management impacts are effective because the value of the integral indicator of the enterprise's overall development increases and reaches the value of IF = 0.332.

JSC "Harverst" is at a descending stage of development, namely, in the state of the middle class of the crisis (Figure 4).

Table 2. The results of cognitive modeling for sustainable enterprise JSC "Finprofil"

Source: Compiled by the authors.

Index	Input value	Present value	Output value	Consonance
Coefficient of financing	–	0.061	Does not change	Reliable (1)
Debt ratio	Reduced by –1.02%	0.062	Reduced by –1.02%	Reliable (1)
Coefficient of current debt	Reduced by –0.85%	0.059	Reduced by –0.85%	Reliable (1)
Coefficient of long-term financial independence	Increases by 0.65%	1.702	Increases by 0.6%	Reliable (1)
Coefficient of provision of stocks and costs with own circulating assets	–	1.957	Increases by 0.76%	Reliable (1)
The coefficient of financial independence of capitalized sources	–	0.879	Does not change	Reliable (1)
Coefficient of current liquidity	–	8.491	Increases by 0.91%	Reliable (1)
Coefficient of maneuverability	Increases by 0.31%	0.658	Increases by 0.86%	Reliable (1)
Profitability of equity capital	Increases by 0.33%	0.562	Increases by 0.33%	Reliable (1)
Return on permanent capital	Increases by 0.31%	0.674	Does not change	Reliable (1)
Coefficient of capital turnover	–	1.984	Increases by 0.26%	Reliable (1)
Coefficient of turnover of own capital	Increases by 0.45%	2.308	Does not change	Reliable (1)
Accounts payable turnover ratio	Increases by 0.3%	78.187	Increases by 1.3%	Reliable (1)
Coefficient of investment	Increases by 0.17%	2.978	Increases by 0.34%	Reliable (1)
Integral finance (Ifin)	–	0.254	Increases by 1.31%	Reliable (1)

Source: Compiled by the authors.

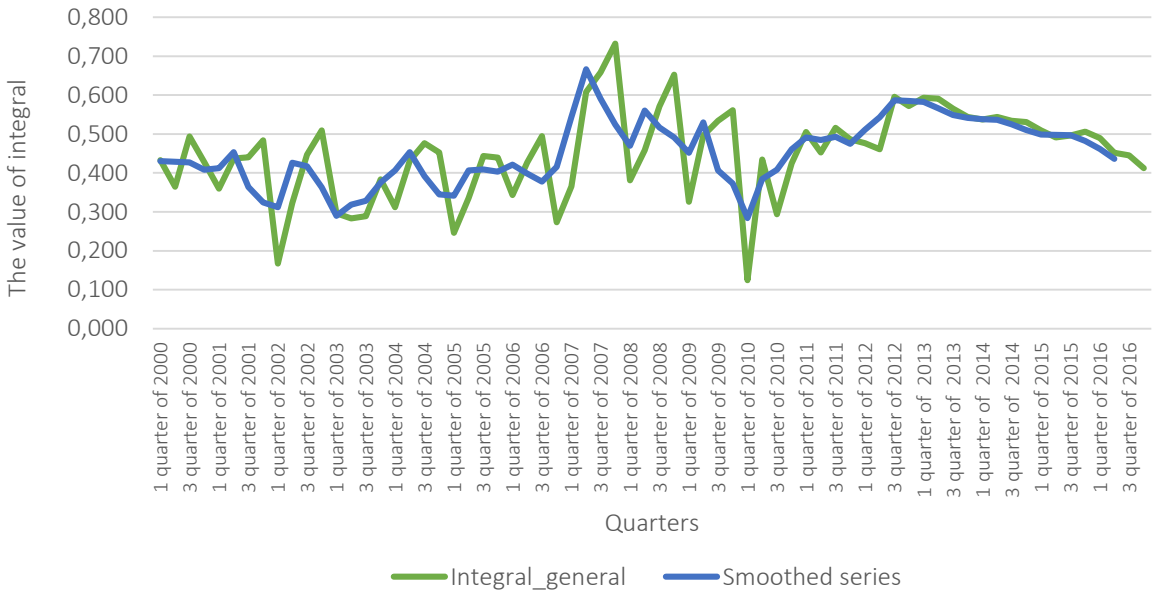

Figure 4. Initial and smoothing values of the overall development index of JSC "Harverst"

For JSC "Harverst" to change its vector of development from top to bottom, it is proposed to solve the inverse problem of cognitive modeling, that is, to direct the control effect on the overall indicator of enterprise's development, and then on the spheres of its life activity.

In order to solve the inverse problem, it is essential to determine the value of the desired growth (momentum) of the enterprise's overall development indicator, which should correspond to its resource capabilities. For this purpose, the Hurst index is used, which allows checking the dynamic range of the integral indicator for the presence of long-term memory. If the value of the indicator changes within 0.5-1.0, then the impulse values should be formed based on the determination of the average values of the indicators that reflect the specifics of the enterprise is development in the past; if the value of the Hurst index varies within the limits from 0 to 0.5, then impulse actions are proposed to be determined based on methods of economic dynamics.

Since Hurst index H = 0.896, this indicates that during the analyzed period, the overall integrated indicator of the machine-building enterprise JSC "Harverst" development can be attributed to a persistent series, that is, to a series that has a long-term memory.

Thus, the value of the pulse per integral index should be formed from the average values of its growth over certain periods.

Analyzing the dynamic series of the integral indicator of machine-building enterprise JSC "Harverst" overall development, two development stages can be distinguished:

1) the ascending stage of development – from the 1st quarter of 2000 till the 3rd quarter of 2007 (Figure 4);

2) the descending stage of development – from the 4th quarter of 2007 till the 4th quarter of 2016 (Figure 4).

To determine the impulse effects, it is proposed to use the average growth rates of the total integrated indicator for each stage of an industrial enterprise's development:

1) scenario – at a descending stage of development;

2) scenario – at an ascending stage of development.

Table 3 presents the results of cognitive modeling for solving the inverse problem.

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Table 3. Result of solving the inverse problem for JSC "Harverst"

Source: Compiled by the authors based on the results of cognitive modeling.

Indicator	Input value	Present value	Output value	Consonance
Scenario 1				
Integral finance	–	0.597	Increases by 2.56% (0.612)	Reliable (1)
Integral production	–	0.202	Increases by 1.24% (0.205)	Reliable (1)
Integral labor	–	0.420	Increases by 1.01% (0.424)	Reliable (1)
Integral_general	(Purpose) increase the value by 1.19%	0.412	0.417	Reliable (1)
Scenario 2				
Integral finance	–	0.597	Increases by 2.86% (0.614)	Reliable (1)
Integral production	–	0.202	Increases by 1.79% (0.207)	Reliable (1)
Integral labor	–	0.420	Increases by 1.05% (0.464)	Reliable (1)
Integral_general	(Purpose) increase the value by 1.81%	0.412	0.419	Reliable (1)

Thus, to achieve the established target values for overall integral indicator of development level, it is necessary to achieve an increase in the development level of JSC "Harverst" in the financial sphere by 2.86%, in the manufacturing sphere – by 1.79%.

5. DISCUSSION

Worldwide enterprises are increasingly focused on crisis management. This is because crisis management is based on the generally accepted idea that the more frequent the crises, the greater their impact on the enterprise's functioning. With increasing frequency and impact of crises, organizations must have the tools to mitigate the crises, which will allow localizing their effects or preventing them. In this sense, the development of effective methods, mechanisms, and models of crisis management is an urgent task of internal management.

The research and analysis of existing developments in this direction showed that scientists and practitioners are interested not only in the sequence of stages for implementing such methods but also the semantic content of each of them. Issues to discuss are the formation of effective system of enterprise's activity indicators, which then form a system of tracking the progress of crisis development; structuring of the system of indicators for resources, spheres of activity, and functional tasks of management; integration of tasks of crisis management in general enterprise's management system, allocation of top management who is responsible for them; modeling of tools, which constitute the core of the crisis management system.

According to the authors, these tasks should be solved taking into account the specifics of functioning and resource constraints of each enterprise. In this regard, this study applied the complex of economic-mathematical methods and models developed by the author to solve each of the problems listed earlier, which generally allow the crisis management of JSC "Harverst" and JSC "Finprofil."

Also, issue to discuss is the mechanisms of crisis management. Most authors emphasize the need for recognition, analysis, and containment of crises. The authors' approach is based on forming a new factor of a stably developing enterprise through the necessity of creating an artificial crisis at a certain time interval of a rising phase of its development. This approach is justified by the existing enterprise resource potential and real opportunities to change the vector of the enterprise's development cycle and enhancing its up-vector. In addition, the application of cognitive and impulse analyses allows developing specific values that act as guidelines for enterprise's further development.

CONCLUSION

The developed methodological approach is an effective tool for managing the enterprise's behavior, taking into account the stage of its business cycle. By analyzing and evaluating the enterprise's resource capabilities, corresponding to the stages of the cycle, the cognitive relationship of the main system-forming areas of the enterprise, the possibility of crisis management is determined – the possibility of provoking an artificial crisis or localization of natural negative crisis. Artificial crisis allows strengthening the upward trend of the enterprise; a natural negative crisis needs to be localized, and managerial decisions need to be formed to change the stage of enterprise's development.

Studies on Ukrainian industrial enterprises JSC "Harverst" and JSC "Finprofil" enabled to identify the areas of dominant influence on the enterprises' activities and develop the scenarios for their further development by forming a system of normative values for local indicators of spheres of life based on implementing the direct and inverse tasks of cognitive modeling.

Also, the experiments conducted to implement the methodological approach allow concluding that it is universally applicable for any business entities, taking into account the construction of a relevant system of indicators for systemically important areas of their activity.

Further study is required by issues related to forming the reference value of indicators when forming managerial actions for adjusting the development vector of a separate system-forming sphere; modeling not only the stages but also the phases of enterprise's development to increase the level of management decisions detail; searching the problems and substantiating the mathematical methods for describing economic dynamics; solving the problem of determining target guidelines for impulse analysis in the formation of enterprise's development scenarios.

REFERENCES

1. Avanzi, D. da Silva, Foggiatto, A., Santos, V. A., Deschamps, F., Loures, E. de Freitas Rocha (2017). A framework for interoperability assessment in crisis management. *Journal of Industrial Information Integration, 5,* 26-38. https://doi.org/10.1016/j.jii.2017.02.004
2. Avdeyeva, Z. K., Kovryga, S. V., & Makarenko, D. N. (2006). Kognitivnoe modelirovanie i reshenie zadach upravleniya slabostrukturirovannymi sistemami (situatsiyami) [Cognitive modeling and solving problems of managing weakly structured systems (situations)]. In *Trudy 6-y mezhdunarodnoy konferentsii "Kognitivnyi analiz i upravlenie razvitiem situatsii" – Proceedings of the 6th international conference "Cognitive analysis and management of the situation"* (pp. 41-54). Moscow: Institute of Management Problems RAS. (In Russian)
3. Belyaev, A. A., & Korotkov, E. M. (2011). *Antikrizisnoe upravlenie [Crisis management]* (2nd ed.) (311 p.). Moscow: YUNITI-DANA. (In Russian)
4. Bénaben, F. (2016). A Formal Framework for Crisis Management Describing Information Flows and Functional Structure. *Procedia Engineering, 159,* 353-356. https://doi.org/10.1016/j.proeng.2016.08.208
5. Bowers, M. R., Hall, J. R., & Srinivasan, M. M. (2017). Organizational culture and leadership style: The missing combination for selecting the right leader for effective crisis management. *Business Horizons, 60*(4), 551-563. https://doi.org/10.1016/j.bushor.2017.04.001
6. Bozhko, V., Balychev, S., Batkovskiy, A. M., & Batkovskiy, M. A. (2013). Upravlenie finansovoy ustoychivostyu predpriyatiy [Managing the financial sustainability of enterprises]. *Statistika i Ekonomika – Statistics and Economy, 4,* 33-37. (In Russian)
7. Buryi, S., & Matsekha, D. (2006). *Antykryzove upravlinnia ta upravlinski rishennia – problemy pidpryiemstv maloho biznesu [Crisis management and management solutions – problems of small enterprises]* (93 p.). Khmelnytskyi: "|Triada-M" Ltd. (In Ukrainian)
8. Chebashkina, G. A., & Nikonova, Yu. A. (2017). Antikrizisnoe upravlenie i effektivnoe upravlenie riskami predpriyatiya v sfere predprinimatelskoy deyatelnosti v narodnoy ekonomike Rossii [Crisis management and effective enterprise risks management in the sphere of entrepreneurship in Russian national economy]. *Internet-zhurnal "NAUKOVEDENIE" – Internet Journal "SCIENCE STUDIES", 9*(3). (In Russian). Retrieved from http://naukovedenie.ru/PDF/04EVN317.pdf
9. Chernyavskiy, A. D. (2000). *Antikrizisnoe upravlenie [Crisis management]*. Kiev: MAUP. (In Russian)

http://dx.doi.org/10.21511/ppm.18(1).2020.17

10. Delloitte (2018). *Deloitte 2018 Global Crisis Management Survey*. Retrieved from https://www2.deloitte.com/content/dam/insights/us/articles/GLOB305_Crisis-management-survey/DI_Crisis-Management-Survey.pdf

11. Dubynska, O. (2012). Diahnostyka ta prohnozuvannia yak skladovi mekhanizmu antykryzovoho upravlinnia [Diagnostics and forecasting as components for crisis management mechanism]. *Ekonomichni nauky: zb. nauk. prats Lutskoho natsionalnoho tekhnichnoho universytetu – Economic sciences: collection of scientific works of Lutsk National Technical University, 9*(34), 108-115. (In Ukrainian)

12. Gerchikova, I. (1995). *Menedzhment [Management]* (2nd ed.) (480 p.). Moscow: Banks and stock exchanges: YUNITI. (In Russian)

13. Gorokhova, O., & Sereda, A. (2012). Teoretycnhyi analiz alhorytmichnykh skhem stsenarnoho modeliuvaniia na osnovi kohnityvnoho pidkhodu [Theoretical analysis of algorithmic model-based modeling schemes based on the cognitive approach]. In *Tezy dopovidei IV Mizhnarodnoi naukovo-praktychnoi konferentsii molodykh vchenykh, aspirantiv, studentiv "Suchasna informatsiina Ukraina: informatyka, ekonomika, filosofiia". Sektsii 6 "Modeliuvannia sotsialno-ekonomichnykh system" – Abstracts of the 4th International Educational and Practical Conference of young people, students, graduates, students of the "Modern Information Ukraine-Oriented Association of Social Sciences. Section 6 "Modeling social and economic systems"* (pp. 50-55). Donetsk: DVNZ DonNTU. (In Ukrainian)

14. Haida, W., & Zaplatynskyi, V. (2017). Innovatsii v upravlinni kryzovymy sytuatsiiamy [Innovations in crisis management]. *Zhurnal MEST – MEST Journal, 15*(1), 32-39. (In Ukrainian)

15. Hryhorieva, O. V., & Mishchenko A. Yu. (2017). Kryzova yavyshcha v ekonomitsi ta yikh proiavy na pidpryiemstvi [Crisis phenomena in the economy and its manifestations at the enterprise]. *Naukovyi visnyk Uzhhorodskoho natsionalnoho universytetu – Scientific Herald of Uzhgorod National University, 13,* 76-79. (In Ukrainian)

16. Kafkova, E., Hudak, I., & Bricova, Z. (2013). Technical efficiency of small and medium sized enterprises in machinery sector of the Slovak Republic. *Economic Annals-XXI, 11-12,* 62-66.

17. Karpun, I. (2013). *Antykryzovi zakhody na pidpryiemstvi: upravlinnia, stratehiia, tsili ta zavdannia [Crisis Measures at Enterprise: Management, Strategy, Targets, and Tasks]* (422 p.). Lviv: Mahnoliia. (In Ukrainian)

18. Koschyk, H., & Wilson, T. (2013). Principles for dealing with financial sustainability risks. *Journal of Risk Management in Financial Institutions, 2,* 129-136.

19. Panyavina, E. A., & Morkovina, S. S. (2011). Mekhanizm obespecheniya ustoychivogo razvitiya malogo predprinimatelstva v usloviyakh vozniknoveniya krizisnykh situatsiy v ekonomike [The mechanism for ensuring the sustainable development of small businesses in conditions of crisis situations in the economy]. *Sotsialno-ekonomicheskie yavleniya i protsessy – Socio-Economic Phenomena and Processes, 12*(034). (In Russian)

20. Peters, T. (1982). *In Search of Excellence: Lessons from America's Best Run Companies* (360 p.). New York, Harper & Row.

21. Rayevnyeva, O. V. (2006). *Upravlinnia rozvytkom pidpryiemstva: metodolohiia, mekhanizmy, modeli [Management of enterprise development: methodology, mechanisms, models]* (496 p.). Kharkiv: VD "INZHEK". (In Ukrainian)

22. Rayevneva, E. V., & Gorokhova, O. I. (2010). Formirovanie metodicheskikh elementov upravleniya krizisami promyshlennogo predpriyatiya [Formation of methodological elements of industrial enterprise crisis management]. *Biznes Inform – Business Inform, 5*(2), 47-52. (In Russian)

23. Rezaei, R., Chiew, T. K., Lee, S. P., & Aliee, Z. S. (2014). Interoperability evaluation models: a systematic review. *Computers in Industry, 65*(1), 1-23. https://doi.org/10.1016/j.compind.2013.09.001

24. Sennewal, C. (2016). Curtis Baillie: Crisis 3, Management. In *Effective Security Management* (6th ed.) (pp. 189-195). Elsevier Science & Technology.

25. Tena-Chollet, F., Tixier, J., Dandrieux, A., & Slangen, P. (2017). Training decision-makers: Existing strategies for natural and technological crisis management and specifications of an improved simulation-based tool. *Safety Science, 97,* 144-153. https://doi.org/10.1016/j.ssci.2016.03.025

26. Tuhan-Baranovskyi, M. I. (1894). *Promyslovi kryzy u suchasnii Anhlii, yikh prychyny i vplyv na narodne hospodarstvo [Industrial crises in modern England, its causes and influence on the national economy]* (390 p.). SPb. (In Ukrainian)

27. Voronkov, D. (2008). Kohnityvne modeliuvannia stratehichnykh zmin na pidpryiemstvi [Cognitive modeling of strategic changes at the enterprise]. *Rehuliuvannia natsionalnoi ekonomiky. Zb. naukovykh prats Donetskoho derzhavnoho universytetu upravlinnia – Regulation of national economy. Collection of scientific works of Donetsk State University of Management, 114*(IX), 86-94. (In Ukrainian)

28. Voronkova, A. E. (Ed.) (2006). *Diahnostyka stanu pidpryiemstva: teoriia i praktyka [Diagnostics of state of enterprise: theory and practice]* (448 p.). Kharkiv: INZHEK. (In Ukrainian)

29. Walecka, A. (2016). Determinants of managers' behaviour in a crisis situation in an enterprise-an attempt at model construction. *Management, 20*(1), 58-70. Retrieved from https://www.researchgate.net/publication/303908505_Determinants_of_managers'_behaviour_in_a_crisis_situation_in_an_enterprise_-_an_attempt_at_model_construction

30. Zahurskyi, O., & Pohorila, A. (2018). Zastosuvannia vartisno-oriientovanoho upravlinnia dlia otsinky finansovoho stanu pidpryiemstva [Applying the Value-Oriented Management to Estimate the Financial State of Enterprise]. *Biznes Inform – Business Inform, 12,* 275-280. (In Ukrainian)