European Proceedings of
Social and Behavioural Sciences
EpSBS
www.europeanproceedings.com
e-ISSN: 2357-1330

DOI: 10.15405/epsbs.2021.07.99

LEASECON 2020
International Conference «Land Economy and Rural Studies Essentials»

HYBRID METHODS FOR ASSESSING THE FINANCIAL SUSTAINABILITY OF AUTOMATED ENTERPRISES

Vladislav B. Gusev (a)*, Natalia A. Isayeva (b)
*Corresponding author

(a) Institute of Control Sciences of V A Trapeznikov of the Russian Academy of Sciences, 65, Profsoyuznaya str., Moscow, Russia, gusvbr@mail.ru
(b) Institute of Control Sciences of V A Trapeznikov of the Russian Academy of Sciences, 65, Profsoyuznaya str., Moscow, Russia

Abstract

The hybrid method under consideration for assessing the financial sustainability of automated systems and enterprises in construction and engineering is based on an analysis of performance. It calculates the characteristics of instability in the course of operation, including estimates of the risk of bankruptcy of an enterprise. In assessing financial risks, multiple sources of information are taken into account: expert data on the interaction of factors in the production activity of enterprises and statistical data. A measure of risk assessment associated with the expected probability of deviation from the required level is introduced. Instability rates are calculated for each of the factors analyzed. On this basis, an integral measure of the risk of bankruptcy of the company is determined. This takes into account the interactions of factors, the scheme of which is set by the expert, and the values of impact assessments are clarified on the basis of expert data. The results of the calculations are presented in the point's scale of the relationship. The sensitivity of the integral risk indicator to variations of instability of each factor or to variations of the factors themselves is also calculated. Sensitivity assessments allow us to form a management strategy aimed at improving the stability of the enterprise and minimizing the risk of bankruptcy of enterprises. Risk analysis procedures are designed to automate the state analysis processes of one or a group of enterprises and are focused on the implementation in information systems of different scales.

Keywords: Estimates, financial sustainability, interactions, risk, scale

https://doi.org/10.15405/epsbs.2021.07.99
Corresponding Author: Vladislav B. Gusev
Selection and peer-review under responsibility of the Organizing Committee of the conference
eISSN: 2357-1330

1. Introduction

The functioning of a modern machine-building and construction enterprise depends on a large number of external factors characterized by instability and even unpredictability (Algin, 1991; Thompson, Michael, 1982). These include fluctuations in product demand, the diffusion of technological complexes and automated systems, currency and financial volatility in general, sporadic crises in the world and national economies, and economic sanctions. Risk analysis is an important function of enterprise management in the modern environment. It makes possible to assess the current state of an enterprise and to make rational decisions under conditions of uncertainty (Axelrod, 1976).

In the considered method, the input data are the regular accounting records of the enterprise, as well as expert knowledge of the interaction of the factors considered, including the effects of the introduction of technological complexes and automated systems, the bankruptcy of the enterprise, force majeure, economic or political crises. In order to analyze the risk of an adverse event (bankruptcy), the method may use an extended financial reporting interaction scheme that includes a scheme for linking the event to financial factors, or transmit the results of the private risk assessment to the Integrated Risk Assessment module, which is designed to calculate the risk assessment of the event in question.

The procedure for calculating and analyzing the assessment of complex risks of complex objects uses expert risk assessments of the functioning (performance) of the related component, as well as their interactions measured in relationship scales, and includes:

- Input of raw data.
- Development of an expert scheme for the interaction of factors.
- Calculation of private risk assessments.
- Calculation of integrated risk assessments.
- Transmission of the results of the calculation for their visualization and interpretation.
-

In the literature on financial risks (Ernst & Young, 2011; Lobanova & Chugunova, 2009) or on risks, technical systems (GOST, 2008) apply qualitative, descriptive or mathematical loss expectation statistics, variance, etc. with regard to the management of complex activities. The analysis of their sustainability and stability should include factors of complexity, multidimensionality. Standard risk analysis methodologies do not consider this specificity in organizational and business processes and need to be refined.

Risk analysis in this area requires the use of formalized representations of the interaction of the elements of a complex object. In particular, if risk analysis is based on financial indicators, their interrelationships must be taken into account. Risk assessments of complex production and organizational systems require a variety of quantitative and structural information and procedures based on multiple-digit logic, reflexive closing of private ratings, complex estimation. Such information can be obtained through the formalization and analysis of expert data. The proposed procedures for financial risk analysis use a point-to-point method and direct and indirect risk assessments of the interacting factors (Gusev, 2017; Gusev & Isayeva, 2017).

https://doi.org/10.15405/epsbs.2021.07.99
Corresponding Author: Vladislav B. Gusev
Selection and peer-review under responsibility of the Organizing Committee of the conference
eISSN: 2357-1330

2. Problem Statement

The stability of a production enterprise is determined by internal and external factors. External causes of instability (market and product demand volatility, crises, external economic sanctions, ruble exchange fluctuations) are usually decisive and require management decisions, both at the operational and structural levels, which can also generate instability leading to risks of undesirable consequences, including bankruptcy.

Factors in the financial relationship of production include both components of financial reporting and facilities that cannot be accurately accounted for, but in fact have a significant impact on the stability of the business of the enterprise. It is also necessary to consider external conditions, such as the quality of management, the scale and growth of economic activity, the volume of State procurement, etc., considered as possible management tools and representing a substantial part of the subject matter. Risk assessment should be based on the variability of the underlying data, the nature of the interaction of the economic factors, and the depth of the estimates.

The effect of some factors on others affects different aspects of functioning that are not always deterministic, and expert analysis may be characterized by the degree of influence and risk (as an antidote to reliability, credibility of the effect). As a result of the cumulative effects of all the chain of influences generated by each factor-cause and ending with the effects, a systemic effect is formed, defined by the totality of direct and resulting indirect linkages. The original system of mutual influences resulting from the reflexive superimposition of all indirect influences of factors forms a system of complete influences as their transitive closure. We note that the analytical method under consideration allows for the use of different source data and thus has a certain universality. For example, the transitive closure procedure was used in the intangible asset analysis method (Gusev, 2017).

3. Research Questions

The initial stage of the analysis is the preparation of expert data, providing initial estimates of the parameters of the interaction of the factors under consideration. The initial analysis of the interplay of factors consists in the study of paired interactions (Gusev, 2017) on the set of considered factors' separate pairs, for which it is possible to present a mechanism of direct interaction of type «cause - consequence». These are so-called «primary» interactions. Indirect influences at this stage are eliminated. The structure of the direct links is determined on the basis of the expert's understanding of the processes under investigation. The relationship topology and the value of the estimates are clarified during the model verification process.

The result of the analysis is complete (integrating) estimates of the parameters of the interactions of factors, taking into account the extended set of transaction chains. The evaluation model shall be presented in terms of points or units. The calculations use estimation operations, which can be attributed to multiple-digit logic algebra (for impact estimates) and pseudo-logic (for risk assessments).

https://doi.org/10.15405/epsbs.2021.07.99
Corresponding Author: Vladislav B. Gusev
Selection and peer-review under responsibility of the Organizing Committee of the conference
eISSN: 2357-1330

4. Purpose of the Study

The purpose of analyzing the transitive closure of interactions from the set of factors under consideration is to draw conclusions about the effectiveness of management mechanisms in terms of their impact on the target. The complete estimates of the parameters of the interactions of the factors (degree of influence and risk) resulting from the analysis can be used to compare different production scenarios in order to select the managers of impacts in long- and medium-term planning.

In order to obtain real expert data, an expert group selection procedure is needed, taking into account the level of the facility under consideration and statistical data available for analysis. For example, in drawing up a scheme of risk assessments taking into account the mutual influence of factors for the real facility (enterprise, industry, economy), statistical data on their evolution over a certain period can be used. Relative increments of relevant assets can be a starting point for determining risk assessments of the interactions of factors. The expert analyses these relationships and identifies those that correspond to the direct effects of some factors on others. To assess the probability of risk, the elements of the resulting matrix are normalized (assuming that the actions of the factors form a complete group of events).

5. Research Methods

The estimation scheme also includes a verification phase (Gusev & Isayeva, 2017) at which it is adjusted according to the expert's experience and available data. The transitive closure of the primary impact estimates should correspond to the increment ratios of the respective assets over a fixed period. In working with the scheme, the estimates, composition and structure of the interactions of the factors are refined and the function of the expert is combined with that of the analyst or the decision maker.

Thus, the selection and training of experts is a complex task that depends on the level of the facility, the volume and structure of the data available, and the requirements of the expertise functions. To formalize the concept of risk and to calculate its estimates, procedures are used to convert the results of the measurement into primary (private) scoring, expert schemes of the interaction of factors, scales of relations and a set of operations over them, tools of risk analysis. Finding reasons for the increase of estimated risk assessments and ways to reduce them, verification of the models and procedures are used.

As a result of the cumulative effect of all the chain of influences generated by each factor-cause and finishing with the factors-effect, a systemic effect is formed, defined by the totality of the resulting indirect relationships. The original system of mutual influences because of the reflexive superimposition of all indirect influences forms a system of complete influences as their transitive closure.

The result of the analysis is comprehensive (complete) risk assessments of the interactions of factors, taking into account an extended set of transaction chains. The scores used in the evaluation model are presented. The purpose of analyzing the transitive closure of interactions from the considered set of factors is to draw conclusions about the effectiveness of management mechanisms in terms of their impact on the complex risk indicator. Feedback from evaluations of interactions can be used as a guide for rational management selection and decision-making.

https://doi.org/10.15405/epsbs.2021.07.99
Corresponding Author: Vladislav B. Gusev
Selection and peer-review under responsibility of the Organizing Committee of the conference
eISSN: 2357-1330

Let the factors considered are the numerical values of the uncertainty indicators (estimates) with the probability of reaching the allowable interval. Then the risk measure can be the value:

$$t_i = \log \frac{1}{p_i} . \qquad (1)$$

This is an indication of the possibility of exceeding the allowed limits. As a result of uncertainties (risks), the uncertainty of the resulting factor changes. If the two factors are independent, the respective probabilities are multiplied and the risk estimates of their sequential effect are added up:

$$t_{i+j} = t_i + t_j . \qquad (2)$$

Evaluations of interaction can be presented on a scale of points. The values of the coefficients a_{ij} of the matrix $\mathbf{A}$, assigned by expert means, are in the range of 0 to $a_{\max}$. Rating ratios can be used to obtain risk scores:

$$\overline{a}_{ij} = a_{ij} \cdot a_{\max} / \max_{i,j} a_{ij} . \qquad (3)$$

If the dependency of the factors is to be taken into account, then in the simplest case the indicator of this dependence may make sense to limit the risk indicator. The existence of a dependency of factor i from factor j reduces the uncertainty or the risk of their sequential effect, in which case, by analogy with the formula of absolute probability, we have:

$$t_{i/j} = t_i + t_j a_{ij} / a_{\max} . \qquad (4)$$

If factors operate in parallel, duplicating each other, the risk of their resulting action is determined by the minimum of them:

$$t_{i \cdot j} = \min(t_i, t_j) . \qquad (5)$$

We mark the risk assessment for the pair of factors i, j as a_{ji} . The following operations can be used to calculate the risk assessment. So if the risk assessment a_{ij} of an operation is measured by the value of the logarithm of the inverse probability of success p_{ij} :

$$a_{ij} = \log \frac{1}{p_{ij}} , \qquad (6)$$

then the probabilities of success are multiplied and the risk estimates of successive operations are formed. For parallel operations, the probability of success corresponds to the most likely event, and the risk assessment is the minimum of the relevant estimates.

Estimation of the R variance in the 10-digit relationship scale (initial risk estimate for factor X, observed for several periods) is calculated by the formula:

$$R = D \bullet 10 / (2 * X_{max} - X_{min}), \qquad (7)$$

where $D = \sum_i \left(Xi - \overline{X} \right)^2 / n$ is the variance function of sampling the values of financial indicators X; X_{max} is the maximum sample value, X_{min} is the minimum sample value, $\overline{X} = \sum_i X_i / n$ is the mean value.

This estimate is proportional to the variance, has the property of additivity and can be subject to the risk assessment operations described above.

https://doi.org/10.15405/epsbs.2021.07.99
Corresponding Author: Vladislav B. Gusev
Selection and peer-review under responsibility of the Organizing Committee of the conference
eISSN: 2357-1330

5.1. Formation of a pattern of interactions

Expert assessments of the degree of dependency can be provided on a scale of points. The values of the coefficients $\overline{a}_{ij}$ of the matrix $\mathbf{A}$, assigned by expert means, are in the range of 0 to a_{ij}. Rating ratios can be used to obtain risk scores:

$$\overline{a}_{ij} = a_{ij} \cdot a_{\max} . \qquad (8)$$

Expert Scheme Verification Method is a method for verifying the estimates of the coefficients of interactions according to observed data in the linearity assumption in a defined range of relationships of system state increments and system response.

Let $\Delta\mathbf{x}$ be the initial vector of the increments of the state of the system, $\Delta\mathbf{y}$ - the resulting response of the system, $\mathbf{S}$ - the matrix of the response structure consisting of zeros and units and determined on the basis of expert knowledge. Then the linear response matrix $\mathbf{A}$ coefficients will be determined as follows:

$$a_{ij} = s_{ij}\Delta y_i / \Delta x_j \text{ when } \Delta x_j \neq 0 . \qquad (9)$$

The structural matrix $\mathbf{S}$ of the response should not contain mirror dependencies, that is to say:

$$s_{ij} \neq s_{ji} , \qquad (10)$$

but in a transitive closure allows for a complete set of connections, that is:

$$\exists k, S^k = [\mathbf{1}] , \qquad (11)$$

where $[\mathbf{1}]$ is a matrix consisting of ones.

Risk analysis of factors interacting. The risk estimates of the financial performance of an enterprise operating independently of the depth of the forecast were calculated, using matrix transactions at each step:

$$\Delta t_i^{k+1} = \sum_j \left| \Delta t_j^k a_{ij} / a_{\max} \right| . \qquad (12)$$

The sensitivity s_i of bankruptcy risk to variations in estimates of financial instability is calculated as a relative error (Seidel, 1968):

$$s_i = \frac{\Delta y}{\Delta t_i} , \qquad (13)$$

where Δy is an increase in bankruptcy risk assessment caused by a reportable disturbance Δt_i in the assessment of financial instability of factor i.

The sensitivity of bankruptcy risk r_{ij} to variations Δa_{ij} in financial factor coupling coefficients are calculated by the formula:

$$r_{ij} = \frac{\Delta y}{\Delta a_{ij}} . \qquad (14)$$

When searching for «bottlenecks» factors and/or elements of the pattern of interactions of factors responsible for the growth or fall of risk assessments of the control set of factors are searched. For this purpose, threshold levels $\overline{s}, \overline{r}$ are introduced, the excess of which by the respective sensitivity coefficients s_i , r_{ij} allows these elements to be included in the definition of «bottlenecks».

https://doi.org/10.15405/epsbs.2021.07.99
Corresponding Author: Vladislav B. Gusev
Selection and peer-review under responsibility of the Organizing Committee of the conference
eISSN: 2357-1330

6. Findings

Accounting statistics of financial indicators of automated machine-building enterprises for several years are considered as a source of objective information. A list of these financial indicators of an enterprise is given below.

F.1 Revolving assets as at the reporting date of the reporting period

F.17 Revolving assets as at reporting date of the year

F.31 Capital and reserves as at the reporting date of the reporting period

F.55 Short-term obligations as at the reporting date of the reporting period

F.59 Accounts payable as at the reporting date of the reporting period

F.69 Balance at reporting date of the reporting period

F.71 Net proceeds from the sale of goods, products, works, services (minus value added tax, excise duties) for the reporting period

F.72 Value of goods, products, works, services sold during the reporting period

F.76 Profit (loss) on sales during the reporting period

F.82 Profit (loss) prior to taxation for the reporting period

F.87 Net profit (loss) during the reporting period

F.3 Intangible assets as at the reporting date of the reporting period

F.21 Value added tax on acquired valuables as at the reporting date of the reporting period

F.101 Expenditure on the purchase of raw materials, materials, purchase preparations and components for the production and sale of products (goods, works, services)

F.106 Average number of on-board staff for the month

F.103 Employees' Payroll (Nonresidents) Fund for the month under review

Risk assessments were calculated using the Excel environment. The dialogue screen shows an expert scheme of the interaction of factors of financial activity of the enterprise, initial estimates of variance of factors and results of the account. Visual identification of the communication coefficients and the results of the account facilitate analysis of the situation are under consideration.

The increase in risk assessments over time is due to the accumulation of negative impacts during the life cycle. At the same time, the sensitivity of bankruptcy risk to the variation of financial factors increases first, and then decreases with the depth of the forecast. The most informative ones are the results of the sensitivity estimation on the depth of the projection 3-4, where one step corresponds to one year. The decline in risk sensitivity at the depth of the projection is due to the approximation of financial risk estimates to their maximum values. In general, the deterioration of risk indicators with the depth of the forecast shows a deterioration in the quality of this (as any) forecast.

7. Conclusion

The effectiveness of risk-based decisions depend on the quality of the information used - the completeness and representativeness of the sample of reporting data, as well as the adequacy of expert data. The preparation of the information base should make it possible to monitor and improve its quality

https://doi.org/10.15405/epsbs.2021.07.99
Corresponding Author: Vladislav B. Gusev
Selection and peer-review under responsibility of the Organizing Committee of the conference
eISSN: 2357-1330

gradually. An important element of the information support of the decision-making subsystem is the verification of the interaction of factors. It includes additional functions in the risk analysis subsystem:

- Determining the sensitivity of risk assessments to variations in control factors.
- Searching for links («bottlenecks») in a pattern of interactions that are critical to the growth of the risk assessments considered.
- Developing optimization procedures aimed at improving the quality of decisions.

When searching for «bottlenecks» factors and/or elements of the pattern of interactions, factors responsible for the growth or fall of risk assessments of the control set of factors are searched. Minimization of risk assessments through variation of management factors within reasonable constraints will allow the identification of long-term business prospects, including the introduction of new technology complexes and automation systems. The implementation of these functions can also be used as a tool for verifying patterns of interaction between factors of production activity.

References

Algin, A. P. (1991). *Risk in Economic Activity*. Moscow, Knowledge .

Axelrod, R. (1976)*. The Structure of Decision: Cognitive Maps of Political Elites*. Princeton, University Press.

Ernst & Young (2011). *Application of IFRS 2011 in 3 parts.*, Alpina Publisher

GOST R ISO/IEC 16085-2007. (2008). *Risk management. Application for system and software life cycle processes.* Moscow, Standartinform.

Gusev, V. B. (2017). The Expert Analysis of Risks during Control of the Intangible. Assets *Proceedings of the 11th IEEE International Conference on Application of Information and Communication Technologies (AICT2017, Moscow): 2*, (pp. 164-168). Moscow, IEEE.

Gusev, V. B., & Isayeva, N. A. (2017). Method of the Reflexive Analysis of Expert Data. *Proceedings of the 11th IEEE International Conference on Application of Information and Communication Technologies (AICT2017, Moscow): 1*, (pp. 63-66). Moscow, IEEE.

Lobanova, A. A., & Chugunova, A. V. (Eds). (2009). *Encyclopedia of financial risk management. 4th edition, revised and enlarged.* Moscow, Publishers: Alpine.

Seidel, A. N. (1968). *Elementary estimates of measurement errors. 3red.* Leningrad, Science.

Thompson, J., & Michael, T., (1982). *Instabilities and Catastrophes in Science and Engineering*. New York, Wiley.