



Modeling of Economic Risks of an Industrial Enterprise using a Tree of Logical Possibilities

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Abstract: *The aim of the study is to simulate the probability of occurrence of economic risks in industrial enterprises using trees of logical possibilities, and the subsequent ability to manage them.*

To solve the set goal, the method of expert survey was used. The expert evaluation was carried out by the ranking method to determine the probability of occurrence of each of the economic risk components. The expert evaluation involved executives of industrial enterprises and managers of commercial banks.

According to the research results, the risk assessment of an industrial enterprise should be focused on the study of the impact of primary economic risks. This can be done by building a tree of logical possibilities (usually called also logic tree) of occurrence of industrial, commercial, and financial risk components of the industrial enterprise. Visualization of the study using trees of logical possibilities along with conducted expert survey will help to establish quickly and clearly the levels of risk components and predict the state of the enterprise based on the actual circumstances.

Index Terms: *economic risk, industrial enterprise, risk assessment, risk management, tree of logical possibilities.*

I. INTRODUCTION

In the context of market relations development and deepening competition, the probability of impact of various risks on the industrial enterprises' activities increases. Especially in the current conditions of financial and economic activity, attention should be paid to the impact of economic risks as probable losses, which can be estimated in cash, and

arise resulting from unforeseen mistakes or existing performance directions and functions of the enterprise.

Integration processes and globalization of world economic relations for domestic enterprises create certain risks in their performance. Proceeding from the definition of risk as a category associated with the probability of choosing areas (activities) to avoid or prevent risks, there is a problem of assessing and measuring the impact of risks on the activities of an industrial enterprise. The risk exists in all performance areas of the enterprise, but since the issue concerns also exploring the possibility of regulating economic risks, the study should pay special attention to the production, financial, and commercial component of the industrial enterprise.

Thus, the risk as uncertainty in the activities of an industrial enterprise should be localized or minimized to the lowest cost, that is, risk should be regulated depending on the situation that has developed in the product market.

The vast majority of decisions are made in the risk zone, which is characterized by two types of the probability of occurrence of predictable and unexpected events: objective, which can be mathematically calculated based on statistical data, and subjective, which is based solely on the experience and intuition of risk managers.

Risk management as a tool to ensure the economic security of an industrial enterprise is one of the important components of effective management. Assessment of risks and their impact on the economic security of the enterprise is in general one of the determining components in the course of predicting ways to protect against possible financial losses.

Systematization of risks at the microlevel, as well as risk accounting at the meso- and macrolevels will allow a new look at the processes of risk management that affect the formation and development of industrial enterprises.

Risk management of industrial enterprises is a system of measures, techniques, and methods that should affect the reduction, and optimization of costs, which enterprises may incur in the course of activities in the domestic and foreign markets. The risk management system should include risk management objectives, management goals, management principles, and tools and leverages to neutralize or eliminate the risks of industrial enterprises. It should be noted that economic risk management is an integral part of the overall management system of an industrial enterprise.

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II. LITERATURE REVIEW

Numerous scientific studies of both foreign and domestic scientists specializing in economic issues deal with the risk management problems.

According to A.M. Dubrov, the presence of different opinions on the essence of the term *risk* indicates its versatility, while the need for their expression is due to the lack of definition of risk in the current economic legislation, as well as the rather limited use of this term in practice. Therefore, following this idea, Dubrov proposes to identify a definition of risk that would be fully consistent with the tasks that are put before the activities of the business entity, as well as would be useful in making management decisions [1].

Baldin K. identifies several approaches to the interpretation of the term *risk*. According to the first approach, the risk is the probability of the enterprise of losing part of its resources, as well as the possibility of income deficiency; according to the second approach, it is an action, which is performed in terms of choice, and in the case of failure there exists an opportunity to get an undesirable result; and according to the third approach, risk is an activity related to overcoming uncertainty in the situation of inevitable choice, during which it is possible to assess the probability of obtaining the planned result, failure, etc. [2].

Along with the approaches mentioned above, O.N. Grimashevich also highlights the following definition: risk is instability, uncertainty in the future, which is associated with any event, some process, as well as adverse conditions and consequences of the enterprise activities [3].

All the above approaches to the definition of the term *risk* can hold independent positions in the system of scientific views on the problem under study. In authors' opinion, two of these approaches can be combined into one, expressed in the following wording: risk is the process of overcoming uncertainty in a situation of inevitable choice, in which it is possible to assess the probability of obtaining the planned result, failure, etc.

Among the above approaches to the interpretation of the term *risk*, one can distinguish the most unusual definition, according to which the risk is an action performed in the terms of choice, and in case of failure, there is an opportunity to get an undesirable result. This means that when performing a certain action, it is possible to obtain the desired result [4].

The following definition of the term *risk* combines two approaches to its interpretation: risk can be both a sign of an uncertain situation in the environment and the need to choose a certain direction to achieve the goals of the economic agent. Another definition of the term *risk* emphasizes the importance of the second approach adopted in the previous definition: risk is a manifestation of economic freedom, which in turn is interrelated with the ability to overcome certain manifestations of uncertainty [5].

It is impossible to ignore the author's definition of risk proposed by A.S. Shapkin: risk is an integral component of any economic processes, which represents inevitable economic relationships with different directions of manifestation through objectively available insufficiency, inaccuracy, or redundancy of information concerning ongoing certain events, or the accidental nature of the latter, and is

calculated based on assessment of the probability of losses in the course of implementation of economic activity during such events [6, pp. 36]. According to the author, the presented definition specifies the manifestations of uncertainty through objectively existing insufficiency, inaccuracy, or redundancy of information about the course of certain events, or their randomness.

Thus, according to the authors, economic risk is inherent in the condition of the enterprise, when it is possible to choose from existing alternative solutions the path that will allow obtaining the least economic losses. The use of probabilistic methods of economic risk modeling will increase the reliability of the occurrence of risks, and eliminate them before emergence.

A large number of scientific works deal with the problems of finding ways to create economic risk modeling and forecasting system. Foreign researchers offer various methods of risk assessment, of which the most common are the following: constructing the *event tree*, using the *event-consequence* method, constructing the *fault tree*, carrying out a cost-benefit analysis, and conducting expert evaluation [7]-[9].

Paying tribute to scientific developments, their contribution to research in relation to the identification and assessment of economic risks in the formation of the enterprises' potential, it should be noted that in this area there are still a number of unresolved problems, associated with the application of various methods of economic risks assessment and forecasting. In this regard, as the authors believe, the probabilistic approach will bring the unsolved aspects of the general problem of risk assessment closer to achieving a positive result.

Thus, in general, the analysis of the existing scientific methods of risk assessment of industrial enterprises has shown that there are a large number of various approaches to this problem, but there is no generally accepted method of risk assessment. Methods of statistical analysis or regression analysis of risks of enterprises are somewhat limited. The methods of expert studies or expert assessments can be used much more effectively, which allow assessing both quantitative and qualitative characteristics.

III. METHODS

Algorithm. To solve the set goal, the method of expert survey was used. The expert evaluation was carried out by the ranking method to determine the probability of occurrence of each of the economic risk components.

Twenty-two experts were involved in the expert evaluation: 12 executives of three industrial enterprises, and 10 managers of commercial banks.

During the expert survey, experts were asked to name the components of economic risk and assess the probability of occurrence of each of them.

Processing of the evaluation results consisted in the construction of trees of logical possibilities representing the emergence of economic risk and each of its components.

Flow Chart. The description of each stage is presented in the flow chart (Fig. 1).

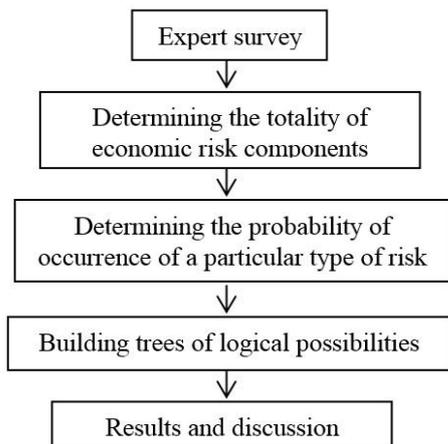


Fig. 1: Description of the research stages.

IV. RESULTS AND DISCUSSION

Based on the risk systematization proposed by the experts, all further actions to assess the risks of an industrial enterprise should be aimed at determining the impact of primary economic risks (ER), which include: production risks (PR), commercial risks (CR), and financial risks (FR) (Fig. 2).

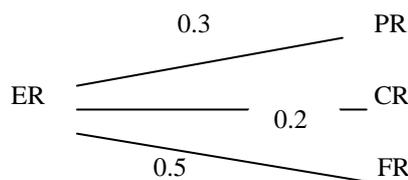


Fig. 2: Systematization of risks.

According to experts, the production risk (PR) is associated with the probability of losses in the course of production, violations of production technology, the use of raw materials, or probable failures of production processes, as well as violations of the workflow.

Production risks are the likely losses associated with:

- a) supply and marketing functions (of raw materials, components, failures due to the problems with suppliers; failures associated with the product sellers, transport logistics flows, the shortfall in material and energy resources, and nonpayment of the advance payments);
- b) organizational and operational functions (failures in operational planning, violation of repair schedules and technical equipment, and poor management of auxiliary departments);
- c) technical and technological functions (technological accidents, noncompliance with technology and labor protection, production of low-quality products);
- d) organizational and operational functions (unreasonably chosen development strategy of the enterprise, failures in operational work planning, and interruptions in economic activity (mismanagement);
- e) management and labor functions (the involvement of unskilled personnel, high turnover due to poor working

conditions, and loss of working time due to disciplinary violations).

Thus, the production risk may emerge due to the probability of occurrence of the following risks: supply and marketing risks (SMR), technical and technological risks (TTR), organizational and operational risks (OOR), and management and labor risks (MLR). At that, the probability of occurrence of all risks equals to unity.

Thus, the tree of logical possibilities of production risk occurrence can be presented as follows (Fig. 3).

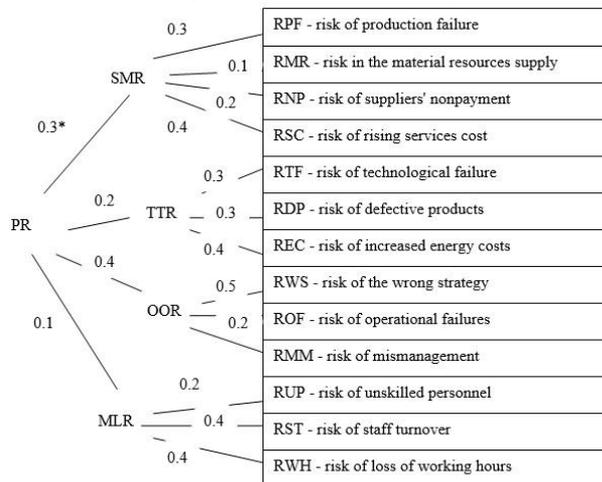


Fig. 3: Logic tree of the possible occurrence of industrial risk components at the industrial enterprises.

0.3* – the probability of occurrence of each of the risk components.

Commercial risks are losses associated with the probability of occurrence of adverse events in the course of product marketing, advertising, and sales.

According to experts, commercial risks are associated with the risks emerging in the course of:

- 1) marketing (RM), namely, consumer demand, without familiarizing potential buyers with the goods (prototypes) (RCD); carrying out marketing with violations of terms and scopes (RCM); incorrectly chosen marketing methods (RMM); incorrectly chosen research object (RIO); insufficient representativeness of the sample (RRS); incorrectly selected respondents (RSR); and erroneous interpretation of the obtained results (ROR);
- 2) implementation policy (IP), namely, the erroneous choice of the target market (RTM); the incompleteness of market segmentation (RMS); the fallacy of sales strategies (RSS); the fallacy of pricing tactics (RPT); incompleteness of a distribution network (RDN); lowering the general market price (RMP);
- 3) advertising and contractual policy (RCP), namely: ineffective advertising (REA); violation of marketing principles of advertising (RMP); conclusion of contractual relations (RCR); delays in the implementation of contractual obligations (RDC); termination of contracts with partners (RTC); unpredictable competition (the emergence of new competitors) (RUC).

Sixth stage. Choosing risk management methods.

Seventh stage. Evaluating the results obtained on the implementation of measures that reduce the negative impact of risks [11].

Studying the process of risk management at the enterprise by stages, V.A. Kunin considers the development of a risk management strategy as the final stage of this process. It is preceded by the identification of risks at the enterprise, the definition of their types and factors, the qualitative and quantitative analysis of risks, as well as the evaluation of the latter [12]. Thus, the last stage of the development of the risk management strategy makes it responsible for achieving the goal of the management process associated with risks of the enterprise. When defining the concept of risk management strategy at the enterprise, the named scientist reduces it to an action plan in a specific risk situation, the implementation of which is aimed at choosing such a solution that contributes to profit, ensuring the competitiveness of the enterprise, or obtaining other economic or social effect [12].

The author's approach to the definition of the risk management strategy is suggested by D.S. Nefedyev, who believes that it is the art of managing the enterprise in an uncertain economic situation, which is based on the prediction of risk and the use of techniques to reduce it [13]. Indeed, this definition differs in part from the definitions proposed by scientists at least by the fact that it notes the need to predict risk in the course of enterprise activity management. Highlighting this aspect in the formulation of risk concept reveals the essence of risk management from the perspective of a long-term process.

Continuing to consider this concept, Nefedyev identifies types of enterprise risk management strategy as cautious, balanced, and risky, of which each uses its own management procedures. Thus, when implementing a cautious risk management strategy, the enterprise uses management procedures, such as risk avoidance or transfer. Instead, a balanced risk management strategy of the enterprise involves the use of management procedures as part of the risks acceptance, their transfer, or avoidance. In the course of implementing a risky strategy, the enterprise manages risks through procedures, such as taking risks or transferring them [13]. As one can see, the enterprise can choose a risk management strategy to be implemented, but at that, it takes into account the types of risks, their possible results, and consequences.

An interesting point in making management decisions about risks is the development of anti-risk management decisions or their complete neutralization. Anti-crisis measures are divided into preventive (warning), limiting, and compensating. At the machine-building enterprise, the main place is held by neutralization of risks associated with loss of income or increase in production costs.

The enterprise can choose among different types of risk management strategies, depending on the types of risks, their possible outcomes and consequences.

Thus, in the course of implementing the risk ignoring strategy, the business entity does not react to its occurrence in any way, and therefore it does not apply risk management methods.

The strategy of careful risk management provides for the use of the method of its avoidance, subject to avoidance of excessive or inappropriate risk, as well as the risk transferring method, in the

case of shifting responsibility for it to other entities (risk transfer). The avoidance of risk involves pre-planned actions aimed at preventing the emergence of risk situation. This method is the easiest and most radical for the enterprise.

Risk transfer involves the avoidance of risk by transferring part of the risk to another organization, supplier/distributor, when it is in a better situation, in order to reduce the risk or control it. Such transfer may be conducted in a qualitative or quantitative form. Besides, the procedure such as risk financing provides for compensation of probable losses. In order to reduce the risk, enterprises need to create insurance funds to cover possible losses.

When implementing a strategy of risk consequences remediation, the enterprise leaves it to the responsibility of the manager, making sure that it has the ability to cover the likely losses, or that the latter do not threaten it, and thus applies the method of taking the risk.

As for the risk prevention strategy, it provides for the application of the method of preventing the occurrence of a risk event by creating conditions at which the probability of the latter will approach zero. Risk prevention occurs in consequence of certain measures aimed at stabilizing the situation. This method is more often implemented when the probability of risk occurrence is high enough, and preventive measures can avoid the occurrence of this category of risk. Application of this method requires an assessment of the economic viability of the measures, determination of costs, which are necessary to avoid this risk, the involvement of experts to prevent the risk situation, the implementation of preventive measures, and monitoring their implementation [14], [15].

And, finally, implementing the risk mitigation strategy, the economic entity provides a reduction of the probability and amount of loss, applying the risk reduction method.

Among all the risk management strategies studied above, the authors consider it necessary to highlight management strategies, the implementation of which requires special expertise on the part of the enterprise. It is a risk prevention strategy, which requires from the economic entity to create conditions ensuring zero probability of occurrence of a risk event, as well as a risk mitigation strategy, when an economic entity, objectively assessing the possibility of a risk event, reduces risk probability and amount of losses.

V. CONCLUSION

Present-day conditions, in which industrial enterprises operate, generate risks that have negative impact on their external environment. At the same time, such risks have adverse impact on the environment inside the enterprise that makes it less stable in terms of competition. Under these circumstances, the business entity must keep the line of protection against the negative impact of risks of both external and internal nature.

Risk assessment of an industrial enterprise should be aimed at studying the impact of primary economic risks. This can be done by building a logic tree of the possible occurrence of industrial, commercial, and financial risk components of the industrial enterprise.

Visualization of the study using logic trees along with conducted expert survey will help to establish quickly and clearly the levels of risk components and predict the conditions based on the actual circumstances.

Risk management consists in the reduction of possible losses at the enterprise level, taking into account macroeconomic methods of regulation or support.

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