Assessment of the Prospects for Bankruptcy of Industrial Sectors of the Sverdlovsk Region

I.V. Naumov, A.A. Bychkova, N.L. Nikulina, V.M. Sedelnikov
Institute of Economics of the Ural Branch of the Russian Academy of Sciences, Yekaterinburg, Russia

ABSTRACT

The subject of the study is the assessment of the financial viability of industrial enterprises. The purpose of the paper is to develop a methodological approach to assessing the prospects for bankruptcy of enterprises in various industries in territorial systems and testing it on the example of an industrially developed region. The relevance of the study is due to the fact that in the conditions of significant sanctions pressure on the Russian economy, narrowing of the markets of sale of produced products and disturbance of logistics chains, restrictions on the import of high-tech equipment, Russian enterprises face problems of shortage of operating funds, non-liquidity of assets, high levels of debt. The significant deterioration in the financial situation of enterprises, that is currently observed, creates the prospects for bankruptcy of entire industries, which creates threats to the socio-economic development of territorial systems. The novelty of the study is the author's methodological approach to assessing the prospects for bankruptcy of industrial sectors, based on the use of multidimensional discriminant analysis of the financial viability of not individual enterprises, but of industrial sectors as a whole to determine sectoral priorities for state support for their development. General scientific and empirical methods, multivariate discriminant analysis were used. During testing of the developed methodological approach using the example of the Sverdlovsk region, the following results were obtained: currently, the risks of bankruptcy of enterprises in the entire industrial complex of the Sverdlovsk region are significantly increasing; The Altman curve has approached a critical threshold value, indicating a high level of probability of enterprise bankruptcy. It was concluded that in the Sverdlovsk region, enterprises in the food production, electrical equipment, chemical production and mineral mining industries are in the most critical condition. Increased risks of loss of financial viability are observed in the industries of metallurgical production, production of finished metal products, as well as other non-metallic mineral products, production and distribution of electricity, gas and water, which dominate the industry structure of the region. These industries require government support in the implementation of industrial policy at the federal and regional levels.

Keywords: probability of bankruptcy; industries; region; multivariate discriminant analysis; financial solvency; threshold levels

INTRODUCTION

The industrial complex plays a key role in the development of the economy of Russian regions. It provides a significant part of their gross regional product, creates jobs, makes a significant contribution to the formation of budgetary provision of territorial systems. It has a significant impact on the social development of the regions where industrial enterprises are located, by creating favorable conditions for the development of infrastructure and the social sphere. Sverdlovsk region is one of the industrialized regions of Russia with a high level of concentration of industrial enterprises and their significant contribution to GRP. The socio-economic development of this region depends on the state and prospects of development of the industrial complex. It is based on enterprises of metallurgy and mechanical engineering, chemical, mining, food industry and transport.

In the current geopolitical situation, in the conditions of significant sanctions pressure on the Russian economy and restrictions on the import of foreign technologies and equipment, on which many Russian enterprises operate, the impossibility of their timely and high-quality service, risks are formed in the economic and financial development of industries in the region. Transaction costs for enterprises increase, the cost of production of goods increases, equipment wear increases, and its breakdowns lead to the shutdown of production processes. All this affects the decrease in the quality of products, its competitiveness in the domestic and foreign markets. Restrictions imposed by foreign countries on the export of Russian producers within the framework of the sanctions policy lead to an increase in the limitation of working capital of enterprises, a decrease in their liquidity, an increase in their level of debt, and, as a result, a decrease in their financial stability. The limited financial resources and the difficulty of adapting enterprises to new conditions significantly increase the prospects for industrial failure. The cessation of production activities of a significant part of enterprises may negatively affect the development of certain industries, and this poses serious threats to the economic security of industrially developing regions, such as the Sverdlovsk region. In such conditions, the assessment of the prospects for bankruptcy not of individual enterprises, but of industries as a whole, becomes an important and urgent task. Analysis of the probability of bankruptcy of enterprises — an essential tool for forecasting and counteracting the negative effects of global economic trends. Currently, there is no universal methodological approach to assessing the prospects for bankruptcy of industries and the industrial complex in the territorial system as a whole. This study is dedicated to its development.

THEORETICAL REVIEW

Multidimensional discriminant analysis is the main method of assessing the probability of financial insolvency of enterprises in the works of both Russian and foreign researchers. This method was used by V. M. Fedorov and A. S. Grisko in the development of a predictive model for crisis prevention at industrial enterprises of the machine-building complex of the Omsk region [1]. Their methodological approach was based on Model E. Altman [2] is the most common tool for financial diagnostics and forecasting the risks of bankruptcy of enterprises. This model was used by N. A. L'vov [3] when conducting financial diagnostics of Russian enterprises operating in developed and emerging markets, V. B. Popov and E. Sh. Kadyrov [4] when predicting the probability of bankruptcy of Russian enterprises. They analyzed the advantages and disadvantages of models of foreign authors, such as E. Altman [2], W. Beaver [5], R. Taffler and G. Tishow [6], as well as models from Russian authors. Multidimensional discriminant analysis was used in the works of M. A. Fedotova [7], O. P. Zaitseva [8]. They highlighted

the need to take into account specific indicators, taking into account the industry affiliation and scale of the enterprise's activities, to increase the reliability of the methodology. Using multidimensional discriminant analysis of R. K. Sharma and N. Bhalla developed a model for predicting the financial instability of companies in the information technology sector in India [9], P. Kopchinsky assessed the bankruptcy risk of Polish joint-stock companies [10], and D. Verma and S. S. Raju predicted the default of large corporations [11].

The theoretical review of the studies showed that the methods used by both Russian and foreign researchers to predict the probability of bankruptcy of enterprises are not universal, as they do not take into account the industry specifics of the activities of enterprises, the territorial features of their location, researchers set standard thresholds to assess the probability of bankruptcy of enterprises of various types of economic activities, and this distorts the real picture of their financial condition. When using multidimensional analysis, the size of enterprises, spatial aspects of their location, their importance for the development of a particular territorial system are not taken into account. The thresholds used by researchers to assess the probability of bankruptcy of enterprises are determined expertly and this contributes to the increase in the subjectivity of the results obtained. The integral indicators of the probability of bankruptcy of enterprises used by researchers are calculated on the basis of data for the last reporting period, the dynamics of changes in this probability in the past are not taken into account, and this reduces the reliability of the forecasts generated.

METHODOLOGICAL APPROACH TO ASSESSING THE PROSPECTS OF BANKRUPTCY OF INDUSTRIES

The methodological approach presented in the work is aimed at eliminating the restrictions of multidimensional discriminatory analysis noted above when assessing the probability of bankruptcy of enterprises of various industries in the territorial system. The basis of this methodological approach is formed by the five-factor model E. Altman (1), characterized by high accuracy of forecasting the financial insolvency of enterprises (up to 94%) and the breadth of coverage of factors:

$$Z = 1,2 * X1 + 1,4 * X2 + 3,3 * X3 + 0,6 * X4 + X5, \quad (1)$$

where $X1$ — ratio of working capital to the sum of all assets of the enterprise; $X2$ — ratio of retained earnings to the amount of assets of the enterprise; $X3$ — ratio of operating profit to the amount of enterprise assets; $X4$ — ratio of the market value of shares to the amount of all liabilities; $X5$ — ratio of revenue to the sum of all assets of the enterprise.

Its main advantage is that it takes into account factors that reflect various aspects of the company's activities and this makes the methodology more universal. At the same time, the model has an important limitation — it can be used to assess the probability of bankruptcy of only large enterprises whose shares are traded on the stock market and is practically not applicable to most small and medium-sized enterprises. And this significantly distorts the actual dynamics of the financial stability of industries. When assessing the prospects for bankruptcy of industries, it is important to take into account the entire set of functioning enterprises. Therefore, the Altman model was modified by us by eliminating the $X4$ factor, reflecting the ratio of the market value of shares to the obligations of the enterprise.

At the initial stage of the study, the modified Altman model is proposed to be used to calculate the probability of bankruptcy of enterprises in various industries. To assess the prospects for bankruptcy of each industry, it is proposed to calculate the average values of Z statistics for the entire set of enterprises (2):
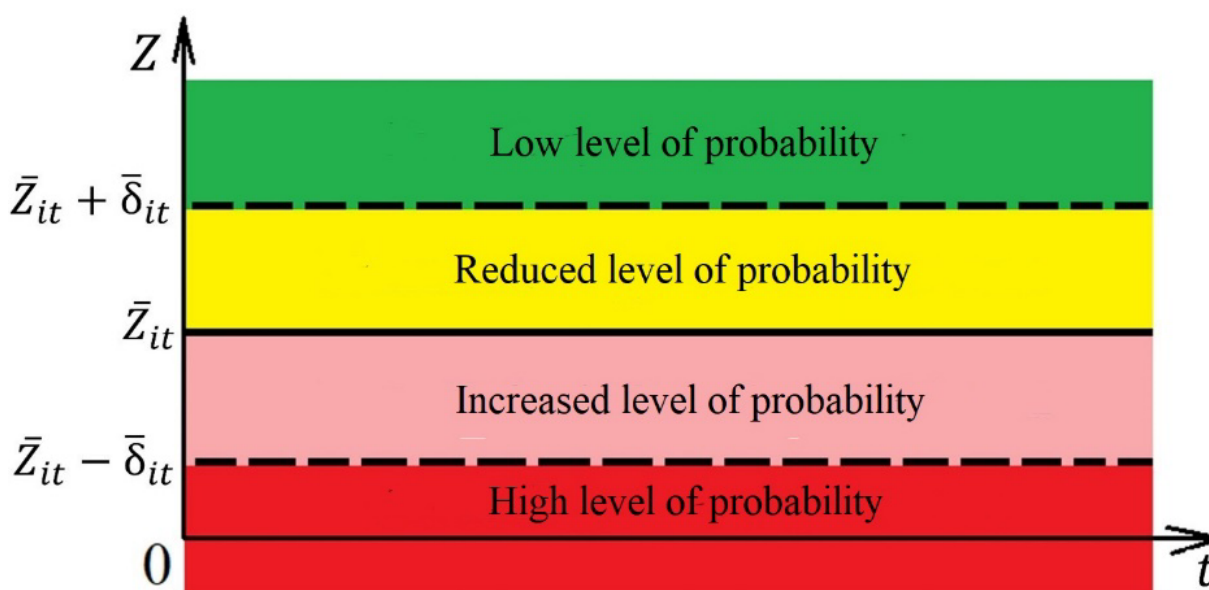
Fig. 1. **Zones of Probability of Bankruptcy of Industries**
Source: Compiled by the authors.

$$\overline{Z_i} = \sqrt[n]{Z_i \cdot Z_{i+1} \cdot Z_{i+2} \cdot \ldots \cdot Z_n} , \qquad (2)$$

where $\overline{Z_i}$ — average geometric value Z of statistics for the entire set of enterprises of a certain industry at a time; Z_i — Z value of statistics for a single industry enterprise; n — total number of enterprises in the industry.

This approach will allow to analyze the dynamics of the financial solvency not of individual enterprises, but of each industry as a whole, establish the prospects for their bankruptcy in the future and determine sectoral priorities for state support for their development, which are so necessary for the development of industrial policy concepts and strategic programs at the regional level. To take into account industry and spatial specifics, it is proposed to use non-standard thresholds proposed by E. Altman, and the values calculated using standard deviations from the average value for all enterprises of the industry for the period under review from 1999 to 2022 (*Fig. 1*).

This will avoid subjectivity in assessing the likelihood of bankruptcy of enterprises and use threshold values specific to a particular industry in a particular territorial system.

According to the methodology of E. Altman, a high level of probability of bankruptcy is observed in enterprises with Z values of statistics less than 1.8, which corresponds to the "red" zone in *Fig. 1*. To take into account the industry specifics of enterprises and calculate the individual threshold value of the high-risk bankruptcy zone of enterprises for each industry, it is proposed to use the formula (3):

$$Z_i < \left(\overline{Z_{it}} - \overline{\delta_{it}} \right) = \sqrt[n]{\overline{Z_t} * \overline{Z_{t+1}} * \ldots * \overline{Z_{tn}}} -$$

$$- \sqrt{\frac{\sum_{i=1}^{n} \left(\overline{Z_t} - \overline{Z_{it}} \right)^2}{n-1}} , \qquad (3)$$

where Z_i — Z value of statistics for a single industry enterprise; $\overline{Z_t}$ — average geometric value of Z, calculated for enterprises of a certain industry in the subject of the Russian Federation at a time; $\overline{Z_{it}}$ — average geometric value Z of statistics calculated for all enterprises of the industry in the subject of the Russian Federation for the analyzed period of time; $\overline{\delta_{it}}$ — average value of the standard deviation of Z statistics for all enterprises of

the industry in the subject of the Russian Federation for the entire period of time; n — duration of the time series.

As a result of this approach, enterprises with Z statistics values below the average by one standard deviation will be in the zone with a high probability of bankruptcy (δ_{it}). A low level of probability of bankruptcy, respectively, will be observed in the "green" zone (*Fig. 1*) in enterprises with Z statistics values exceeding the industry average by one standard deviation. The uncertainty zone in assessing the probability of bankruptcy of enterprises according to the Altman method corresponds to the intermediate values between the "red" and "green" zones. Studies using this model show that a significant part of the evaluated enterprises fall into this zone and the use of standard thresholds introduced by Altman creates difficulties in the study of their financial viability. For a more accurate assessment of the prospects for bankruptcy of enterprises, this methodological approach proposes the allocation of a zone with a moderate (average) level of probability of bankruptcy of enterprises ($\overline{Z_{it}}$), as well as two additional risk zones (with increased and reduced probability). An increased level of probability of bankruptcy according to this approach will be observed in enterprises whose statistics Z value is below the average level calculated for all enterprises in the industry for the entire period under review from 1999 to 2022, but does not reach the standard deviation from the average (4):

$$(\overline{Z_{it}} - \overline{\delta_{it}}) < Z_i < \overline{Z_{it}} \,. \qquad (4)$$

The reduced level of probability of bankruptcy of enterprises, respectively, will be determined in the range of values from the middle level to the upper limit of the spread of values determined using the standard deviation. The allocation of a reduced and increased level of bankruptcy probability increases the sensitivity of assessing the prospects for bankruptcy of industries. The methodological approach proposed in the work allows a more correct approach to

the assessment of the financial viability of enterprises — to take into account their size, sectoral and spatial specifics, differentiation of the levels of probability of their bankruptcy. Its novelty is the use of individual thresholds calculated for each industry, based on the dynamics that has been observed for all enterprises over a long period of time. This approach eliminates the subjectivity of assessments, which is characteristic of most studies using multidimensional discriminant analysis. Its novelty also lies in the use of tools for dynamic analysis of bankruptcy prospects. Calculation of Z statistics in dynamics makes it possible to establish patterns of changes in the probability of bankruptcy of enterprises during periods of increasing crisis phenomena in the economy and its recovery.

Spatial features of the placement of enterprises are also important in assessing the prospects for bankruptcy of industries. And in part, the approach proposed in the work takes them into account when calculating individual thresholds for each industry of the probability of bankruptcy of enterprises. It is obvious that in each territorial system, the Z values of statistics for enterprises of the same industry will differ, which means that the thresholds of the probability of bankruptcy of enterprises in different territorial systems will also differ. The spatial features of the location of enterprises are most fully disclosed when assessing the prospects for bankruptcy of the entire industrial complex of the territorial system. Each territory is unique and distinguished by its unique industry structure. And the adjustment of the calculated Z values of the probability of bankruptcy of industries for their share in the industry structure of the territory would allow to take into account the spatial features of the development of the industrial complex (5):

$$\overline{Z} = \overline{X_i} \cdot \overline{Z_i} + \ldots + \overline{X_{in}} \cdot \overline{Z_n} \,, \qquad (5)$$

where $\overline{Z}$ — value Z of a statistic calculated for all enterprises of an industrial complex in the

subject of the Russian Federation at a certain time; $\overline{Z_i}$ — average geometric value of Z, calculated for enterprises of a certain industry in the subject of the Russian Federation at a time; $\overline{X_i}$ — weighted average for a certain period of time specific weight of industry i in the structure of the industry of the subject of the Russian Federation.

To level the random changes observed in the dynamics of the sectoral structure of territorial systems and use its really established proportions, it is advisable to use the weighted averages for a certain period of time, for example, the last 5–7 years, coefficients reflecting the occupied share of industries in its structure. Since individual thresholds are used to interpret the results of the assessment of the financial viability of industries, summing up the results of this analysis throughout the industrial complex requires the calculation of thresholds generalized for all industries. To generalize them, it is proposed to use a standard approach — the calculation of average values.

Assessment of the prospects of bankruptcy of the industrial complex of the territorial system in general and its industries in particular, a comparison of their dynamics will help to establish those areas of production activities of enterprises, Currently in a difficult financial situation and requiring increased attention and support from public authorities.

RESULTS

The developed methodological approach to assessing the prospects for bankruptcy of industries was tested on the example of an industrially developed region — the Sverdlovsk region. The main branch of its specialization is metallurgical production, the weighted average share of which in the industry structure over the past seven years (from 2016 to 2022) was 46.6%. A significant share in the industry structure of the region is occupied by the production, distribution of electricity, gas, water (10.2%), production of vehicles (7.2%), finished metal products (7.1%)

and food products (6.1%). The calculation of Z statistics and thresholds showed that these industries are in a difficult financial situation and have an increased level of probability of bankruptcy. In many branches, the Altman curve has approached the red zone (*Fig. 2*).

In the metallurgical production industry in 2022, Z statistics reached 1.16 at a critical level of 1.01 for this industry, indicating a significant probability of bankruptcy of enterprises. During the periods of financial and economic crisis, which was observed in 2009, significant sanctions pressure in 2014, the coronavirus pandemic in 2020–2021, this curve crossed the specified threshold and was in the red zone of high risk of loss of financial solvency by enterprises. Currently, such large metallurgical enterprises of the Sverdlovsk region are in the field of increased financial risks as JSC "Svyatogor" (in 2022 the Z value of Altman's statistics reached the level of 0.97), PJSC "Revdinsky Non-Ferrous Metals Processing Plant" (1.4), JSC "Seversky Pipe Plant" (1.23), JSC Ural Mining and Metallurgical Company (1.06), JSC "UMK-Steel" (1.17) and JSC "Kamensk-Ural Metall Metallurgical Plant" (0.6). Small metallurgical enterprises in the region are in the most difficult financial situation — 69 enterprises out of 240 are located in the red zone with the highest level of bankruptcy and 29 — in the zone of increased probability. Metallurgical production forms the basis of the industrial complex of the Sverdlovsk region, makes a significant contribution to the formation of its GRP and the deterioration of the financial stability of metallurgical enterprises, which is currently observed, has a negative impact on the pace of economic development of the region.

The Z values of statistics in the enterprises of the electricity, gas and water production and distribution industry throughout the period under review from 1999 to 2022 were close to zero. The use of standard Altman thresholds to interpret the results of the assessment of the probability of bankruptcy of

Metallurgical production

Production and distribution of electricity, gas and water

Production of other non-metallic mineral products

Production of finished metal products

$\overline{Z}_{it} + \overline{\delta}_{it}$ (Low probability of bankruptcy of industrial enterprises)

$\overline{Z}_{it}$ (Average probability of bankruptcy of industrial enterprises)

$\overline{Z}_{it} - \overline{\delta}_{it}$ (High probability of bankruptcy of industrial)
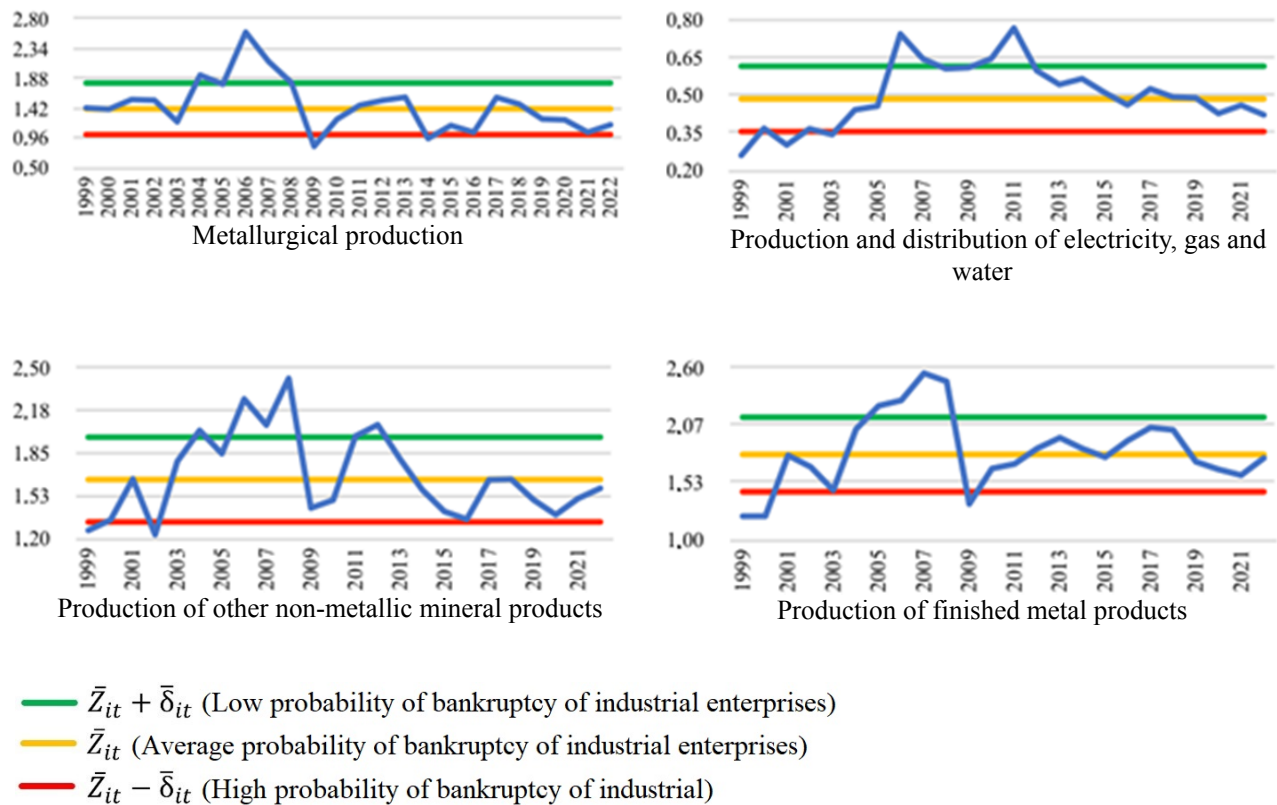
Fig. 2. **Dynamics of *Z* Statistics for Industries in the Sverdlovsk Region with an Increased Level of Probability of Bankruptcy of Enterprises**

Source: Compiled by the authors.

this industry in the region would lead to false conclusions, to the conclusion that enterprises are in a deep financial crisis. However, it should be noted that most large and medium-sized enterprises in this industry are financially stable and have an extremely low level of probability of bankruptcy. The *Z* values of statistics calculated in the industry as a whole were influenced by small enterprises with an extremely unstable financial situation. Their predominance in the industry (497 enterprises) contributed to obtaining near-zero *Z* values of statistics. The use of individually calculated thresholds for this industry, presented in *Fig. 2*, made it possible to draw more correct conclusions about the probability of bankruptcy of enterprises in the industry: there are increased risks of loss of financial solvency by enterprises and they have been increasing significantly since 2012. The high level of dependence of enterprises

on foreign technologies, equipment and the growth of foreign currency quotations had a negative impact on their financial stability.

An increased level of probability of bankruptcy is also observed in enterprises engaged in the production of non-metallic products (*Fig. 2*). However, the situation in this industry is not as critical as in metallurgical production. In 2022, *Z* statistics calculated for industry enterprises approached the average level of probability of bankruptcy of enterprises. Moreover, for a significant part of the period under review, the values of this indicator were in a reduced risk zone. A significant decline in the dynamics of *Z* statistics, indicating an increase in the risks of bankruptcy of industry enterprises, was observed during periods of economic turmoil 2008–2009, 2014–2015, 2018–2021. Currently, the financial situation of enterprises engaged in the production of finished metal products
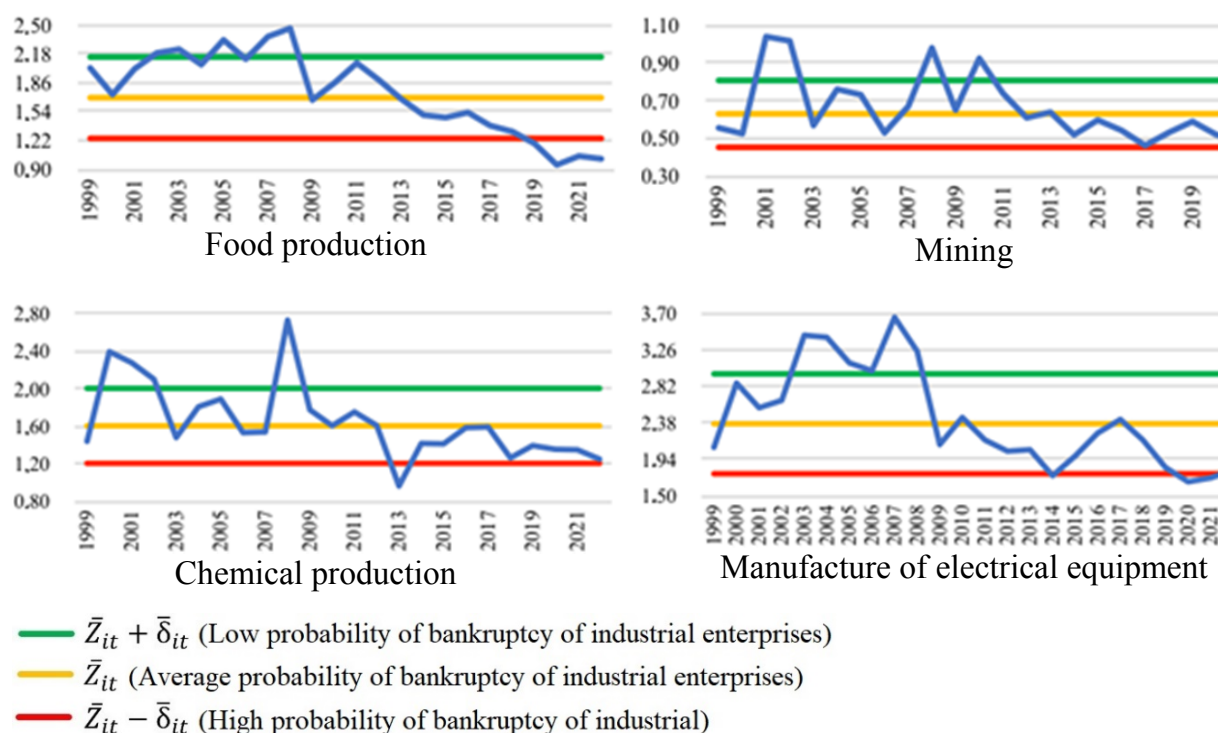
Food production

Mining

Chemical production

Manufacture of electrical equipment

$\bar{Z}_{it} + \bar{\delta}_{it}$ (Low probability of bankruptcy of industrial enterprises)

$\bar{Z}_{it}$ (Average probability of bankruptcy of industrial enterprises)

$\bar{Z}_{it} - \bar{\delta}_{it}$ (High probability of bankruptcy of industrial)

Fig. 3. **Dynamics of *Z* Statistics for Industries in the Sverdlovsk Region with a High Level of Probability of Bankruptcy of Enterprises**

Source: Compiled by the authors.

is improving and it is quite possible that next year this industry will move to the category with a reduced risk of bankruptcy of enterprises.

A similar dynamics of *Z* statistics was observed in the production of other non-metallic mineral products and currently enterprises in this industry are characterized by an increased level of probability of bankruptcy. However, unlike manufacturers of metal products, the difficult financial situation of these enterprises has been observed over the past 10 years, the values of Altman statistics fluctuate in the zone of increased probability of bankruptcy. Not only small, but also a significant part of the average revenue of enterprises are in the most vulnerable position. These include: plant LLC "Atomstroycomplex Cement" (with a value of *Z* statistics 0.1 in 2022), LLC "BETONSTROY" (−31.1), LLC "ZAPSIBNEFTESTROY" (1.2), LLC "Severouralsky ZhBK Plant" (1.1), LLC "Isetsky Granite" (1.6), LLC "Monolit" (−0.6).

At the same time, the financial situation of enterprises producing other non-metallic mineral products improved significantly by 2022, and the value of *Z* statistics for the industry as a whole reached the average level. Enterprises in this industry have good prospects for development in the future, since the National Project "Safe and Quality Roads" is currently being implemented in the urban agglomerations of the region, which involves the construction of new roads, infrastructure facilities, and this will significantly increase the demand for products of industry enterprises.

The Z-dynamics study of Altman statistics showed that the most difficult financial situation is found in enterprises engaged in food production, electrical equipment, chemical production and mining (*Fig. 3*). The values of this indicator in these industries are in the red zone with a high level of probability of bankruptcy of enterprises. And if in chemical production and mining this level
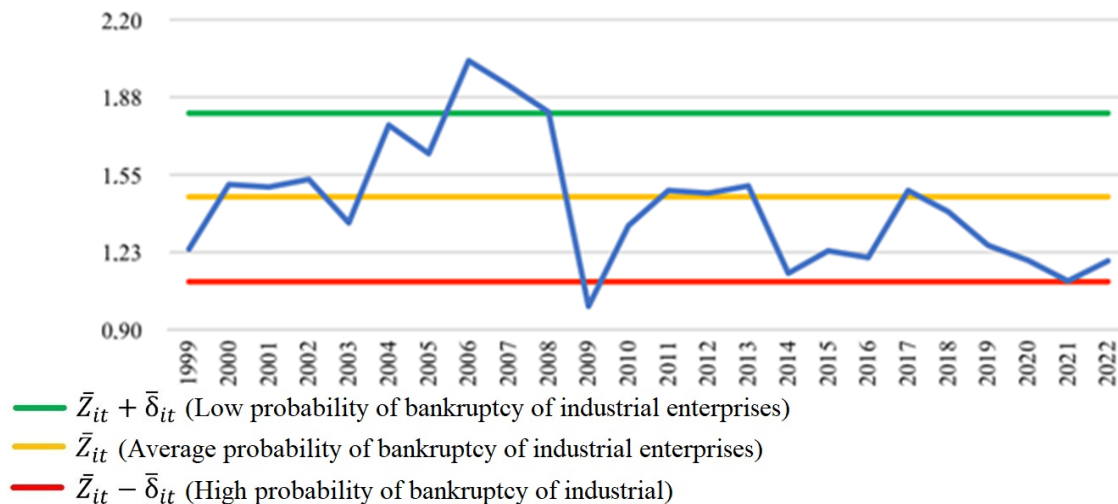
Fig. 4. **Dynamics of *Z* Statistics for All Enterprises Industrial Complex of the Sverdlovsk Region for the Period from 1999 to 2022**

Source: Compiled by the authors.

was reached by enterprises only in 2022, then in food production it has been observed for 5 years. In the critical zone with a very high level of probability of bankruptcy (*Z* statistics below 1.24 for this industry) there are such large enterprises as: JSC "Zhirovoy Combine" (0.33), LLC "KDV Nizhny Tagil" (1.19). An increased level of probability of bankruptcy is observed in JSC Food Combine "Khoroshii Vkus" (1.69), JSC "SMAK" (1.49). The food industry occupies a significant share in the sectoral structure of the Sverdlovsk region (6.1%) and ensures food security of the region, therefore, the bankruptcy of enterprises in this industry is simply unacceptable.

Mining is not the leading branch of specialization in the region, its share in the industry structure on average for the period from 2016 to 2022 did not exceed 4%. However, its importance for the region is very great — it is closely interconnected with the metallurgical complex and the production of non-metallic mineral products. Among large enterprises, a high level of probability of bankruptcy is observed in LLC "Mechanoremontnyi Complex" (the value of *Z* statistics in 2022 was 0.39), LLC "Saratov-Cement" (0.01), JSC "EVRAZ Kachkanar Mining and Processing Plant" (−4.98). In

the zone of high risk of bankruptcy, as the calculations of *Z* statistics showed, there are 141 out of 463 small enterprises with revenues of up to 198 million rubles. And this forms significant risks for the future development of the mining industry in the region.

Chemical production enterprises are also in a difficult financial situation, as evidenced by the dynamics of the Altman curve, which reached a critical value of 1.2 in 2022 (*Fig. 3*). The highest level of probability of bankruptcy is observed in small enterprises, whose share in the industry according to 2022 is 96%. Since 2008, the probability of bankruptcy of enterprises in the field of electrical equipment production has increased significantly (*Fig. 3*). The development of this industry is under considerable pressure: the increasing cost of imported equipment used by enterprises due to the growth of foreign currency quotes, as well as the restriction of imports of high-tech equipment. Industry enterprises in the region are very dependent on foreign components that are used in the production of electrical equipment, and the difficulties arising in the process of their purchase and transportation due to sanctions restrictions and broken logistics chains significantly increase the cost of their products, which ultimately affects

the decrease in the financial stability of industry enterprises. Small enterprises were in the most difficult financial situation: a high level of probability of bankruptcy (below the threshold of 1.76) is observed in 204 out of 624 enterprises, and an increased level of probability of bankruptcy (with $Z < 2.37$) — 39 enterprises.

In the most stable financial position, with Z values of statistics in the zone with a reduced level of probability of bankruptcy of enterprises are such industries as: mechanical engineering, production of vehicles, rubber and plastic products, textile and clothing production, as well as wood processing and production of wood products. In the vehicle industry, only a small part of small businesses are experiencing financial difficulties (26 out of 126). An increased level of probability of bankruptcy (with $Z < 2.13$) is observed only in some enterprises producing rubber and plastic products, in particular: LLC "Polymer Technologies" (–0.93), LLC "Ural Tire Plant" (1.52), PJSC "Ural Plant RTI" (1.66), LLC "Ural Plant of Lining RTI" (2.1). In the field of woodworking and production of wood products, increased risks of bankruptcy (at a value of $Z < 1.93$) are observed in PKF Prominvest LLC (0.94) and in JSC Turin Pulp and Paper Mill (1.52). The textile and clothing industry is the only one in the region that was not significantly affected by the financial and economic crisis of 2009 and the sanctions pressure that began in 2014. The Z values of Altman's statistics for enterprises in this industry for a long period, from 2007 to 2022, were located in a zone with a reduced level of probability of bankruptcy (above 1.64). The development prospects of enterprises in this industry, taking into account the reduced competition in the textile market due to the withdrawal of foreign manufacturers from the country, are good, the probability of bankruptcy of enterprises in this industry in the future is very low.

To assess the risks of bankruptcy of enterprises of the entire industrial complex of the Sverdlovsk region as a whole, the average geometric levels of Z statistics for all industries were summed up with the use of weighing coefficients, based on the averages for the period from 2016 to 2022, characterizing the share of a particular industry in the production structure. Calculations of Z statistics showed that currently the risks of bankruptcy of enterprises as a whole of the entire industrial complex of the Sverdlovsk region are significantly increasing. The Altman curve has approached a critical threshold indicating a high level of probability of bankruptcy of enterprises (*Fig. 4*).

The industrial complex of the region did not recover after the financial and economic crisis of 2009, and this is evidenced by the dynamics of Z statistics, which until 2022 fluctuated in the zone of increased risks of bankruptcy of enterprises. The dynamics of this indicator, shown in *Fig. 4*, indicates the current phase of recovery of the industrial complex after the coronavirus pandemic. The same phase of recovery was observed in 2015 after the introduction of severe sanctions restrictions and in 2010 after the financial and economic crisis. Therefore, it is quite possible to expect the restoration of the financial stability of industrial enterprises in the region in the next 4–5 years, the achievement of the Altman curve of the moderate risk zone (values $Z = 1.46$).

CONCLUSION

The paper presents the author's methodological approach to assessing the prospects of bankruptcy of enterprises in various industries, involving the use of multidimensional discriminant analysis of the dynamics of development not of individual enterprises, but of their totality, the calculation of individual threshold values for the correct interpretation of the results and taking into account the industry specifics of the territorial system.

The industrial complex of the Sverdlovsk region is currently located in a zone with

an increased probability of bankruptcy of enterprises. Enterprises in the food production, electrical equipment, chemical production and mining industries are in the most critical condition. Increased risks of loss of financial solvency are observed in the industries of metallurgical production, production of finished metal products, as well as other non-metallic mineral products, production and distribution of electricity, gas and water, which prevail in the industry structure of the region. These industries require state support in the implementation of industrial policy at the federal and regional levels.

The results obtained in the future will be used for regression analysis of internal and external factors in the formation of industry bankruptcy risks and the development of multivariate scenarios for changing its dynamics in the future.

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REFERENCES

1. Fyodorov V. M., Grisko A. S. Predicative model of pre-empting crises at industrial enterprises of machine-building complex in the Omsk region on the basis of multiple discriminant analysis. *Rossiiskoe predprinimatel'stvo = Russian Journal of Entrepreneurship*. 2010;(1–1):66–70. (In Russ.)

2. Altman E. I. Financial ratios, discriminant analysis and the prediction of corporate bankruptcy. *The Journal of Finance*. 1968;23(4):589–609. DOI: 10.1111/j.1540–6261.1968.tb00843.x

3. L'vova N. A. Financial diagnostics of Russian enterprises with the Altman's model application for developed and emerging markets. *Finansovaya analitika: problemy i resheniya = Financial Analytics: Science and Experience*. 2015;(7):37–45. (In Russ.).

4. Popov V. B., Kadyrov E. Sh. Analysis of models for predicting the probability of bankruptcy of enterprises. *Uchenye zapiski Tavricheskogo natsional'nogo universiteta im. V. I. Vernadskogo. Seriya: Ekonomika i upravlenie = Scientific Notes of the Tauride National University named after V. I. Vernadsky. Series: Economics and Management*. 2014;27(1):118–128. (In Russ.).

5. Beaver W. H. Financial ratios as predictors of failure. *Journal of Accounting Research*. 1966;4:71–111. DOI: 10.2307/2490171

6. Taffler R. J., Tisshaw H. Going, going, gone — four factors which predict. *Accountancy*. 1977;88(3):50–54.

7. Fedotova M. A. How to assess the financial stability of an enterprise. *Finansy = Finance*. 1995;(6):13–16. (In Russ.).

8. Zaitseva O. P. Anti-crisis management in a Russian company. *Sibirskaya finansovaya shkola = Siberian Financial School*. 1998;(11–12):66–73. (In Russ.).

9. Sharma R. K., Bhalla N. Insolvency prediction model of the Indian information technology companies using multiple discriminant analysis: The case of the Republic of India. In: India Finance Conference (Kolkata, December 19–21, 2019). Kolkata: Indian Finance Association; 2019.

10. Kopczyński P. Bankruptcy risk assessment of Polish listed companies using Asian multiple discriminant analysis models. *Zeszyty Teoretyczne Rachunkowości*. 2022;46(2):69–96. DOI: 10.5604/01.3001.0015.8810

11. Verma D., Raju S. Predicting corporate defaults using multiple discriminant analysis. *CASS Studies*. 2019;3(2):1–19. URL: https://onlinejournals-heb.pen-nic.in/cass/admin/freePDF/qwe23cmok7mgp2zf68tn.pdf

ABOUT THE AUTHORS

Ilya V. Naumov — Cand. Sci. (Econ.), Assoc. Prof., Head of the Laboratory for Modelling of Spatial Development of Territories, Institute of Economics of the Ural Branch of the Russian Academy of Sciences, Yekaterinburg, Russia
https://orcid.org/0000-0002-2464-6266
naumov.iv@uiec.ru

Anna A. Bychkova — Junior Researcher of the Laboratory for Modelling of Spatial Development of Territories, Institute of Economics of the Ural Branch of the Russian Academy of Sciences, Yekaterinburg, Russia
https://orcid.org/0000-0001-8676-5298
bychkova.aa@uiec.ru

Natalia L. Nikulina — Cand. Sci. (Econ.), Senior Researcher of the Laboratory for Modelling of Spatial Development of Territories, Institute of Economics of the Ural Branch of the Russian Academy of Sciences, Yekaterinburg, Russia
https://orcid.org/0000-0002-6882-3172
Corresponding author:
nikulina.nl@uiec.ru

Vladislav M. Sedelnikov — Junior Researcher of the Laboratory for Modelling of Spatial Development of Territories, Institute of Economics of the Ural Branch of the Russian Academy of Sciences, Yekaterinburg, Russia
https://orcid.org/0000-0003-0494-2647
sedelnikov.vm@uiec.ru

Author's declared contribution:
I.V. Naumov — problem statement, article concept development, development of methodological and methodological approaches, calculations, description of results, formation of research conclusions.
A.A. Bychkova — development of methodological approach, collection of statistical data, calculations, tabular and graphical presentation of results, description of results, formation of research conclusions.
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