# EMPIRICAL STUDY OF RISK ASSESSMENT OF INVESTMENT PROJECTS OF INDUSTRIAL ENTERPRISE OF UZBEKISTAN

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## ABSTRACT

*This article identifies typical problems of risk assessment of investment projects of industrial enterprises of Uzbekistan, focused on the modernization and renewal of their production base. On the example of industrial enterprises of Uzbekistan, a phased development of a special methodology is considered, the use of which will solve the identified problems. The implementation of this methodology is designed to provide an assessment of the risks of investment projects in industrial enterprises and, in general, with a focus on achieving the criteria values of key performance indicators.*

**KEYWORDS:** *Risk Of Investment Projects, Industrial Enterprise, Methodology Of Risk Analysis, Economic Factors, High Uncertainty, Effective Method Of System Analysis.*

## INTRODUCTION

In the current conditions of the mass restructuring of not only large, but also medium-sized enterprises taking place in Uzbekistan, the role of solving the problems of their development in conditions of high uncertainty is growing, when, in addition to quantitative financial and economic factors, it is also necessary to take into account factors that are not quantified. First of all, we are talking about the need to assess the numerous risk factors that accompany the implementation of investment projects. The available methods of risk analysis are mainly of a purely qualitative nature, or are based on production statistics, which, for obvious reasons, are still insufficient in the economy of Uzbekistan.

The current situation in this area of economic knowledge necessitates the use of modern effective methods of system analysis, which, in particular, include modeling and forecasting methods that make it possible to compare investment projects for a number of quantitative and qualitative factors. These methods have already been sufficiently mastered by economists and analysts, but there are still no methodological developments that would allow them to be introduced into the practice of top managers of industrial enterprises.

Based on the foregoing, the task of improving the methodology for assessing the risks of investment projects of an industrial enterprise for the modernization of production processes, based on the latest modeling and forecasting methods, is an urgent task.

The issues of developing a methodology for evaluating investment projects, including the problems of risk analysis, were considered in the works of E.M. Blekha, I.M. Volkova, P.L. Vilensky, O.S. Vikhansky, M.V. Gracheva,D. Gozibekova, N. Zhumaeva,PM Kachalova, G.B. Kleiner, V.N. Livshits, N.P. Tikhomirov,M. Khamidulina, N. Khaidarova, B. Toshmurodova, S. Elmirzaevaand etc.

The analysis of these works showed that the theoretical and methodological provisions contained in them can be used in the development of the chosen research topic, at the same time, the scientific development of the methodology for assessing the risks of investment projects of an existing industrial enterprise cannot be considered sufficient.

The purpose of the study is to develop methods for assessing the risks of investment projects of an industrial enterprise for the modernization of production processes.

In the period 1991 - 2000. The development of the economy of Uzbekistan proceeded against the backdrop of a deep investment crisis, the external manifestations of which were an acute shortage of capital-forming investments in the market and a steady reluctance of investors to invest in the production (real) sector of the economy. The main reasons are inflation, high growth of interest rates with inadequate low profitability of production, high riskiness of investments, long payback periods compared to investments in operations with securities, bonds, the negative impact of the shadow sector, an unprecedented outflow of capital abroad.

The current period of development of the real sector of the economy of Uzbekistan is characterized by an increase in the investment activity of industrial enterprises, and in this regard, the urgency of developing scientifically based methods for analyzing investment projects intended for practical use directly by the top management of industrial enterprises is increasing. At the same time, since the adoption of investment decisions is associated with a high level of risk, an indispensable requirement for their development is to take into account risk factors in the course of investment design.

As a result of a comparative analysis of methods for assessing the risks of investment projects of industrial enterprises, it was found that in the conditions of high uncertainty that accompanies investing in the modernization of production processes, an expert-analytical approach to risk analysis and risk management takes the lead. This approach has recently been increasingly used in the practice of making managerial decisions insofar as it allows taking into account numerous risk factors that either cannot be quantified in principle, or such an assessment is associated with labor-intensive calculations, which, however, are not based on reliable data.

In this case, it is natural to turn to expert knowledge.

At present, a rather coherent theory of expert-analytical modeling has been developed, which, in fact, is an important section of system analysis. Within the framework of this theory, it is postulated that any, even a weakly structured problem can be represented as a hierarchy of interacting layers (levels) of this problem - goals, subgoals, factors, criteria, actors (actors), goals of actors, their policies, alternative scenarios for the development of the situation. The main method of expert-analytical modeling is proposed - the method of analysis of hierarchies (MAH), mathematically based on the theory of inversely symmetric matrices.

Later, the method of analysis of hierarchies was significantly improved, and now we can talk about the creation of a generalized method of analytical networks (MAN), a special case of which is the method of analysis of hierarchies (MAH). In mathematical terms, the method of analytical networks (MAN) involves the construction of a supermatrix, blocks and which are matrices of individual hierarchies; With the help of fairly simple operations on the supermatrix, it is possible to significantly refine expert information by taking into account feedback and interactions between layers and elements of the hierarchical model.

Despite the existence of a complete theory of expert-analytical modeling, as well as quite numerous examples of its application to solving specific problems of the economy, including the analysis of investment projects, it is still too early to talk about the widespread use of expert-analytical modeling not only by specialists - practitioners directly involved in implementation of investment projects, but also by specialists of consulting firms. There are several reasons for this, but the main one is the creativity of solving specific problems. Among such problems is the risk - the analysis of investment projects of industrial enterprises. Existing methods of risk analysis of investment projects based on expert-analytical modeling are fragmentary and do not cover all its aspects; in particular, methods for analyzing the sensitivity of investment projects to changes in risk factors have not been developed. In addition, the known methods do not reflect the latest achievements of the method of analytical networks, accounting for which can significantly increase the reliability of management decisions on choosing the direction of investment.

The paper substantiates that the development of risk assessment methods for investment projects of industrial enterprises based on expert-analytical modeling should be carried out simultaneously in three areas:

1) development of basic risk analysis models based on the hierarchy analysis method (MAH) and the analytical network method (MAN);

2) development of econometric models for sensitivity analysis of investment project risk assessments;

3) improvement of risk tools - analysis of investment projects based on the use of neural network technologies.

It seems that the combination of these areas can ensure the achievement of a new quality of risk management.

The central idea of the expert-analytical approach to quantitative risk assessment of investment projects is to represent a weakly structured problem in the form of a cognitive hierarchical model, which in the simplest case contains three levels: focus (goal), criteria, alternatives. In the specific case of risks of investment projects of industrial enterprises, these are the following levels:

- The first level - focus - assessment of the priorities of alternative investment projects in terms of their risks;

- The second level - types of risks of investment projects (production, investment and financial, market, financial, social, environmental and political risks);

- The third level - alternative investment projects.

In most cases, investment projects of existing industrial enterprises are associated with the modernization of production processes, and in this regard, the following types of projects should be considered: transition to less expensive technologies; replacement of worn out equipment; release of products new to the enterprise; personnel training. However, these investment projects are not alternative in the classical sense either - for example, the release of new products for the enterprise will most likely be accompanied by the replacement of equipment and the transition to other technologies; personnel training accompanies each of these areas, etc. Therefore, we should rather not talk about alternative projects, but about alternative directions of investment - in view of the limited resources, it seems unlikely that full investment will be made simultaneously in all directions.

Using the example of a risk-analysis of investment projects of an industrial enterprise to modernize the production process, a basic hierarchical model is substantiated, which allows, as a result of its filling with expert knowledge, to obtain estimates of risk weights by investment areas, on the one hand, and types of risks, on the other. The peculiarity of the proposed basic model is that it takes into account both direct and reverse influence of the two main components of the hierarchy - types of risk and areas of investment, which makes it possible to increase the reliability of expert assessments of the ratio of their priorities.

In this regard, new concepts are introduced in the work - direct and inverse hierarchical models of risk analysis. The direct hierarchical risk-analysis model (MAH - 1 model) contains the above three levels in sequence: goal (focus) - types of risks of investment projects - alternative directions of investments. The inverse hierarchical risk analysis model (MAH - 2 model) also contains these levels, but in a different sequence: goal (focus) - alternative investment directions - types of investment project risks. In principle, both models provide an estimate of the priorities of both types of risk and areas of investment, but if in the first case the estimates of the priorities of areas of investment are more reliable, since they are calculated as components of the final priority vector,

The iterative nature of the process of expert-analytical modeling lies in the fact that if the experts recognize some elements of the hierarchy as insignificant, or, on the contrary, the need to include additional elements in the cognitive model, adjustments are made. As a result of excluding any elements from the cognitive model created in the Expert Decide expert-analytical system, all assessments made by experts are saved, and it becomes possible to obtain the final result. When adding elements, experts are invited to supplement the matrices of paired comparisons with their judgments about the degree of significance of new pairs of elements, while maintaining the paired comparisons made by him and earlier.

The basic hierarchical model discussed above, however, does not take into account the feedback between the levels "types of risk" and "directions of investments", as well as the interaction of elements at these levels. The purpose of the network, as before, is to assess the risks of investing in the modernization of a food industry enterprise. But now the top level is the types of investment risks: production, investment and financial, market, political, financial, institutional and legal, social, the bottom is the areas of investment: replacement of equipment, transition to less expensive technologies, release of new products. These levels form two components, each of which contains the specified elements. It is assumed that the types of risk, as well as the direction of investment, are interrelated. It is also assumed that not only the types of risks determine the priorities of investment areas,

According to the theory of analytical networks, the network model corresponds to a supermatrix, which has a block structure.

In the paper, supermatrices corresponding to a complicated model are considered step by step: taking into account feedback (MAN-1 model); taking into account the correlation of risk types (MAN-2 model); taking into account the correlation of investment directions (MAN-3 model); taking into account both feedback and correlation of risk types and investment directions (MAN-4 model).

Estimates of the priorities of investment directions and types of risk, obtained as a result of a survey of experts and subsequent mathematical operations with supermatrices, are presented in Table. 1. Here are the results obtained earlier on the hierarchical models MAH-1 and MAH-2.

Table 1 Comparison of priorities of investment directions and types of risk of investing in the modernization of production processes of a food enterprise

industries according to hierarchical network models

| Model | Investment directions | | | | Types of risk | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Equipment replacement | Transition to less expensive technologies | Release of new products | Education personnel | Production risk | Investment and financial risk | Market risk | financial risk | social risk |
| MAH -1 | 0,287 | 0,180 | 0,459 | 0,065 | 0,156 | 0,111 | 0,471 | 0,198 | 0,069 |
| MAH -2 | 0,189 | 0,129 | 0,462 | 0,053 | 0,145 | 0,187 | 0,279 | 0,282 | 0,103 |
| MAH -1 | 0,319 | 0,217 | 0,619 | 0,076 | 0,181 | 0,211 | 0,201 | 0,259 | 0,141 |
| MAH -2 | 0,281 | 0,171 | 0,479 | 0,072 | 0,164 | 0,199 | 0,227 | 0,268 | 0,127 |
| MAH -3 | 0,313 | 0,209 | 0,398 | 0,069 | 0,178 | 0,229 | 0,219 | 0,249 | 0,116 |
| MAH -4 | 0,281 | 0,170 | 0,481 | 0,066 | 0,165 | 0,234 | 0,241 | 0,253 | 0,101 |

It can be seen that the priority vector of investment directions according to the hierarchical model MAH-2 differs markedly from the priority vectors of investment directions according to the hierarchical model MAH-1, as well as the priority vectors of investment directions according to network models. On the other hand, the vector of priorities of types of investment risks according to the hierarchical model MAH -1 differs from the vectors of types of investment risks according to the hierarchical model MAH - 2, as well as from the vectors of types of investment risks according to the network models MAN - 1 ... MAN - 4.

Since the spread of priorities of the elements of hierarchical models is small, i.e. five models MAH - 2, MAN - 1 ... MAN - 4 in the case of assessing the weights of risk types, on the one hand, MAH - 1, MAN - 1 ... MAN - 4 in the case of assessing risk weights by investment areas, on the other hand, are homogeneous samples, they are averaged. Investments in the creation of products new to the enterprise are characterized by the greatest risks; here, too, there is the greatest variability of expert estimates for different models. Minimum risks - for investments in personnel training, the minimum spread of expert estimates also corresponds to the same direction of investment. Market risks are less than financial risks, but exceed investment and financial risks. Social risks are less - 95% confidence interval is below the average for this hierarchical level of 0.2.

The obtained results confirm the expediency of using network expert-analytical models for risk analysis of investment projects, taking into account the feedback between risk types and investment directions, as well as the correlation of individual types of risk and investment directions. The representation of network expert-analytical models in the form of a hierarchy facilitates the work of experts in the process of risk analysis of investment projects, which increases the reliability of the estimates obtained.

An important part of the risk analysis of investment projects is the assessment of the sensitivity of project risk priorities to changes in the factors that determine them. As a rule, sensitivity analysis occurs sequentially - a single change in each variable: only one of the variables changes its value by the predicted percentage, and on this basis the new value of the criterion used is recalculated. We propose a different approach, based on econometric modeling, which allows moving from a sequential-single change in each variable to a simultaneous change in all variables included in the analysis.

The paper proposes a method for forming an empirical base for econometric and neural network modeling of the sensitivity of risk assessments of investment projects. This technique is based on obtaining simulation scores when paired judgments are changed (variation of paired comparison scores within ± 1 division of the ratio scale) in a matrix created by experts.

Based on the empirical base obtained in this way, linear models for assessing the sensitivity of investment projects have been developed:

$$Y_1 = 0{,}532 - 0{,}496x_1 - 0{,}119\,x_2 + 0{,}044\,x_3 - 0{,}209\,x_4 - 0{,}421\,x_5 \qquad (1)$$

$$Y_2 = 0{,}471 + 0{,}168x_1 - 0{,}059\,x_2 + 0{,}183\,x_3 + 0{,}301\,x_4 + 0{,}132\,x_5 \qquad (2)$$

$$U_3 = 0{,}089 + 0{,}276x_1 + 0{,}112\,x_2 + 0{,}009\,x_3 - 0{,}006\,x_4 + 0{,}402\,x_5 \qquad (3)$$

Here, $Y_1$, $Y_2$, $Y_3$ are risk assessments of the investment directions "New product launch", "Equipment replacement", "Switching to less expensive technologies", respectively; $x_1, x_2, x_3, x_4$, $x_5$ - estimates of the priorities of production, investment and financial, market, financial and social risks.

Models (1) - (3) are statistically significant at a level no worse than 0.0005, which made it possible to calculate the elasticity coefficients in the center of the simulation "experiment", characterized by the following values of risk assessments: production risk $(x_1)_{aver}$ = 0,158; investment and financial risk $(x_2)_{aver}$ = 0,106; market risk $(x_3)_{aver}$ = 0,398; financial risk $(x_4)_{aver}$ = 0,188; social risk $(_{x5})_{aver}$ = 0,061, according to the formula

$$Ei = bi * (x_i)_{aver} : Y_{aver}$$

where bi is the regression coefficient.

The results obtained are presented in table 2.

The most sensitive risk factors include: production risk - rating 1 in the direction of investments "Launch of new products" and rating 2 in the directions of investments "Switching to less expensive technologies" and "Replacement of equipment"; social risk - rating 2 in the directions "New product launch" and "Switching to less expensive technologies"; financial risk – rating 3 in the New Product Launch segment and rating 1 in the other two investment segments. Obviously, when quantifying cash flows, special attention should be paid to these types of risks.

Table 2 Elasticity coefficient and rating of risk factors by areas investments in the production process of enterprise modernization Food Industry

| Predictor (type of risk) | Direction of investment | | | | | |
|---|---|---|---|---|---|---|
| | Release of new products | | Equipment replacement | | Transition to less expensive technologies | |
| | Elasticity | Rating | Elasticity | Rating | Elasticity | Rating |
| Production risk | - 0.156 | 1 | 0.059 | 2 | 0.059 | 2 |
| Investment and financial risk | - 0.028 | 5 | 0.000 | 0 | 0.026 | 3 |
| Market risk | - 0.037 | 4 | 0.057 | 3 | 0.000 | 0 |
| Financial risk | - 0.064 | 3 | 0.061 | 1 | 0.061 | 1 |
| social risk | - 0.075 | 2 | 0.024 | 4 | 0.051 | 2 |

In principle, to analyze the sensitivity of investment project priorities, it is sufficient to have linear models of multiple regression of the type of models (1) - (3). However, it is not always possible to confine oneself to linear models; in addition, they give an estimate of elasticity only on the "average", in the center of the simulation experiment. In this regard, using the example of modeling the assessment of the sensitivity of investments in the direction "Transition to less expensive technologies" for three types of risks (see formula (3)) the paper substantiates the fundamental possibility of using neural network models for this purpose, which can be used to describe nonlinear dependencies in practice any complexity.

The Neural Connection v. system was chosen for neural network modeling 2.1, which compares favorably with a combination of interface transparency with advanced functional characteristics. This system allows you to apply four types of neural networks and three statistical methods, of which two neural networks are most often used to solve modeling and forecasting problems - a multilayer perceptron (MLP) and a radial basis function (RBF). The network of the first structure can simulate a nonlinear function of almost any complexity, moreover, this complexity is determined by the number of layers and the number of elements in each layer.

Based on this, to solve the problem, a multilayer perceptron was built - a network based on a multilayer perceptron with automatic parameter settings, consisting of: a central module multilayer perceptron (MLP-1), input module Input-1, output text and graphic modules Text-1, Output -1, TSP-1, Graph-1, Whatlf-l, control modules - Filter-1, Sim-1 simulator.

When forming a set of training examples, it is recommended to have at least $N=l0*(m+n)$ "examples", where m is the number of input factors, n is the number of output factors, which in this case is $10*(3+1)=40$ "examples". However, the available data array with the number of "examples" N = 21 turned out to be sufficient to divide the initial sample into training (17 facts), test (2 facts) and control (2 facts).

An analysis of the diagrams of the actual and predicted values of the output variable by the non-network model showed that the multilayer perceptron (MLP) network provides a satisfactory match between the expert and model-predicted risk assessments in the areas of investment "Switching to less expensive technologies".

The Neural Connection 2.1 system allows you to build a graph and dependencies of the output variable on the levels of input factors in the form of so-called "grid surfaces", in which each combination of input factor levels is compared with the calculated values of the output variable - in this case, the risk assessment predicted by the neural network model by investment directions "Transition to less costly technologies". There are three input risk factors, so an analysis of a set of three similar graphs can give a complete picture.

The "WhatIf ..." module available in the Neural Connection system - "What if?" allows you to build "sections" of the resulting three-dimensional graphs in order to analyze the change in the output variable when the input factors change, as well as to evaluate the elasticity of the output variable for any input factor, which is extremely important in economic research.

The predictive capabilities of the "WhatIf..." tool are demonstrated in the work on the example of predicting the elasticity of the risk of the direction of the investment project “Switching to less expensive technologies” for social risk.

The results of the prediction of the elasticity coefficient are given in the text part of the working field: with an increase in the priority of social risk from 0,076003 to 0,079680, i.e. by 6,25%, the risk priority of the Investment direction "Switching to less expensive technologies" increases by 0,92% (from 0,180630 to 0,182279). Hence we have:

$E(Y_3/x_5) = 0{,}92/6{,}25 = 0{,}147.$

This forecast corresponds to the investment and financial risk priority of 0,119 and the initial value of the social risk priority of 0,074; both values can be changed using the "sliders" on the horizontal and vertical axes of the left diagram of the working field.

Similarly, estimates of risk elasticity of the considered direction for investment and financial risk $E(Y_3/x_2) = 0{,}068$ and risk elasticity of this direction for production risk $E(Y_3/x_1)$ = 0,271 were obtained.

Comparing the obtained estimates of elasticity, we can conclude that the risk elasticity of the considered direction of investment for production risk exceeds the elasticity for social risk by 1,85 times and for investment and financial risk by 4,00 times.

The paper notes that sensitivity estimates obtained using neural network technologies have an undoubted advantage over estimates and linear multiple regression models - if the latter are "average" estimates, then the first are "instantaneous" elasticity values corresponding to a specific combination of risk priorities of different kind.

Based on the results obtained, the above methodology for analyzing the sensitivity of project assessments to risk factors based on neural network modeling can be recommended for practical use.

The main results of the work are as follows:

1. A basic, hierarchical model for assessing the risks of investment projects of an industrial enterprise has been developed, which, as a result of filling it with expert knowledge, allows

obtaining estimates of risk weights by investment areas, on the one hand, and types of risks, on the other. The peculiarity of the proposed basic model is that it takes into account both direct and reverse influence of the two main components of the hierarchy - types of risk and areas of investment, which makes it possible to increase the reliability of expert assessments of the ratio of their priorities.

2. A technique has been developed for the formation of an empirical base for econometric and non-grid modeling of the sensitivity of risk assessments of investment projects. The technique is based on obtaining simulation estimates when paired judgments are changed in a matrix created by experts.

3. The insufficiency of using multiple linear regression models for assessing the sensitivity of investment projects is shown. A neural network model has been created, with the help of which the fundamental non-linearity of the sensitivity model has been revealed and the risk elasticity of projects has been assessed by types of main risks.

**LITERATURE**

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