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MAXIMUM ALLOWABLE RISK IN DECISION MAKING PROCESS

Abstract. In the article it is analyzed the opportunity to lead the system with maximum permissible risk, as a part of the chain of interrelated notions: goals, ways, means, and risk; it is determined, that risk-taking increases the adaptability of the system, opens the system for innovations, allows achieving established goals by less means and more simple ways; it is stated that location in the sensitive framework of stepwise of taking of maximum permissible risk, according to the minimax criteria, makes the system secure; it is argued that maximum permissible risk in decision-making process reduces the overall risk of system functionality; it is proposed the algorithm to lead the system with a maximum permissible risk as a theoretical and practical model to lead the system effectively.

Keywords: decision-making process, maximum permissible risk, minimax criteria, an algorithm to lead the system with a maximum permissible risk, leadership of the system.

ГРАНИЧНО ДОПУСТИМИЙ РИЗИК У ПРОЦЕСІ ПРИЙНЯТТЯ РІШЕНЬ

Анотація. У статті проаналізовано можливість керівництва системою з гранично допустимим ризиком як складової взаємопов'язаних понять: цілі, шляхи, засоби, ризик; визначено, що застосування ризику збільшує адаптивність системи, відкриває систему для інновацій, дає можливість досягти поставлених цілей із затратою менших коштів і більш простішими шляхами; вказано, що покрокове прийняття граничного ризику відповідно до мінімаксного критерію робить систему захищеною; аргументовано, що граничний ризик у процесі прийняття рішень зменшує загальний ризик функціональності системи; запропоновано алгоритм керівництва системою з гранично допустимим ризиком як теоретичної та практичної моделі для ефективного керівництва системою.

Ключові слова: процес прийняття рішень, гранично допустимий ризик, мінімаксний критерій, алгоритм керівництва системою з гранично допустимим ризиком, управління системою.

ПРЕДЕЛЬНО ДОПУСТИМЫЙ РИСК В ПРОЦЕССЕ ПРИНЯТИЯ РЕШЕНИЙ

Аннотация. В статье проанализирована возможность руководства системой с предельно допустимым риском как составляющей взаимосвязанных понятий: цели, пути, средства, риск; определено, что применение риска увеличивает адаптивность системы, открывает систему для инноваций, позволяет достигать поставленных целей с затратой меньших средств и более простыми путями; указано, что нахождение в чувствительной рамке пошагового принятия предельного риска относительно с минимаксным критерием делает систему защищенной; аргументировано, что предельный риск в процессе принятия решений уменьшает общий риск функциональности системы; предложен алгоритм управления системой с предельно допустимым риском как теоретической и практической модели для эффективного руководства системой.

Ключевые слова: процесс принятия решений, максимально допустимый риск, минимаксных критерий, алгоритм управления системой с предельно допустимым риском, управления системой.

Target setting. The need of quick changes under influence of the environment, fear of change increase effectiveness of an organization, society, a government (system) and do not allow achieving the goal even with enough means and ways. Notions such as ends, ways and means with a possible permissible level of risk are fundamental in the decision-making process (DMP). In case of lack of means and measured ways, achievement of the goal becomes problematic without taking increased risk. Thus, risk is an important part of any decision.

Analysis of the recent research and publications. Scientists identify and analyze the factors that may affect the use of risk, decision-making process, a leader's ability to achieve the goal successfully when risk may be relative and changeable.

B. Fischhoff suggests that people "often take the form of risk comparison, in which an unfamiliar risk is contrasted with a more common use." But "risk decisions are not about risks alone. One can accept large risks if they bring large benefits and reject small risks if they bring no good [5, p. 141]." The Sandman, Covello and Slovic guide to risk comparison tells that "use of data in this table for risk comparison purposes can severely damage your credibility [13]"

D. Bernoulli argued that the perceived risk of each, on its own way, cannot be assessed equally. The assessment of the utility of goods is not a simple linear function and depends on the person who is in a risky situation. Thus, knowledge of the price and the probability is not always sufficient for the outcome of the value because the usefulness in a particular case may depend on the subject, who makes evaluation.

And each subject responds to risk in accordance with its system of values [1, p. 49–50].

D. Bernoulli suggested that "there is no reason to assume that of two persons encountering identical risks ether should expect to have his desires more closely fulfilled, the risks anticipated by each must be deemed equal in value." In 1738 Bernoulli published the article "The presentation of a new theory on the risk dimension" [1], where he formulated his famous paradox: the price at which a coin thrown is inadequate to average cash prize. He puts forward the idea that the value of something should not be the basic price, but rather the usefulness of which is associated with the desirability or pleasure.

J. Neumann and O. Morgenstern [12] developed Bernoulli's idea and proposed that if a player can always arrange such fortuitous alternatives in the order of his preferences, then it is possible to assign to each alternative a number or numerical utility expressing the degree of the player's preference of that alternative. The assignment is not unique but two such assignments must be related by a linear transformation.

The Neumann-Morgenstern utility theorem shows that, that under a certain rational behavior, a decision-maker, faced with risky (probabilistic) results of different choices, while he maximizes the expected value of a specific action (function) over the potential results in a particular point in the future. This function is known as the Neumann-Morgenstern utility function. This theorem is the basis for the expected utility theory.

In 1947, J. Neumann and O. Morgenstern proved that any individual preference has the utility function. Individual's preferences can be represented on an interval scale. The individual will always prefer actions that maximize expected utility.

Last the most significant study of human behavior in terms of risk and uncertainty was accomplished by psychologist D. Kahneman and A. Tversky. For the best known their "Prospect Theory" D. Kahneman was awarded by the Nobel Prize in Economics in 2002. The most important result of "Prospect Theory" is a phenomenon of asymmetry in decision-making — to achieve a prize, and solutions to prevent loss.

D. Kahneman and A. Tversky in their "Prospect theory" confirm that "People underweight outcomes that are merely probable in comparison with outcomes that are obtained with certainty. This tendency, called the certainty effect, contributes to risk aversion in choices involving sure gains and to risk seeking in choices involving sure losses. In addition, people generally discard components that are shared by all prospects under consideration. This tendency, called the isolation effect, leads to inconsistent preferences when the same choice is presented in different forms [6, p. 263]."

The purpose of the article — by analyzing the DMP identify possible ways and levels of possible permissible risk, using a sensitive approach to a permissible risk in a dynamic and changeable environment. The DMP does not look rational in this environment because of complexity and big amount of players. The DMP under changeable levels of risk can be carried out step by step, short phases like a rational process for each step, but not a

rational for the whole process. Overall, the way of actions may seem irrational, but effective according to the minimax criteria. Each phase of the DMP will be the most rational. This rationality may require increased, but permissible risk.

The statement of basic materials. In condition of the complex changeable environment decision-makers should pay more attention to risk-taking. To balance ends, ways and means in the framework of permissible risk is fundamental in order to achieve the goal. The task is to find appropriate ways to achieve the end-state by available means without losing system functionality. Decision-makers often play with ends, ways and means to decrease risk. Meanwhile, increased risk-taking can facilitate opening the system for adaptation when low risk may delay it. Thus, to provide required system effectiveness may require changing of the level of risk-taking.

Sensitive approach to risk-taking, as a part of the DMP, may facilitate more successful achieving the goal. The purpose of any DMP is to establish equilibrium between the system and the environment through system change, as adaptation, and/or shaping of the environment. It is possible to suppose that any goal is an artificially created subject to satisfy human needs through establishing this equilibrium.

In 1950, John Nash stated that "finite non-cooperative game always has at least one equilibrium point [11, p. 286]" at which all players choose actions, which are best for them given their opponents' choices. In our case, the system and the environment, like players, are always in the process of endless mutual influence. There is an equilibrium point when they are both satisfied by chosen actions.

It is possible to raise some questions about risk-taking. For instance, which level of risk is acceptable and how to determine it? In any case, the risk will be taken and the question is about its feasibility: do we need to do it in order to satisfy our ambitions, passion and wish? Will we save our system on the way of its development and adaptation? Is it possible to increase risk and when? How can it be connected with time and suitable conditions, which should provide synergy effect? Can it decrease means and simplify ways to achieve goals?

The research problem is to find a method to achieve the end-state by playing with risk in the DMP. It can be based on the mini-max criteria when the goal is achieved by minimum means and the simplest ways with maximum possible permissible risk. The authors propose call it the edge risk. *This risk is taken in a certain favorable moment in order to maintain system effectiveness.* The question is how to determine maximum possible permissible risk or the edge risk on each stage on the way of achievement of the goal.

Human freedom of actions may define risk-taking. P. Bernshtein stated that "the actions we dare to take, which depends on how free we are to make choices, are what the story of risk is all about. And that story helps define what it means to be a human being [2, p. 4]."

The laws of probability are the most powerful tool of risk management. Risk may be a possibility for the leader to make mistakes and still maintain system functionality. Then less prob-

ability of a mistake then lower risk is. "Not-acting has value. The more uncertain the outcome, the greater may be the value of procrastination [2, p. 15]."

The probability is measured. Gravity and probability should influence a decision... A decision should involve the strength of our desire for a particular outcome as well as a degree of our belief about the probability of that outcome [2, p. 71]. This statement may define the level of risk that a decision-maker is ready to take in order to achieve a desired goal.

Risk is a matter of human perception based on different biases, prejudices, illusions, previous experience and accepted samples. "The most critical decisions would be impossible without sampling [2, p. 73]." D. Kahneman states that "when an unpredicted event occurs, we immediately adjust our view of the world to accommodate the surprise [7, p. 197]." Therefore, it is possible to assume that the roots of risk-taking are located in human accepted samplings, which are essential in risk-taking. We use samples of the past and the present to guess about the future. With change of conditions, the level of risk may require revising also. It is possible to suggest that delay in risk-taking decreases system effectiveness. To maintain system balance or effectiveness, risk-taking in time may be much lower than risk-taking with delay. This approach allows saving means and simplifies ways to achieve the goal.

Hence, it is possible to assume that maximized permissible risk is a way to achieve the goal with less means and the easiest ways. There is always a room for risk-taking because of relativeness of the level of risk. It may depend on human perception about risk and underestimating of the system opportunities. Power of the system can be determined as multiplication of system mass and its acceleration ($P = m \times a$). A system mass (m) can be compensated by system acceleration (a) to produce the same power. Indeed, a big system is inertial and has lower acceleration.

Therefore, acceleration or time is an essential part of risk-taking. The problem is how to determine the level of permissible risk, as a time function, in conditions of environmental change. "Time is a dominant factor in gambling. Risk and time are opposite sides of the same coin. If there were no tomorrow, there would not be any risk. Time transforms risk, and the nature of risk is shaped by the time horizon: the future is the playing field [2, p. 15]." Thus, time becomes a key in risk-taking.

The moment of risk-taking may influence the outcome. There is a moment when the mutual conditions (system-environment) are the most favorable to make decision with the highest possible risk. Hence, time changes quality of the result and may create a decision highlight. This moment can correspond to taking of the maximum acceptable risk. It may allow getting maximum result through synergy effect when all conditions together facilitate achieving the end-state. It is like buying shares in the Stock Market, when the prices are minimum and selling them when the prices are maximum.

Decision is made naturally in order to get maximum result with minimum consumptions. Organizational culture may influence the level of risk-taking. To increase risk means to increase system acceleration in development, for

instance. In these conditions, a leader should imagine the future, open all communication lines, deliver messages simply and clearly, decide and act fast, create learning organizational culture with creativity and critical thinking.

A decision-maker looks for a decision to provide equilibrium between the system and the environment. The decision is based on current data, which is probably different with future data when the goal should be achieved. Hence, taking in account a delay between an environmental action and system reaction to this action, risk is a degree of difference between a probable future composition or simulation of the data and real future conditions to provide equilibrium. Ideally, to predict the future and act accordingly decrease risk to zero. On the other hand, misunderstanding of the future data may increase risk drastically, as an attempt to maintain equilibrium. This risk will be counted as an unjustified risk, which can destroy the system and not allow achieving the goal. But maximum acceptable risk may facilitate saving system effectiveness and achieving the goal successfully.

Implementation of the decision, which is based on the past or current data and the feedback loop, always creates a delay in system reaction or adaptation to the environmental change. Coefficient of dynamic equilibrium between the system and the environment (Keq) defines this delay [10, p. 9]. In the dynamic and changeable environment, the delay may decrease the system effectiveness and, eventually, destroy it. To control the system through monitoring the level of risk-taking is essential. Thus, understanding of possible change of risk in the framework of "ends – ways – means – risk" may be significant to increase system effectiveness.

New technologies and ways of communication can influence on samples and, hence, risk-taking. Artificially created samples of the future may be a key for risk-taking in order to achieve the goal by existing means and possible ways. The problem is to determine current level of risk-taking in order to achieve the goal in the future. On the way of achieving of the goal, existing conditions will transform to future conditions. Hence, during this transformation, risk-taking can be changed also. Thus, it is possible to assume that a sensitive and gradual approach to risk-taking may be important for the successful DMP.

There are some, proposed by authors, functions of connections and mutual dependencies among probability to achieve the goal, level of maintaining of system balance, maximum permissible risk (edge risk), and human perception.

$$\text{Probability to achieve the goal} = f(\text{Level of Maintaining of System balance}) \quad (1)$$

$$\text{Level of Maintaining of System balance} = f(\text{Speed of system adaptation } (K_{eq}) / \textit{Riskedge}) \quad (2)$$

$$\textit{Riskedge} = f(\text{Human perception} \times \text{System structure} \times \text{Leader}) \quad (3)$$

$$\text{Human perception} = f(\text{national and organizational culture, leader's previous experience and personal characteristics}) \quad (4)$$

From the function (2), it is possible to suppose that a high-speed adaptive system allows taking higher risk and still maintain system balance. In other

words, the adaptable and effective system allows taking high risk without fear. To balance ends, ways, and means with the edge risk in the current environment is a primary activity on each stage of achievement of the end-state. Changeable environment forces a leader to revise all of them regularly. It is possible to assume that the level of risk can be different for each stage because of human perception or leader's ability to take risk, environmental change and complexity, culture and structure of the system (fig. 1). Thus, in order to maintain equilibrium between the system and environment a leader should take different risks (for instance, *Risk*1, *Risk*2 or *Risk*3).

To take the edge risk in advance may provide effectiveness of the system when low risk may decrease this effectiveness. A vector of risk-taking in different moments of time shows the most effective way to achieve the goal (fig. 2). For description of this vector it is possible to apply the mini-max criteria when the goal can be achieved by taking of the edge risk and the use of minimum means with the simplest ways. Accordingly, the edge risk creates a paradox to achieve the goal successfully with high risk-taking than with low risk-taking.

This approach facilitates decreasing overall system risk because the system becomes open and adaptable through innovations and structural change. Thus, the system becomes a learning organization with high level of flexibility, decentralization and survivability. Moreover, the system has additional reserve means with simple and realistic ways to achieve the goal.

System balance and the edge risk stay on the opposite sides of the scale, but they work together to achieve the goal. To maintain minimum required balance and take the edge risk may create a learning organization (an adaptive system). It proves that the mini-max criteria is a right approach to maintain system effectiveness through step-leading with the edge risk.

According to P. Senge learning organizations are "organizations where people continually expand their capacity to create the results they truly desire, where new and expansive patterns of thinking are nurtured, where collective aspiration is set free, and where people are continually learning to see the whole together [14, p. 3]."

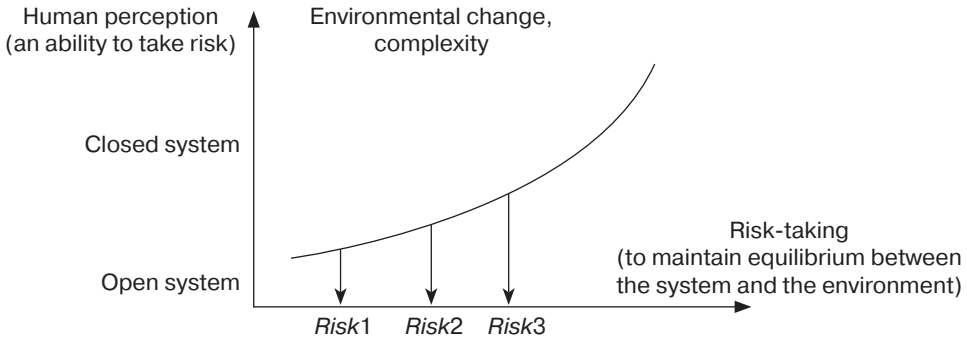

Fig. 1. **Risk-taking dependences**
Sources: created by Authors

A scheme of risk-taking in the DMP (fig. 2) is based on the mini-max criteria and directs the leader to adapt the system and/or shape the environment.

This approach may allow avoiding bifurcation points or revolutions on the way of system development and creating continuous balance through short steps like a digital net, which is invisible for the human awareness. This makes the system solid and highly adaptable to the environment.

The vector of risk-taking in the DMP (fig. 2) is based on taking a Risk "*x*" (R_x) that should be always very close to the edge risk. Thus, R_1, R_2, R_4, and R_5 (fig. 2) are equal or close to the edge risk in the given environment and in a certain moment. This approach may provide achievement of the goal by minimum means and the simplest ways.

Complex dynamic environment forces the system to be flexible and adaptable like a learning organization with leader's irrational view that challenges human perception and accepted samples and, therefore, motivates revising the level of risk-taking. To understand and feel the edge risk is a leader's quality, which may be developed.

How to determine the edge risk in the given environment, how to follow the line of this risk? It is a matter of clear understanding of the system and the environment through feedback and open communication lines. They can allow making the system available to take risk and survive. Risk-taking is a way to open the system and make it adaptable. However, on one hand, the edge risk-taking may maintain system functionality through opening of the system, and make it vulnerable, on the other hand.

The problem is to determine the edge risk and open the system as much as possible. A learning organization has very high level of the edge risk because it is maximally opened system through continuous feedback and participation in leadership all members of the system. Thus, a decision-maker has to maintain a certain level of risk in the DMP in order to achieve the goal. The mini-max

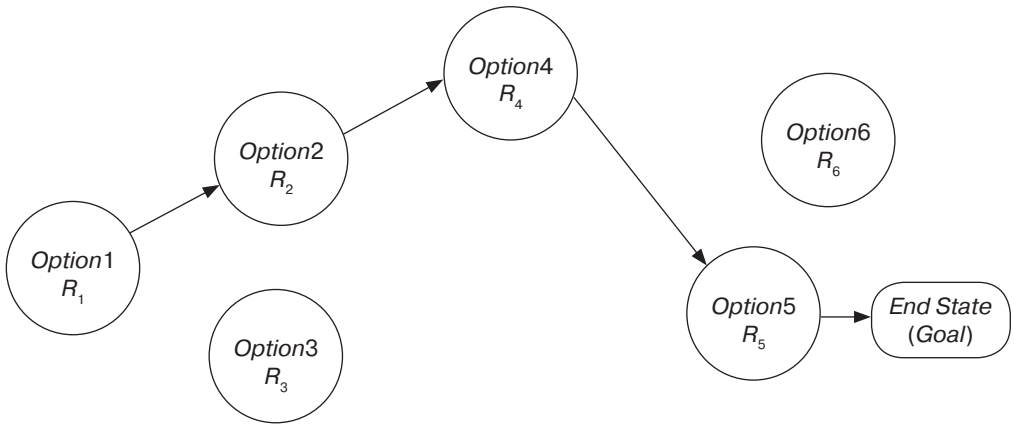

Fig. 2. **A scheme of risk-taking in the DMP**
Sources: created by Authors

criteria may provide an approach and mechanism how to do it.

How evaluate risk and to determine the edge risk? The authors propose that the edge risk can be determined as a function of equilibrium between the system and the environment.

$$Riskedge = f(1/K_{eq}). \qquad (5)$$

A learning organization, as a highly adaptive system, can prove this function. This system may have the lowest level of the edge risk because of continuous changes as graduate and short-step adaptation to the environment. The open or adaptive system (with high Keq) requires low level of the edge risk to restore equilibrium. A closed system can require taking higher edge risk than an open system to maintain equilibrium between the system and the environment. Big delay in adaptation increases the level of the edge risk. It can jeopardize the system functionality. On the other hand, taking the edge risk facilitates opening the system and, hence, decreases the level of general risk for the system.

Dynamic environmental change requires risk-taking to adapt the system. The notion of risk may be more important than existed means and ways because they can become obsolete as nonfunctional tools to maintain equilibrium, because lack of innovations as low risk-taking. In the changeable environment speed of reaction, time and favorable situation, as parts of risk, are getting primary to win.

Risk-taking is a leader's ability to think critically to understand mutual influence between the system and the environment. The right risk means risk, which corresponds to the current situation and the system in a certain moment. If there is no correspondence, the level of risk-taking may be lower or higher than the edge risk. It makes the system not effective because of more consumption of means and complicated ways to achieve the goal.

On the way of risk-taking it is important to recognize the edge risk and do not cross it. It is a fluctuation process, which depends on a level of mutual equilibrium between the system and the environment. If the system seeks equilibrium with the environment like a "roly-poly" toy there is no reason to take high risk. If the system is far away from the equilibrium, this condition can require taking increased risk in order to restore equilibrium. On the other hand, to keep system always in condition of change makes it vulnerable. To feel and understand risk, to take edge risk and stop it in time is an important leader's quality. Therefore, *to keep the system structurally solid is also profitable until the system will not achieve the critical low level of system effectiveness, which exactly corresponds to the need to take the edge risk in order to save required system functionality*. Thus, the system development may look like step by step process of adaptation with requirement to take the edge risk in a certain moment in order to provide maximum system effectiveness by minimum means and the simplest ways.

It is possible to suppose that risk-taking is a matter of satisfaction, perception and personality in the link of "a person — a society." The wish of satisfaction, as a trigger, motivates to take risk to restore or restore equilibrium. It puts forward the thesis that the value of something should not be the base price,

but rather the usefulness of which is associated with the use of the desirability or satisfaction [1, p. 22]. The motivation factors (psychological, moral, economical, level of life, recognition by others, social, passion, ambitions) are changeable because of human grow or development [8].

Human perception of risk is based on rules, samples, adapted standards and defines risk-taking as an action. Rules or samples originate from previous experience and correspond to the situation of the past. How far a decision-maker is ready to go from his/her experience and accepted standards may define the level of risk-taking. Sensitivity of the edge risk is a valuable leader's quality, which is connected with visualization of the future environment and an ability to leave past experience and accept new conditions. It presents an endless process of mutual adaptation between the system and the environment. It is a policy of survivability when old rules already started losing their relevance and new rules have not worked yet.

The personality and a level of responsibility may define an ability to make decision on the line of the edge risk. There may be diverse types of risk, for instance, personal, collective, emotional, moral, organizational, social, and economical risks. Level of responsibility may defer them or who will blame who in case of failure. Collective risk supposes shared responsibility about risk. Thus, types of risk may influence the DMP through the ability to take edge risk. Fear of risk depends on human perception, personal understanding of the situation, organizational and national culture, and expected stability.

In the DMP "risk and benefit are linked in people's perceptions and consequently in their judgments [4, p. 14]." On one hand, risk is also about what and how leader thinks, how energetic, optimistic and useful the proposed idea is.

On the other hand, risk — is also about what and how people think, how optimistic and motivated they are by the proposed idea. The power of idea realization is function of means and possible ways (*Force*) and human will ($P = Force \times Will$). Thus, it creates an energetic inspiration of success and power to change the system and/or move obstacles (to shape environment) with taking the edge risk, even if you do not have enough means today.

It is possible to assume that there are necessary and sufficient conditions of system effectiveness. The necessary condition indicates that the system is in balance (stability). Leadership power, styles and structural change can provide system balance [9, p. 72]. The sufficient condition indicates that equilibrium between the system and the environment is established or strives to it ($K_{eq} \rightarrow 1$). System adaptation and/or shaping of the environment may provide equilibrium. Risk-taking may facilitate establishing equilibrium.

Even if there is no enough level of equilibrium between the system and the environment, the system can be in balance, but starts losing effectiveness. Thus, only satisfaction of both conditions should provide required system effectiveness. An algorithm to lead the system with edge risk shows how to maintain system effectiveness (fig. 3).

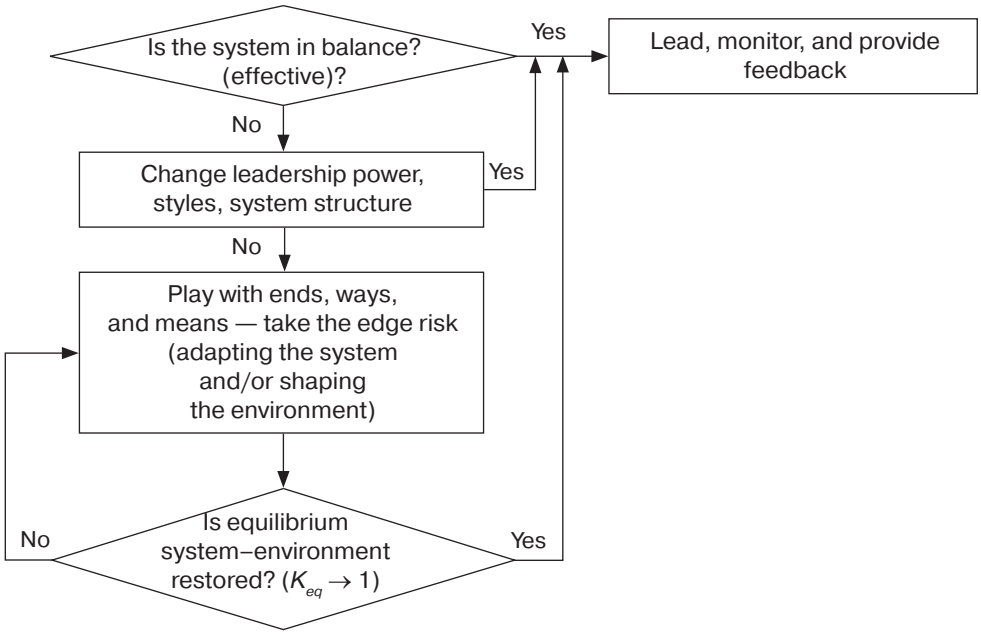

Fig. 3. **An algorithm to lead the system with edge risk**
Sources: created by Authors

Conclusions. This article analyses the possibility to lead the system with maximum acceptable risk or the edge risk in the framework of notions ends, ways, and means with risk. Leading of the system with the edge risk can improve system effectiveness through revising the human perception to the risk-taking. It increases adaptability through opening of the system to innovations and allows achieving the goal by less means and simplest ways. Staying in the sensitive framework of the graduate step edge of risk-taking according to mini-max criteria makes the system safe. The paradox of this approach is — the edge risk in the DMP decreases general risk for the system functionality because the system opens and becomes a learning organization as a highly adaptable and survivable system. Also the authors propose an algorithm to lead the system with edge risk as a theoretical and practical model to lead the system effectively with the edge risk.

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