

STRATEGIC DECISION MAKING IN THE INCENTIVES CHANGES EARLY WARNING AND RESPONSE SYSTEM

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ПРИЙНЯТТЯ СТРАТЕГІЧНИХ РІШЕНЬ В СИСТЕМІ РАННЬОГО ПОПЕРЕДЖЕННЯ І РЕАГУВАННЯ НА ЗМІНИ ЕКОНОМІЧНИХ СТИМУЛІВ

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Summary. The probability evaluation mechanism of changes in economic incentives and associated risks is developed. It provides an opportunity to manage the corporate development strategy and its current implementation. Expert determination of the amount of loss or lost profit due to the economic incentives changes according to existing or alternative enterprise development strategy with a certain confidence level and decision making about the appropriateness of changing the corporate strategy is suggested. The proposals on formation of methodical approach to economic risks assessment are given. It allows to provide reliable quantitative risk assessment of the corporate development strategy implementation using mathematical apparatus of the generalized fuzzy numbers theory, even when expert groups are formed by specialists with different experience and professional level.

Key words: strategic decisions, early warning and response system, incentives, strong signals, weak signals, fuzzy numbers, probability.

Анотація. Розроблено механізм оцінки ймовірності змін економічних стимулів та пов'язаних з ними ризиків, який надає можливість управляти стратегією розвитку підприємства та її поточною реалізацією. Запропоновано визначати експертним методом з певним рівнем впевненості величину шкоди або упущеної вигоди від зміни економічних стимулів за існуючої або альтернативної стратегії розвитку підприємства та приймати рішення щодо доцільності зміни корпоративної стратегії. Надано пропозиції щодо формування методичного підходу до оцінки економічних ризиків, який дозволяє на основі застосування математичного апарату теорії узагальнених нечітких чисел надати достовірну кількісну оцінку ризику реалізації стратегії розвитку підприємства, навіть коли експертні групи сформовані з фахівців із різним досвідом і рівнем професіоналізму.

Ключові слова: стратегічні рішення, система раннього попередження і реагування, стимули, сильні сигнали, слабкі сигнали, нечіткі числа, ймовірність.

Introduction. The problems of the corporate early warning and response system development were reflected in many research papers, in particular by A. Cevolini, R. Poli, S. Haji-Kazemi, E. Arica, M. Semini, E. Alfnes, B. Andersen, O. Kuzmin, M. Adamiv, V. Lytvyn, O. Tsmots, O. Melnik, S. Pavlovskyi, O. Tereschenko and others. However, attention needs to be paid to the timely risk identification of economic incentives changes, for example, rates on bank loans and tax conditions, probability assessment of their occurrence and, on this basis, management of the corporate development strategy and its current implementation.

The early warning indicators values may be influenced by changes in several economic incentives, as well as by other corporate environment factors. The probability of changes in individual economic incentives and factors is not the same. Changes in individual economic incentives and factors can have both positive and negative impact on the early warning indicators values and the target integral indicator of the corporate development. It requires using operational and strategic responses, that are systemically interconnected.

The system of early warning and response to economic incentives changes is inherently a subsystem of the overall corporate early warning and response system. Not all factors can always be used by the management as incentives for corporate development, but in any case, the risks arising from these factors must be identified and evaluated in a timely manner. On this basis, a set of appropriate responses should be developed.

Thus, the purpose of the study is the early warning system formation for economic incentives changes by weak and strong signals and development of strategic and operational responses.

The main chapter. Influence combinations of economic incentives and other institutional environment factors cannot be reduced to the mathematical sum of these effects, because in this case attention isn't paid to qualitative changes that require adjusting the accepted corporate development strategy or even switching to another one. Response measures to changes in individual economic incentives and factors of external and internal corporate environment usually require using time, financial, material and human resources. Thus, decision on response measures development, not to mention their implementation, a priori cannot be made on the basis of achievement of the established thresholds by an early warning indicator due to the effect of each individual incentive or other factor.

First of all, it is necessary to evaluate quantitatively the cumulative effect of economic incentives changes on the early warning indicators values. It is worth paying attention to the fact that the early warning indicators are not universal for the economic incentives. In particular, they differ significantly in terms of credit and tax incentives, endogenous and exogenous factors.

Predictability of changes in economic incentives by weak signals is probabilistic. Therefore, a decision making person (DMP) should determine minimal occurrence probability of an event that requires responses. This limit probability value should be applied not only to the occurrence or change of each individual incentive but also to their quantitative cumulative effect.

Solving this problem requires using only basic mathematical apparatus of probability theory. Exogenous economic incentives are mostly independent of each other. In other words, the occurrence or change of one stimulus does not affect the transformation probability of another one. For example, the establishment of state compensation for loans (event A) does not affect change in the discount rate and the banking institutions credit rates (event B). Thus, the probability of these two independent events simultaneous occurrence is evaluated as their probability multiplication:

$$P(A \cap B) = P(A) \times P(B), \quad (1)$$

where $P(A \cap B)$ is the probability of two independent events simultaneous occurrence;

$P(A)$ is the event A probability;

$P(B)$ is the event B probability;

The aggregate probability of several simultaneous, unrelated changes in economic incentives A_i is calculated as follows:

$$P\left(\prod_{i=1}^n A_i\right) = \prod_{i=1}^n P(A_i) \quad (2)$$

Proceeding from the given formulas, the probability of simultaneous change in two (several) economic incentives may not correspond to the limit value defined above, according to each individual incentive. Under these circumstances, decisions on the responses development expediency should be made on the basis of the impact on the early warning indicator of the most likely event or several events with high probability of simultaneous occurrence.

Changes in incentives that have a negative impact on the financial position of the company require the development of response measures, regardless of whether or not they are compensated by other positive changes in incentives. This is explained by the risks of non-use, further deterioration or cancellation of effective corporate development incentives and the threat of further negative trends in the future. Therefore, it is expedient to carry out probability operations separately for changes in incentives that have positive and negative impacts on the

early warning indicators. Exception to this rule is logical for high cost of measures necessary to maintain the acceptable indicator values under conditions of economic incentives deterioration and for significant differences between the resource requirement for the implementation of these measures and their involvement opportunities.

Changes in exogenous and endogenous incentives are mutually compatible events. In other words, the onset of an event affects the second one. Thus, the probability of their compatible occurrence can not be calculated on the basis of the formula (1). For example, the deterioration of such an internal incentive for corporate development as creditworthiness (borrower class) due to the endogenous factors under the conditions of the National Bank discount rate increasing.

In this case, the simultaneous occurrence probability of two mutually compatible events is defined as the probability multiplication of the first event onset by the second one if the first one happens:

$$P(A \cap B) = P(A) \times P_A(B), \quad (3)$$

where $P(A \cap B)$ is the simultaneous occurrence of two compatible events;

$P(A)$ is the probability of the event A occurrence;

$P_A(B)$ is the probability of the event B if the event A already takes place.

In case of several compatible changes in economic incentives A_i , their aggregate probability is determined by the following formula:

$$P\left(\prod_{i=1}^n A_i\right) = P(A_1) \times P_{A_2}(A_1) \times P_{A_3}(A_1 \times A_2) \times \dots \times P_{A_n}(A_1 \times A_2 \times \dots \times A_{n-1}) \quad (4)$$

Specific probability assessment mechanism should be applied to interconnected incentives that functionate efficiently only when combined. Usually the basis of such incentives is a certain legal norm and its implementation mechanism. The corporate stimulation practice has a lot of examples when the imperfection of subordinate normative acts significantly reduces and sometimes even nullifies the establishment effect of economic incentives provided by the current legislation. This include in particular the burdensome automatic VAT refund procedure for exporters in the recent past regarding their breakeven and compliance with certain wage criteria as well as the practical absence of the tax bills implementation mechanism for Ukrainian shipbuilding enterprises. The implementation probability of such interconnected incentives should be determined by an event with the least predictable probability.

Upon reaching the limit values of the early warning indicators, decisions on response measures development, financing and implementation can be made only within the framework of the selected corporate development strategy. For credit incentives this includes measures to increase the company's creditworthiness, ensure compliance with the conditions for providing interest payments compensation on loans and the use of alternative sources of funding. Changing the corporate development strategy requires not only the information on the individual early warning indicators values. However, on the basis of such information, it is legitimate to ask questions about the appropriateness of adjusting or changing the strategy (for example, in terms of changing the capital structure).

In order to justify strategic decisions it is necessary to apply an integral target indicator of the corporate economic development and reliable methods for assessing the risks of existing and alternative strategies implementation. The publication [1, Rogov, 2017] proved the expediency of orienting the company to maximize its value. However, the well-grounded early warning indicators of changes in economic incentives are the results of decomposing integral indicators determined on the basis of cost approach. The system of indicators includes the structure and value of capital, financial results of the entity and key characteristics of its financial position which determine the risks of obtaining envisaged by the corporate strategy future cash flows.

In modern realities strategies are formed in the form of a strategic set that includes the overall corporate strategy as well as strategies in business directions, functional subsystems and

resources used. Hence the question arises, the risks of which strategy should be evaluated. The answer to it logically follows from the essence of economic incentives and the integral target indicator of the corporate economic development. Undoubtedly, the strategic vision of the company is determined by the market needs and, taking into account the financial capabilities of the company, finds its detailed reflection in the marketing strategy. On this basis, a general strategy is formed from such alternatives as growth, stabilization of rates and forms of development, restructuring, reduction of activity and its liquidation. Its purpose is described by the change trajectory of the economic development integral indicator during the long-term planning period.

Economic incentives primarily affect the rationale for selection and implementation of a financial strategy, the core of which is capital structure optimization, its funding cost minimization and cash flows balancing. The remaining strategies in addition to general, marketing and financial one perform a security function. Thus, precisely because of the financial strategy risks assessment on the basis of determining the impact of economic incentives on the target integral indicator, it is possible to establish the general corporate strategy implementation probability.

The risk assessment reliability of the corporate strategy implementation depends crucially on the validity of the valuation method. Forecasting of changes in economic incentives for corporate development is a complex system. It is carried out expertly under conditions of uncertainty. It is extremely difficult for each expert to give an accurate probability assessment of an event. Such tasks are successfully solved by using methods of the fuzzy sets theory. However, experts' experience, professionalism and therefore their confidence in own forecasts often differ significantly. So when selection opportunities of experts are limited to the company staff, even verbal assessment may be problematic. To solve this problem, it is expedient to use the mathematical apparatus of the generalized fuzzy numbers theory. It has been recently widely covered in scientific publications [2; 3; 4; 5].

According to the author of the theory Chen S. H., the generalized fuzzy number for the trapezoidal function R is a fuzzy subset of R , whose membership function ($u_A(x)$) is described as follows [3, 2006, p. 1756]:

- $u_A(x)$ is a continuous projection of R on the segment $[0; w]$, $0 \leq w \leq 1$;
- $u_A(x) = 0$ for all $x \in (-\infty, a)$;
- $u_A(x)$ continuously increases on the segment $[a, b]$;
- $u_A(x) = w$ for all $x \in (b, c)$, where w is a constant and $0 \leq w \leq 1$;
- $u_A(x)$ continuously decreases on the segment $[c, d]$;
- $u_A(x) = 0$ for all $x \in (d, +\infty)$;

a, b, c, d are valid numbers, $a \leq b \leq c \leq d$;

w – confidence degree of the decision making person.

The definitions are illustrated in the Figure 1 for two trapezoidal generalized fuzzy numbers $A=(0,1; 0,2; 0,3; 0,4; 1,0)$ та $B=(0,1; 0,2; 0,3; 0,4; 0,8)$.

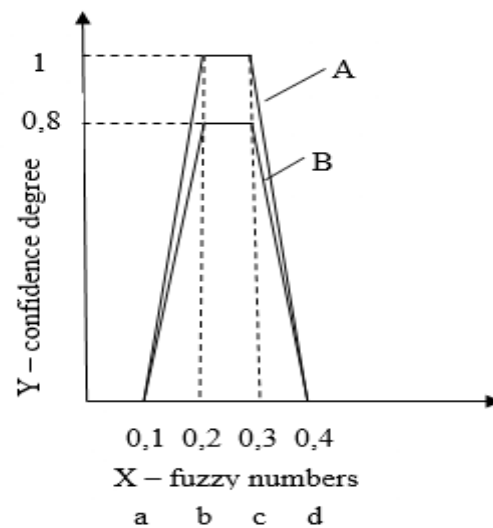


Fig. 1: Generalized fuzzy numbers

Source: [3, p. 1756].

Mathematical operations with generalized fuzzy numbers $A = (a_1, a_2, a_3, a_4, W_A)$ and $B = (b_1, b_2, b_3, b_4, W_B)$ are shown in the Tab. 1.

Tab. 1: Mathematical operations with generalized fuzzy numbers

Arithmetic operations with generalized fuzzy numbers. a) addition $A + B = (a_1 + b_1; a_2 + b_2; a_3 + b_3; a_4 + b_4; \min(W_A, W_B)).$ b) subtraction $A - B = (a_1 - b_1; a_2 - b_2; a_3 - b_3; a_4 - b_4; \min(W_A, W_B)).$ c) multiplication $A \cdot B = (a_1 \cdot b_1; a_2 \cdot b_2; a_3 \cdot b_3; a_4 \cdot b_4; \min(W_A, W_B)).$ d) division $A / B = (a_1 / b_1; a_2 / b_2; a_3 / b_3; a_4 / b_4; \min(W_A, W_B)).$	Standardization of each generalized fuzzy number component a_{ij}^* : $a_{ij}^* = \frac{a_{ij}}{k},$ where $k = \max_{ij}(a_{ij}, 1)$ Generalized fuzzy number average value: $\chi_{Ai} = \frac{a_{i1}^* + a_{i2}^* + a_{i3}^* + a_{i4}^*}{4};$
Arithmetic operations with graded average integration a) addition $A + B = (P(A) + P(B); \frac{W_A + W_B}{2}).$ b) subtraction $A - B = (P(A) - P(B); \frac{W_A + W_B}{2}).$ c) multiplication $A \cdot B = (P(A) \cdot P(B); \sqrt{W_A \cdot W_B}).$ d) division $A / B = (\frac{P(A)}{P(B)}; \frac{\min(W_A, W_B)}{\max(W_A, W_B)}).$	Graded average integration of generalized fuzzy numbers A and B: $P(A) = \frac{a_1 + 2a_2 + 2a_3 + a_4}{6}, P(B) = \frac{b_1 + 2b_2 + 2b_3 + b_4}{6}$

Source: based on [3; 4; 5].

When using the mathematical apparatus of the generalized fuzzy numbers theory to determine the implementation risk of existing or alternative corporate development strategy, a

decision making person should take into account the problem specificity, the phased solution process, which is presented in the Figure 2.

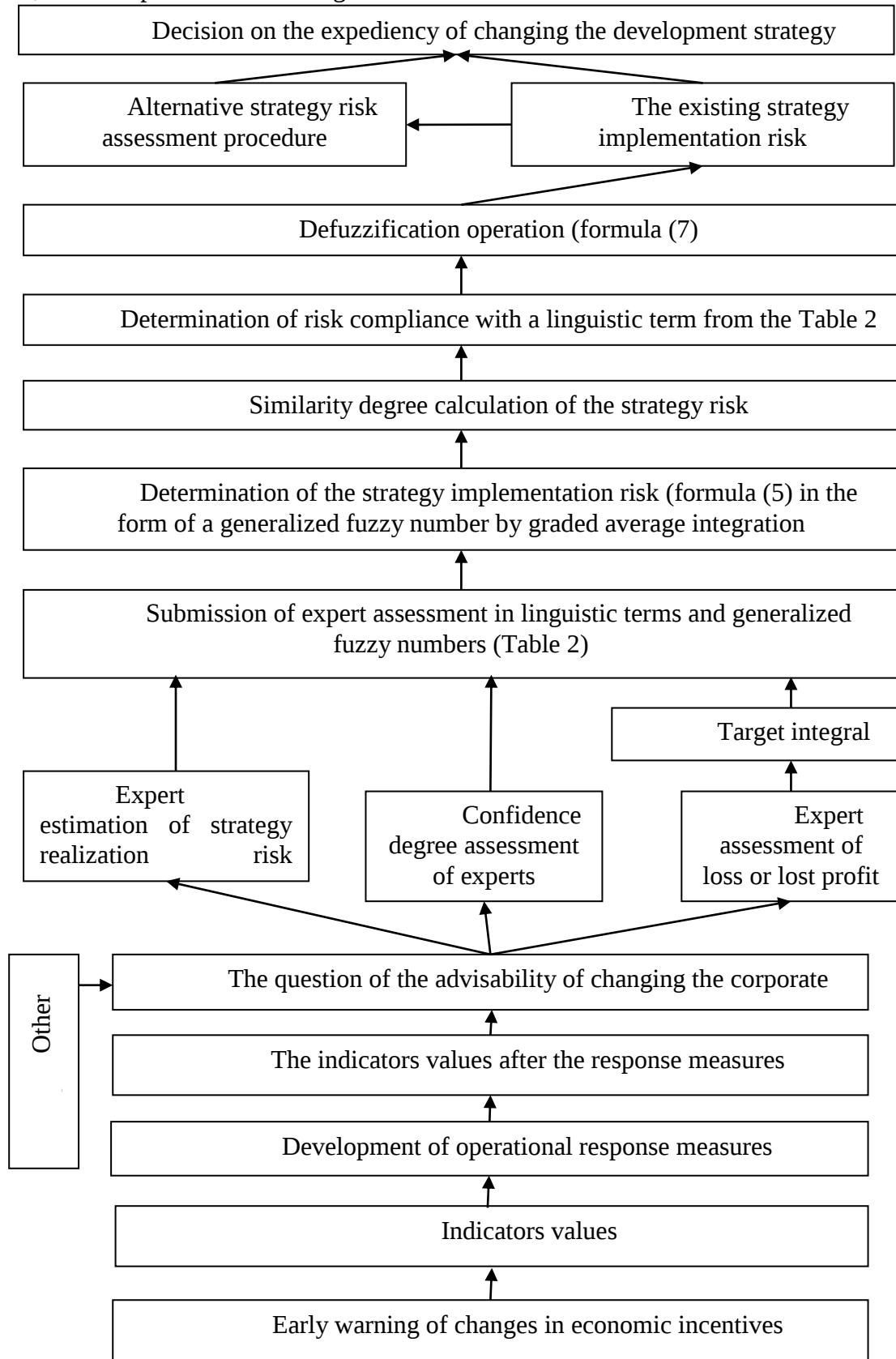


Fig. 2: Determination of a corporate strategy implementation risk

Source: compiled by the author.

The starting point is a set of linguistic terms that characterize three necessary linguistic variables. Two of them, namely, "The corporate development strategy implementation risk", "Risk implementation probability of changes in economic incentives and enterprise institutional

environment factors" are universal. The third one depends on the impact of economic incentives and institutional environment factors on the target integral indicator value of the corporate development.

The formulation of the question of changing the corporate development strategy is meaningful only if there is a significant positive or negative impact of the economic conditions transformation. If influence is negative, there is necessity to assess the existing strategy implementation risks, based on projected loss from changes in economic incentives or enterprise institutional environment factors. In case of positive impact, lost profit for maintaining the existing strategy should be estimated.

Impact assessment of incentives should be made on the basis of the rules mentioned above and mathematical operations with generalized fuzzy numbers (Table 1). When implementation risk of the existing strategy is high, it is also advisable to assess risks of alternative strategies. If an alternative strategy is oriented to achieve higher integral indicator values of the corporate development than the existing one, its realization risk should be evaluated under the conditions of negative changes in corporate environment. If an alternative strategy is not able to provide satisfactory financial results, positive trends in corporate environment should be considered. Thus, the third linguistic variable in the general form can be defined as follows: "The amount of loss or lost profit from economic incentives change under the existing strategy or applying an alternative strategy for corporate development".

In the generalized fuzzy numbers theory a nine-digit set of linguistic terms that characterize linguistic variables is used (Tab. 2).

Tab. 2: The set of linguistic terms that characterize variables

№	Name of the linguistic term	Generalized fuzzy numbers
1	Extremely low	(0,0; 0,0; 0,0; 0,0; 1,0)
2	Very low	(0,0; 0,0; 0,02; 0,07; 1,0)
3	Low	(0,04; 0,1; 0,18; 0,23; 1,0)
4	Quite low	(0,17; 0,22; 0,36; 0,42; 1,0)
5	Average	(0,32; 0,41; 0,58; 0,65; 1,0)
6	Quite high	(0,58; 0,63; 0,80; 0,86; 1,0)
7	High	(0,72; 0,78; 0,92; 0,97; 1,0)
8	Very high	(0,93; 0,98; 1,0; 1,0; 1,0)
9	Extremely high	(1,0; 1,0; 1,0; 1,0; 1,0)

Source: [3, 2006, p. 1759].

On the basis of data of the incentives changes early warning and response system and information about other institutional environment factors, guided by the Table 2, experts should give verbal risk assessment of the corporate development strategy and its consequences as loss or lost profit. It should be noted that the amount of loss or lost profit is initially estimated quantitatively by changes in the integral target indicator of economic corporate development using the standardization method (Table 1) and only then determined in the linguistic form. When assessing the occurrence probability and loss or lost profit for each risk factor i , experts should determine self-confidence degree (w_i).

The next step is the strategy implementation risk evaluation in the form of a generalized fuzzy number or by graded average integration. For this purpose, the weighted average risk probability (R) is calculated [3, 2006, p. 1760]. The weighing factors are amounts of loss and lost profit (V_i):

$$R = \frac{\sum_{i=1}^n P_i \cdot V_i}{\sum_{i=1}^n V_i}, \quad (5)$$

At the next stage of calculations it is necessary to determine the similarity degree of the strategy implementation risk level with each linguistic term from the nine-digit set of linguistic variable "The corporate strategy implementation risk". The strategy implementation risk level is convenient to represent as a generalized fuzzy number: (a, b, c, d, w_R) . The value of R should be expressed through the graded average integration $(P(R), w_R)$ for accurate mathematical calculation.

The similarity degree of the strategy implementation risk level with linguistic terms $(S(R, T_i))$ is calculated by the formula [3, 2006, p. 1759; 5, 2018, p. 148]:

$$S(R, T_i) = \frac{1}{1 + |P(R) \times w_R - P(T_i) \times w_{T_i}|}, \quad (6)$$

where $P(R)$ is graded average integration of the strategy implementation risk level;

$P(T_i)$ is graded average integration of the i -th linguistic term;

w_R and w_{T_i} are the DMP confidence degrees in the assessment of R and T_i respectively.

The similarity degree for identical generalized fuzzy numbers is equal to one. Consequently, the corporate development strategy implementation risk level corresponds to the linguistic term from a nine-digit set of a linguistic variable with the maximal value of $S(R, T_i)$.

In order to translate verbal risk strategy implementation assessment to quantitative, defuzzification operation should be performed. It is transformation of a generalized fuzzy number into a valid one. Defuzzification operation is carried out by known methods of the fuzzy sets theory. When using the centroid method, the defuzzification result (Y) is calculated by the formula:

$$Y = \frac{\int_{\min}^{\max} x \times u(x) dx}{\int_{\min}^{\max} u(x) dx}, \quad (7)$$

where x is the linguistic variable "The corporate development strategy implementation risk". It takes values in the range of the generalized fuzzy number of the linguistic term, determined on the basis of the similarity degree calculation $(S(R, T_i))$;

$u_A(x)$ is a fuzzy set membership function.

On the basis of the defuzzification value (Y), it is possible to make a decision with sufficient reliability about changing the corporate development strategy to more aggressive (when economic incentives have a positive impact on the integral indicator) to more cautious (when the impact is negative).

Conclusions. In case of significant impact of incentives it is important to consider the question of changing the corporate development strategy. Changes in incentives that have a negative impact on the financial position of the company require the development of response measures, regardless of whether or not they are compensated by other positive changes in incentives. Forecasting of changes in economic incentives for corporate development is carried out expertly under conditions of uncertainty. Expert evaluation is provided in linguistic terms and generalized fuzzy numbers. The next stage is the strategy implementation risk determination in the form of a generalized fuzzy number by graded average integration. In order to translate verbal risk strategy implementation assessment to quantitative, defuzzification operation should

be performed. On the basis of the defuzzification value, it is possible to make a decision with sufficient reliability about changing the corporate development strategy.

References:

- [1] Rogov, V.H. (2017). Maksymizatsiia vartosti pidpriemstv sudnobuduvannia yak kryterii efektyvnosti stymuliuvannia yikhnoho rozvytku [Maximizing the value of shipbuilding enterprises as an effectiveness criterion for their development stimulation]. *Stratehichni oriientyry rozvytku natsionalnoi ekonomiky v umovakh permanentnykh kryzovykh yavysch – Strategic benchmarks for the national economy development in permanent crisis mode*, 56-57 [in Ukrainian].
- [2] Su, X., Jiang, W., Xu, J., Xu, P., Deng, Y. (2011). A New Fuzzy Risk Analysis Method based on Generalized Fuzzy Numbers. *Journal of Software*, 6(9), 1755-1762 [in English].
- [3] Chen, J.H., Chen S.H. (2006). A new method for ranking generalized fuzzy numbers for handling fuzzy risk analysis problems. *Proceedings of the Ninth Conference on Information Sciences*, 1196-1199 [in English].
- [4] Deng, Y., Su, X., Jiang, W., Xu, J., Xu, P. (2010). Risk Analysis Method: A Fuzzy Approach. *Proceedings of the 3rd International Symposium on Electronic Commerce and Security Workshop, Guangzhou, China*, 146-150 [in English].
- [5] Wu, D., Liu, X., Xue, F., Zheng, H., Shou, Y., Jiang, W. (2018). Fuzzy risk analysis based on a new method for ranking generalized fuzzy numbers. *Iranian Journal of Fuzzy Systems*, 15(3), 117-139 [in English].

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