INFORMATION DIAGNOSTIC SUPPORT OF ENTERPRISE UNDER THE CONDITIONS OF UNCERTAINTY

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Abstract

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The dynamics and uncertainty of business environment greatly complicate the decision-making processes for the company's executives and managers. That's especially important if they do not possess high-quality and reliable information database on the state of internal and external environment. Thus, the purpose of this paper is the development of specialized probability diagnostic techniques for enterprise operating under the conditions of uncertainty. Two basic research methods were used in our research. Firstly, the study was conducted on the basis of review and analysis of specialized literature in the field of information diagnostic support of enterprises under the conditions of uncertainty. This allowed us to propose our own solution in this regard. Secondly, the developed diagnostic method was tested on one of the Ukrainian enterprises. The obtained results enabled us to determine the most probable threat to the functioning of the entity. We also conducted the quantitative assessment of its possible impact on the performance of the company. Therefore, suggested diagnostic techniques aim at forming the grounded information basis about different potential changes of business environment, as well as the enough time reserve, and can be recommended for the company's managers during the decision-making process under the conditions of uncertainty.

Keywords: diagnostics, uncertainty, functioning environment, information, weak signals, opportunities, threats.

INTRODUCTION

The current environment of many businesses is characterized by high dynamism, uncertainty and unpredictability of conditions, which leads to an acute shortage of information and time resources for executives and managers of such businesses. In such conditions, management of the enterprise has to make managerial decisions under high time pressure, often based on incomplete, inaccurate and unverified information data. It accordingly reduces the effectiveness of management decisions on the use of opportunities or avoiding threats for operating conditions of business structure.

In the context of the abovementioned problem, the theory of events of the functioning environment,

based on weak and strong signals, has proven to be of practical value. According to this theory, any potential event is characterized by a certain period of development from weak to strong signals, that indicate the occurence of the relevant phenomena. Weak signals are the very first, early, initial signs of a certain phenomenon that contain vague, incomplete and not very reliable information on the phenomenon, but represent a significant time lag between their occurence and onset and impact of the phenomenon on the company. During a certain period such signals develop, modify, acquire information completeness and turn into strong signals. As a rule, strong signals already contain clear, obvious information data about a certain

event and are characterized by only a small time period between the points of identifying the signal and occurrence of the phenomenon or event.

The value of identifying, analyzing and evaluating the potential effects of weak signals is that with the implementation of diagnostic procedures for directors and managers of companies they get a reliable information base and enough time for a mindful and informed decision-making regarding the effective use of opportunities and eliminating threats to the environment of operation. This, in turn, enables businesses to gain new competitive advantages, improve efficiency of operation, avoid exposure to hazards, ensure stable and progressive development, and so on. After all, as the current practice of successful players of the world market show, to maintain effective competition and achieve high performance in today's highly dynamic and unpredictable functioning environment, it is far not enough to be able to just adapt to changes in operating conditions, there is a need in anticipation of potential effects on the basis of diagnosis of weak signals and effective decision-making.

The diagnosis of weak signals of business environment represents the growing interest among the scientific community. The paper of Baklan *et al.* (2011) disclosed a concrete method of identification and evaluation of weak signals of business environment. It includes the classification, quantative evaluation and identification of dominant influence factors on the enterprise activity, as well as the calculation of the generalized integrated indicator that represents the influence of all factors. Such indicator covers the evaluation of factors' influence in different operating areas of enterprise: economic, socio-cultural, political, productive, technological, market, competitive, international ones. The generalized integrated indicator also considers the interaction and interdependence between all factors of influence on the enterprise activity.

The significant contribution in the research of the field of information diagnosis support of enterprises under the conditions of uncertainty was made in the work of Lysenko *et al.* (2009). In this paper there is a list of concrete specialized qualitive and quantitive methods for identification and evaluation of weak signals of potential events. In particular, according to authors the mathematical instruments give an opportunity to detect the weak signals on the basis of research of development history of company's indicators and include the quantitative forecasting methods. The quantitative models and methods are aimed at the establishment of behavior patterns, formal confirmation or refutation of hypotheses, reflecting the weak signals in the form of numerical arrays with the possibility of their further processing. These instruments include: discriminant and factor analysis, correlation and regression analysis, cluster analysis, taxonomy methods, neural network, cards of Kohonen, etc. Simultaneously, the qualitive expert methods

are useful for monitoring and detection of weak signals of non-standard events and processes. Such instruments include: brainstorming techniques, aimed at generation of new ideas; methods of scenarios, reflecting a logical sequence of events or alternative solutions to problems; methods of expert assessments. It should be noted that in the works (Lysenko, Rudenskyi, Yehorova, *et al.*, 2009; Rudenskyi, 2009) there is developed a specialized mechanism of identification of weak signals of potential events that includes the combination and implementation of expert methods, instruments of neural networks and fuzzy logics.

In turn, Ashley and Morrison (1997) propose a diagnostic management model for making better decisions that is grounded on the identification of weak signals of business environment in the context of anciitiation of potential changes. Such model includes scanning, monitoring and forecasting of weak signals to the concrete events, challenging assumptions, conducting issue vulnerability audits, writing scenarios, prioritizing issues, evaluating performance.

Voloshyna (2010) proposes specific techniques of identification of weak signals of operating environment, but they are characterized by cybernetic approach to the detecting and processing of weak signals, that is too complicated to use on different enterprises and requires the special resource support.

In addition to the above mentioned theoretical sources there is also a list of scientific papers (Ansoff, 1988; Ansoff, 2007; Harper, Glew, 2008; Hiltunen, 2008; Hiltunen, 2007; Rebernik, 2000; Kuokkanen, 2009; Potocan, 2002; Richter, 1996; and others) that disclose some particular aspects of information diagnosis support of enterprises under the conditions of uncertainty, but don't reflect the complete grounded mechanism, model or method in research field.

So, Ansoff is a founder of the theory of management on the basis of weak signals. In the works (Ansoff, 1988; Ansoff, 2007) there is described an idea of development of the potential event in operating environment from its weak to strong signals. According to this conception the author distinguishes management on the basis of weak signals that is aimed at early preparation of organization to potential changes of business environment through the identification and interpretation of their weak signals.

Harper and Glew (2008) reveal only the role of identification of weak signals of business environment in the context of protection of enterprise from possible hazards or reducing their impact, as well as increasing of its competitiveness through the better using of opportunities of operating conditions.

In the papers (Hiltunen, 2007; Hiltunen, 2008) there are presented the results of specialized research of information sources of weak signals in operating environment. According to given research

results the basic sources of weak signals are research scientists, specialists of planning and prediction, educational and scientific journals, reports of research institutions. To our minds, this list is not complete and must be supplemented by sources from other areas.

Kuokkanen (2009) considers the need of scanning of weak signals of operating environment for supporting of anticipatory decision-making at enterprises in changing environment. But in the paper (Kuokkanen, 2009) the key attention is directed at the decision-making process, not at the mechanism of scanning of weak signals of business environment.

Other works (Rebernik, 2000; Potocan, 2002; Richter, 1996) describe only the role of diagnosis of weak signals of operating environment in the context of supporting of decision-making at enterprises under the conditions of uncertainty, but don't represent the concrete practical techniques in this field.

Given these facts, the purpose of this paper is the development of specialized probability diagnostic techniques for enterprise operating under the conditions of uncertainty. Two basic research methods were used in our research. The study was conducted on the basis of review and analysis of specialized literature in the field of information diagnostic support of enterprises under the conditions of uncertainty, as well as on the results of testing of the developed diagnostic method on one of the Ukrainian enterprises.

MATERIALS AND METHODS

The study was conducted on the basis of review and analysis of specialized literature in the field of information diagnosis support of enterprises under the conditions of uncertainty. We also reviewed the findings of one particular research of functioning environment, conducted by a Ukrainian company PJSC 'Bulat' in terms of identifying weak signals of potential effects of its activities, expert evaluation and simulation of weak signals of potential phenomena in 'Bulat' operation sphere. To get the results we used the following methods: theoretical generalizations and comparisons – for isolation, grouping and matching existing theoretical and applied materials in the study area; expert assessment and identification – to determine the weak signals in the environment of the enterprise; causal analysis – to build the tree model of events for weak signals in the environment of the enterprise; simulation, including the Monte Carlo method – for probabilistic assessment of the impact, caused by the opportunities and threats, identified by the weak signals, on the resulting performance of the company.

Next research was carried out in stages according to the developed logically consistent methods of diagnostics of enterprises under the conditions of uncertainty. First, during January–June 2016, we carried out environment monitoring in the organization which was selected for research purposes – Ukrainian engineering company PJSC 'Bulat'. Our aim was to identify weak signals which may be indicators of some potential effects that may reflect on the activity of investigated entity. Selection and attribution the signals to weak or strong category were done on the basis of an expert assessment of their strength. It was followed by a quantitative analysis of the signal power parameter by determining the entropy of each of them. The results of qualitative and quantitative study of identified power levels of potential effects in functioning of PJSC 'Bulat' allowed us to rate them in accordance with the following principle: the highest entropy signal indicates its weakness and accordingly makes it the highest rating position among other signals.

Later, with the help of expert evaluation, we formed the tree of events for each priority weak signal within the operating environment of PJSC 'Bulat', reflecting the logically-consistent path of transformation of a weak signal to a certain phenomena. We also identified the probability of relevant events at each stage of their development. The output of this tree was identified by a specific event (threat or opportunity) that was the most likely to occur and may affect the activity of PJSC 'Bulat' as a result of the corresponding weak signal. Later we conducted a probabilistic exposure assessment of identified opportunities or threats on the resulting performance of PJSC 'Bulat' on the basis of simulation modeling (Monte Carlo method), which enabled us to model the interval of changes of the resulting performance under the impact of a certain phenomenon. The result of the diagnosis of weak signal of a operating environment PJSC 'Bulat' allowed us to form a structured conclusion that reflects the arrangement of specific potential phenomena identified by their weak output signal, the probability of their occurrence and displays quantitative impact on the effectiveness of a certain sphere of the entity.

RESULTS

Diagnosis of the enterprise functioning under the conditions of uncertainty is based on target detection of weak signals in operating environment, their probability processing and ranked ordering, selection of the most significant weak signals, interpreting their further development to certain conditions, opportunities or threats in operating conditions and assessing the impact of the latter on a certain type of company's activity. The results of this diagnostic form a reasonable quantitative and qualitative information base for the development and adoption of advanced management solutions with the focus on identified opportunities and threats for operating conditions.

I: *The identified characteristics of the signals of potential phenomena of operating environment classified by signal strength (Rudenskyi, 2009)*

No	Identified characteristics of the signal	Signal strength		
		(1) Weak	(2) Medium	(3) Strong
1.	Known possibility of potential changes in operating environment	Yes	Yes	Yes
2.	Identified the source of the potential effects of the operating environment	Yes	Yes	Yes
3.	Defined specific characteristics of potential effects, trends of influence (positive, negative), spheres of influence	No	Yes	Yes
4.	Known possible administrative decisions regarding the use of possibilities or eliminating threats to operating conditions	No	Yes	Yes
5.	Determined the influence of identified opportunities and threats to the organization in view of the possible reactions of management	No	No	Yes

For targeted diagnosis of the enterprise functioning under the conditions of uncertainty, we have developed a special diagnostic method, a staged implementation sequence which we discuss below.

Stage 1. Monitoring of operating environment aimed at determining the signals, characterized by incomplete and probabilistic semantic content, and identifiying how they are linked to possible effects which may occur.

As noted above, the weak signals of operating environment – these are early, initial signs of future changes in operating conditions that are probabilistic basis to report the possibility and potential sources of certain phenomena. In modern working conditions of any enterprise, even over small periods of time there may occur a significant number of such weak signals that are early indicators of possible changes in the internal or external environment of the organization. Obviously, quantitative and qualitative parameters of weak signals depend on the size of the company, the scale of its activities, industry sector, situational features of internal and external environment and so on. However, due to the fact that weak signals are characterized by the ability to develop and strengthen there are many signals of varying strength in the operating environment of the company. This is the fact that to some extent complicates the distinction of weak and strong signals that charcterise the origin of opportunities and threats for the company. In order to facilitate qualitative identification of weak signals we provide the characteristics of the signals of varying strength which report of potential effects on the environment of operation in Tab. I.

According to Tab. I, all of the signals of potential effects fell into three categories depending on their strength: weak, medium and strong signals. Weak signals contain information only about the possibility of potential changes in operating conditions and sources of their origin, and therefore require further processing and interpretation in order to form a complete vision of the future situation. Thus, we mean that diagnostic specialsts should interpret the further development of weak signals and their transition to medium and strong signals, instead of waiting for their own organic development, to anticipate the effects that will be identified by the relevant weak signals.

Thus, on the first stage the process of comprehensive monitoring of internal and external environment of the enterprise is implemented, with the purpose of qualitative detection and identification of weak signals which may indicate some potential events. The staff plays an important role on this stage, since they use their intuitive and logical reasoning to identify early signals, which are characterized by incomplete and probabilistic semantic content, and their impact on potential changes in operating conditions of the enterprise. Therefore, for successful implementation of the first stage, it is advisable to involve workers with high level of monitoring, identifying, prognostic skills, with intuition and insight, those who have creative approach to things and have experience in early diagnostics etc. It also should be mentioned that in functioning environment weak signals are usually accompanied by information noise. Therefore, at this stage it is advisable to implement the filter for input information, based on the exclusion of any false and erroneous information. Diagnostics specialists should carefully analyze all incoming signals, estimate their significance for the company in terms of their semantic content and try eliminate all information noise.

Stage 2. Evaluation of entropy of registered signals as the defining parameter of signal strength; signal identification priority, where signals with the highest entropy are estimated as weak signals of operating environment.

The results of monitoring of operating environment aimed at determining weak signals of potential effects, which were obtained phenomena at the previous stage on the basis of expert opinions and conclusions, can be characterized by a certain level of subjectivity, inaccuracy, and therefore require a quantitative study. For this purpose we propose to estimate the level of information entropy for each detected signal as a possible predictor of certain changes in the enterprise.

Nowadays the concept of "entropy" is used in various disciplines as a measure of chaos, disorder of the system consisting of many elements. First time the concepts of entropy and information were linked by an American engineer and mathematician K. Shannon in 1948. Information entropy or Shannon entropy describes the extent of uncertainty, randomness and chaos, disorder of information system and determines the amount of useful information, which can be found in one information source that generates statistically independent events (Melnyk, 2005; Kudriashov, 2009).

The situation of maximum uncertainty involves multiple equally probable alternatives of a certain phenomenon or even. Thus, the more equally probable options there are, the greater the uncertainty, the more difficult it is to make a clear choice and the greater amount of information needs to be obtained. The minimum uncertainty is zero, that is a situation of complete certainty, which means that the choice is made and all necessary information is received. In case if there are only two alternatives with equal probabilities of occurrence of certain events ($p_1 = p_2 = 0.5$), the information entropy becomes maximum, indicating the complete uncertainty. Whereas, zero entropy corresponds to a situation where the likelihood of a phenomenon or event is unity, and the other – zero (Kudriashov, 2009).

Due to the fact that there may be a lot of weak signals in the environment of the enterprise, the calculation of entropy values for each signal should be simplified to calculation of probabilities for two opposite alternatives of the course of event identified by the relevant signal ($p, p - 1$). Which means that we should view the potential effect from the position of expert estimation of its probability. Thus, on the second stage of the proposed methodology, the experts based on their own judgment, experience, characteristics of weak signals and so on, determine the probability of potential effects that may occur as a result of weak signal registered.

Taking into consideration all the abovementioned, the level of information entropy for independent random events identified by weak signals, can be calculated according to the formula (Kudriashov, 2009):

$$H_x = -\left(P_0(x)\log_2 P_0(x) + P_1(x)\log_2 P_1(x)\right),$$

where:

H_x........is the level of information entropy of the signal of potential effect in the environment of the enterprise, bit;

x..........is a potential phenomenon or effect that may occur as a result of a relevant weak signal;

$P_0(x)$....is the probability of non-occurence of the potential effect of a relevant weak signal;

$P_1(x)$....is the probability of potential effect of a relevant weak signal.

According to the identified information entropy of weak signals, we rank them, based on the following principle: the highest entropy signal indicates its weakness thus makes it the highest rating position among other signals. It should also be noted that there is no specific criterion entropy values, which would form the base for identifying weak signals as signs of potential events. The criterion for classifying a signal as medium or strong is logically suggested to be a significant deviation of entropy from its highest values downward.

Based on ranking, we choose several signals with the highest rating, which indicates their weakness and need for further processing. In addition, the results of signals priority identification with the highest levels of entropy as weak signals can be supplemented by expert judgments concerning the importance of weak signals in the future of the enterprise. Particularly relevant is this supplement in case of a large number of signals with high entropy, that shows the effectiveness of the results of the first stage. Then, as indicated above, the selection of weak signals for further study is carried out by expert methods based on estimation of the significance of weak signals in the future of the enterprise.

Stage 3. Construction of the tree of events for each priority weak signal of potential effects in the environment of the enterprise. Note that this stage and all subsequent stages of the proposed method should be consistently implemented for each previously identified priority weak signal in the operating environment of the enterprise.

3.1. Evaluation and study of a weak signal as the initial indicator of potential effects in the operating environment of the enterprise. On the basis of the results of previous stages we choose a specific weak signal, which is characterized by the highest or one of the highest ranking positions in the established rating for its level of entropy and / or level of significance, and is identified as the initial sign of probability of the potential effect. At this stage, it is advisable to carefully examine and describe the weak signal by features such as the source of a weak signal; availability of analogues of weak signals and ways of their development in prior years of the enterprise, business competitors and other companies and so on.

3.2. Formation and interpretation of probabilistic trajectories of a weak signal to alternate strong signals that notify of potential effects in the environment of the enterprise, based on the establishment of logical cause and effect relationships between events. Application of causal connection allows to form the logic of events (from a weak signal to strong signals) through linking one event which is the cause, and other event, which is the result and therefore follows the first event. At this stage, based on the characteristics of a weak signal, we should be logical and reasonable and consistently consider all alternatives of its development into strong signals that indicate certain opportunities or threats
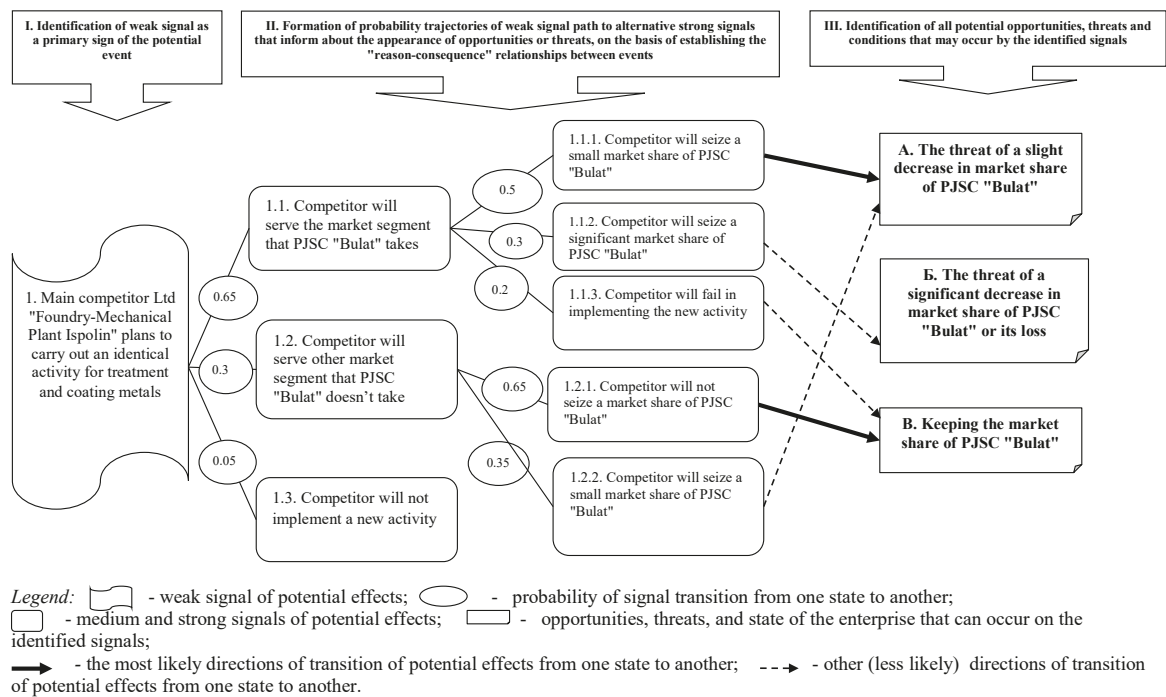
1: *Tree of events based on the registered weak signal "Main competitor Ltd "Foundry-Mechanical Plant Ispolin" plans to carry out an identical activity for treatment and coating metals" in the operating environment of PJSC 'Bulat'*

in the environment of the enterprise. It should be noted that strong signals should directly and obviously indicate the specific potential events and their characteristics (direction of influence, object and sphere of influence, etc.). Each signal transition from one state to another should fill the likelihood of the underlying events that will allow pre-form an idea of the least and most likely phenomena or effect that can occur in the environment of the enterprise. Since the probability is rather abstract and complex notion in terms of quantitative calculation, it is advisable to set its value in expert way.

3.3. Identification of all opportunities, threats and states that may occur based on identified signals in the environment of the enterprise. In accordance with the strong signals, which clearly indicate the occurrence of certain events, we identify all opportunities, threats or future condition of the enterprise. While constructing the tree of events we should also take into consideration the fact that one and the same weak signal in the course of its development may indicate the potential simultaneous positive effects and negative.

As a result of the research of operating environment of PJSC 'Bulat' in terms of determining the weak signals of potential effects on the abovementioned stages, we formed the model of the tree of events for registered weak signal "Main competitor Ltd Foundry-Mechanical Plant Ispolin" plans to carry out an identical activity with treatment and coating metals" (Fig. 1).

Stage 4. Probabilistic exposure assessment of opportunities and threats based on identification of weak signals on the resulting performance of

the enterprise using the simulation modeling method of Monte Carlo.

As far as it is quite difficult to determine the specific impact of identified opportunities and threats on the efficiency of the company in quantitative terms, it is advisable to use economic and mathematical methods of probabilistic nature. The most appropriate solution in this case is the method of statistical tests, or Monte Carlo method. In modern conditions using Monte Carlo method we solve a wide range of tasks, whose main objective is to find the best solution to the problem of a plurality of analyzed options. Monte Carlo is a numerical method for solving problems through simulation of random variables (Gmurman, 1999; Sobol, 1968). Let us consider the use of Monte Carlo method for evaluating the impact of identified opportunities and threats based on weak signals.

From the standpoint of the theory of probability, identified by a weak signal opportunity or threat is a random event, ie an event which under given conditions can either happen or not happen (in this case, there is a probability ($0 \leq p \leq 1$) that it will happen at the set conditions). Therefore, if you choose a certain indicator, which reflects the impact of potential developments on the performance of the enterprise, its importance in this context is a random variable, that is, the one which can obtain certain values (from the set of its values) with a certain level of probability (Gmurman, 1999; Sobol, 1968).

In view of the above, the nature of Monte Carlo method is the implementation of a large number of trials of a random variable to determine the most

likely options for its values. As far as it is difficult to accurately estimate specific values of change indicator of the company due to the influence of certain phenomena with a weak signal, then using the Monte Carlo method it can be replaced by the interval of possible values. Further we model different options of a random variable with set boundary values, each time using a different set of random probability values (Gmurman, 1999; Sobol, 1968).

4.1. Identification of objects of impact of opportunities or threats identified by weak signals to the enterprise and the selection of indicators that can represent the impact of potential effects on the efficiency of the selected object.

In our opinion, at this point the most representative objects of impact of identified opportunities and threats are functional activities of the company. Each activity is characterized by a clear set of indicators measuring both its status and properties that provide an opportunity to assess the impact of potential phenomena on the performance of a certain type of activity and describe its trends. This accordingly simplifies the process of finding and selecting indicators that can represent the impact of opportunities and threats on the effectiveness of a particular type of business. Depending on the type of economic activity, its mission, goals, objectives, management features and other characteristics, any company can carry out production activities, scientific and technical preparation of production, financial, economic, marketing, logistics, human resources and foreign economic activity. In addition, identifying specific activity as an object of impact of potential events clearly indicates the direction of anticipative measures, the members of staff, responsible for the implementation of these measures and others.

Turning to Fig. 1, in this case a priority threat to PJSC 'Bulat' is a slight decrease in market share of the enterprise and the object of its impact is marketing activity. The volume of sales (V_p) is chosen as an indicator, which represents the impact of this threat on the marketing activities of the company.

4.2. Set change intervals of chosen indicator due to the impact of each potential phenomena identified by the weak output signal.

Since, as mentioned above, is difficult to establish the specific values of certain indicators as a random variable and the corresponding probabilities, so the random variable (indicator representing the impact of potential events identified by weak signals on the effectiveness of the company) is continuous, possible values of which fill a a certain range. Thus, at this stage, we should identify a possible interval of its change due to the impact of some potential events (threats or opportunities) identified by the relevant weak signals. Performing of this task should be based on consideration of the impact of various factors, approximate calculations, logical reasoning and so on.

Due to the impact of the threat A on the activity of PJSC 'Bulat' (a slight decrease in market share of the enterprise) by applying an expert method we found that the range of variation in sales (ΔV_p) equals to 200,000 UAH – 300,000 UAH per month. State "Keeping the market share of PJSC 'Bulat' " does not anticipate the substantial changes in the volume of sales due to occurrence of a weak signal.

4.3. Selecting the type of probability distribution of the random variable (chosen indicator or group of indicators that represent the impact of potential events indicated by the weak signal) and setting its parameters.

As noted above, to determine the random variable we must estimate all of the possible values and corresponding probabilities. The law of distribution of a random variable establishes the relationship between the possible values of the random variable and the corresponding probabilities. The main laws of distribution of continuous random variables are: uniform, normal, exponential distribution and so on. The choice of a certain type of distribution depends on the characteristics of the selected indicator as a random variable. For example, variables can have a uniform distribution, include income from the future sales of a new product, whereas the indicators that can be described by a normal distribution, are inflation, energy prices and so on. Each distribution is defined by certain parameters, such as the mathematic expectation, standard deviation, etc. (Gmurman, 1999; Sobol, 1968).

Typically, the Monte Carlo method, which involves a large number of tests, often uses a normal probability distribution of a random variable, which is characterized by two parameters: the mathematic expectation and standard (mean) deviation of the normal distribution. Figure density of the normal distribution curve is defined as normal curve (Gaussian curve). It should be noted that in case of large number of tests carried out during the implementation of Monte Carlo method, the arithmetic mean of observations is close to its expected value (Gmurman, 1999; Sobol, 1968).

In the abovementioned case study of a functioning environment of PJSC 'Bulat' we choose the normal type of distribution, which is characterized by parameters such as the expectation (or mean) and standard deviation in the sample.

4.4. Simulation of possible values of the random variable (chosen indicator, which represents the impact of potential events identified by the weak signal on the performance for a certain activity of company).

First of all, we need to calculate the parameters that determine the distribution of a random variable. For normal distribution we estimate the mean value of a random variable and the sample standard deviation (as output data we use the value from a set range of random variable changes in relevant limits). Then we need to determine the number of tests that must be performed for optimal modeling of a random

variable. Number of iterations to be made is quite large and is dependent on a specified interval of change of a random variable. Typically, the amount of these tests is hundreds, thousands, tens of thousands of iterations. Using the mathematical function RAND in MS Excel we need to make the probability distribution of a random variable. This function generates uniformly distributed within [0, 1] random numbers as the likelihood of possible values of a random variable. Based on these calculations we perform simulation of probability values of certain indicators as random variables using statistical function NORMINV in MS Excel. This function returns the inverse normal distribution for the specified mean value of a random variable and its standard deviation (Minko, 2004).

For the abovementioned case study of operating environment of PJSC 'Bulat' we calculate the parameters of normal distribution (Feshchur, Barvinskyi, Kichor, *et al.*, 2003):

- the average value of sales ($\bar{V}_p$) for the interval [200,000–300,000], which is 250,000 UAH;

- standard deviation of sales for the sample (σ), that is 28,867.95 UAH.

For optimal simulation of random values (of sales) we determine the number of tests that will be 1000 iterations. In MS Excel, using function RAND we carry out the probability distribution of values ($P_1,...,P_{1000}$) occurrence of a random variable (volume of sales, V_p) for 1000 tests. For example, below we show first ten generated values of probability of a random variable (volume of sales of PJSC 'Bulat') (Tab. II). There after, using function NORMINV in MS Excel we model the probabilistic values of sales of PJSC 'Bulat' as a result of a threat A and its impact on the company. Below we present the first ten simulated values of sales PJSC 'Bulat' (Tab. III).

In practice, the evaluation of error of Monte Carlo method is done by calculation of the upper limit of an allowable error δ and defined reliability γ using the formula:

$$P\left(\left|\bar{X}-a\right|\leq\delta\right)=\gamma,$$

where:
$\bar{X}$.... is the average value of a random variable X;
a .... is the expectation of a random variable X;

II: *Fragment of distribution of the potential value of sales of PJSC "Bulat" due to the impact of threat A ("A slight decrease in market share")*

No of iteration	Generated probabilities of occurence of values of sales of PJSC 'Bulat'
1	0.820
2	0.033
3	0.348
4	0.282
5	0.649
6	0.461
7	0.300
8	0.073
9	0.298
10	0.820
…	…
1000	0.197

III: *Fragment of simulation of probability values of sales of PJSC 'Bulat' due to the impact of threat A ("A slight decrease in market share")*

No of iteration	Simulated probability values of sales of PJSC "Bulat", V_p, UAH
1	276,424.8
2	196,980.7
3	238,699.1
4	233,415.2
5	261,069.8
6	247,145.2
7	234,838.3
8	207,974.4
9	234,696.8
10	229,329.2
…	…
1000	225,429.5

δ ..... is the upper limit of an allowable error of the results of the trials of a random variable X;

γ ..... is reliability of an allowable error of the results of the trials of a random variable X.

In case of normal distribution of a random variable with known standard deviation value σ the upper limit of an error δ with reliability γ is calculated by the formula (Gmurman, 1999):

$$\delta = t\sigma / \sqrt{n}$$

where:

t .... is the value of the argument of Laplace function, in which $F(t) = \gamma/2$;

σ ..... standard deviation of X;

n .... number of trials of a random variable X.

Thus, for example, for the abovementioned case, we will calculate the upper limit δ of allowable error with defined reliability $\gamma = 0.95$:

$$\delta = 1,96 \times \frac{28867,95}{\sqrt{1000}} = 1,789.41 \text{ UAH.}$$

4.5. Construction of an interval scale of simulated values of the random variable (selected indicators of the company) and estimation of the most probable interval of changes of the resulting indicator under the impact of a potential phenomena identified by the weak output signal.

At this stage, each modeled array of values of the random variable (the corresponding indicator of the company) due to the impact of potential effects is divided into a certain number of intervals of changing its values. The width of a relevant interval Δx is determined by the formula (Gmurman, 1999):

$$\Delta x = \frac{x_{max} - x_{min}}{1 + 3.32 \log n},$$

where:

x_{max} ... is the maximum simulated random variable in the sample;

x_{min} ..... is the minimum simulated random variable in the sample;

n .... sample size.

Then for each interval we determine the number of hits of random variable values at relevant intervals using the conditional filtering of data. Based on these results we choose the interval with the most hits value that identifies this interval as the most likely change interval due to the impact of certain potential effects identified by the weak signals.

To demonstrate the abovementioned example, let us calculate the width of the interval of changes of simulated values of sales of PJSC 'Bulat' (ΔV_p):

$$\Delta x = \frac{353,062 - 163,859}{1 + 3.32 \log 1,000} \approx 17,263 \text{ UAH.}$$

Tab. IV shows the results of filtration of simulated values of sales PJSC 'Bulat' due to the impact of threat A, in accordance with the estimated limits of its change.

As it can be seen from Tab. IV, the most probable range of variation of sales PJSC 'Bulat' due to the influence of threat A is [232,915–250,178] UAH, and the upper limit of allowable error δ with reliability $\gamma = 0.95$ is 1,789.41 UAH.

Stage 5. Formation of structured conclusions based on potential final events (opportunities, threats) from the positions of reflection of probability of their perspective occurence and quantitative effect on the efficiency of a certain type of company activity.

In accordance with the analysis of the results of weak signals of operating environment, we can form a generalized conclusion, reflecting the orderly arrangement of finite potential phenomena identified by the weak output signal, the probability of their occurrence and the quantitative impact on the effectiveness of a certain type of company activity. At the end we should also mention a specific opportunity or threat to the enterprise from the tree of events that has highest probability of occurrence, and display the interval of the most likely values of changes indicator of the impact on certain kind of activity as the result of a potential influence of this phenomenon.

IV: *The results of simulation modeling of the values of sales of PJSC 'Bulat' due to the impact of threat A ("A slight decrease in market share") on the company*

Intervals of changes of simulated values of sales of PJSC 'Bulat', UAH	Frequency of hits of modeled values of sales of PJSC 'Bulat' at appropriate intervals
163,859–181,122	8
181,123–198,386	29
198,387–215,650	66
215,651–232,914	159
232,915–250,178	224
250,179–267,442	221
267,443–284,706	166
284,707–301,970	87
301,971–319,234	31
319,235–336,498	5
336,499–353,762	4

DISCUSSION

In the literature sources on features of diagnostic information support of enterprises under the conditions of uncertainty, some of the material is devoted to the research methods of weak signals of the operating environment. It should be noted that in the works (Baklan, Poplavska, Tsmots, 2011; Voloshyna, 2011; Hiltunen, 2008; Lysenko, Rudenskyi, Yehorova, *et al.*, 2009) the authors developed specific methods for detection and processing of weak signals of potential phenomena, which are characterized by a significant theoretical and practical value. However, the results of the study of literature (Baklan, Poplavska, Tsmots, 2011; Voloshyna, 2011; Hiltunen, 2008; Lysenko, Rudenskyi, Yehorova, *et al.*, 2009; Ansoff, 1988; Ansoff, 2007; Harper, Glew, 2008; Hiltunen, 2008; Hiltunen, 2007; Rebernik, 2000; Kuokkanen, 2009; Potocan, 2002; Richter, 1996; Rudenskyi, 2009; Voloshyna, 2010) showed that at present the scope of diagnostic of weak signals of the functioning environment as key indicators of its uncertainty is less explored, so diagnosis of enterprises under the conditions of uncertainty is complicated by such problems as:

- current methodical base in the diagnosis of weak signals of functioning environments is underdeveloped, as it is characterized by a small number of specific methods and techniques for identification, assessment and processing of weak signals in the environment of operation and their insufficient substantiation;
- existing diagnostic methods and techniques of weak signals, are not usually characterized by systemic and complexity, have narrow functionality (focused on a certain assignment in terms of some study of weak signals), which makes impossible their consistent and interconnected use on one object research;
- much of diagnostic methods and techniques of weak signals are characterized by cybernetic approach to the identification and processing of weak signals that is too complicated to use on different enterprises, requires a high level of expertise and experience in the relevant field, special software, etc;
- existing diagnostic methods and techniques of weak signals almost do not disclose the quantitative impact of potential impact of the phenomena identified by their weak signals on

the performance of companies that respectively increases the risk of unjustified economic position of developing responses to changes of operating conditions of enterprises;
- some weak signals diagnostic methods do not take into consideration the impact of factors of internal environment as sources of weak signals, which indicates incompletness of these methods and so on.

Suggested technique of diagnostics of enterprises activity under the conditions of uncertainty, unlike the existing instruments in this area, aimes at addressing the problems outlined above, since it involves implementation of complex, coherent, cohesive and applicale diagnostic procedures, it allows us to not only identify weak signals in operating environment for early identification of potential conditions, opportunities or threats, but also assess the probability of their impact on the effectiveness of certain activity of business.

Using the proposed method of diagnostics of enterprises under the conditions of uncertainty brings us the following benefits:

- in terms of highly dynamic operating environment it provides early indication of all the potential effects on the basis of identification and predictive interpreting of weak signals that mark their occurrence and thus forms a considerable time allowance for reasonable development and timely decision-making on the use of identified opportunities or threats for operating conditions of the company;
- reduces the level of uncertainty of the operating environment by processing all unclear and incomplete reports on possible changes in operating conditions and prognostic supplement of their essence in order to create on this basis a reasonable information base regarding the potential occurrence of specified events in the future of the enterprise;
- in terms of increased competition in the market serves as an effective instrument for obtaining new competitive advantages and saving existing ones, increasing the level of use of promising opportunities and avoiding threats to the competitive environment on the basis of their timely identification and more adequate consideration of the future of the company compared to its competitors.

CONCLUSION

According to the results of the research, we found that in the current highly dynamic and unpredictable operating environment, most companies do not possess adequate diagnostic tools to ensure stable operation in an uncertain environment. With this purpose we developed a special method of diagnostics of enterprises operating under the conditions of uncertainty, which aims to identify weak signal of operating environment as an early indicator of potential events with a view to timely identifying appropriate opportunities or threats for the operating conditions of the entity and assessing their impact on the efficiency of the company.

On the basis of the proposed method we performed diagnostic study of the operating environment of PJSC 'Bulat' during January–June 2016, which resulted in identified priority weak signal "Main competitor Ltd "Foundry-Mechanical Plant Ispolin" plans to carry out an identical activity of processing and coatings metals"; identified probabilistic ways of development of this weak signal to alternative strong signals about future changes in the environment of operation of PJSC 'Bulat'; we identified the most probable strong signals, including "The competitor will get a small market share of PJSC 'Bulat'", "A competitor can not seize market share of PJSC 'Bulat'"; we identified all potential threats and conditions that may occur at the appropriate signals and determined the most likely threat to the slight decrease in market share of PJSC 'Bulat'; identified the receptor of the identified threats (marketing activities of the company) and the indicator representing its impact on the effectiveness of marketing activities (income from sales of enterprise); established the most probable range of variation of monthly income from sales PJSC 'Bulat' due to the impact of threats – [232,915-250,178] UAH.

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