Forecasting bankruptcy models for agrarian business

N Baryshnikov1, D Samygin2*, D Murzin1

1 Penza State Agrarian University, 30 Botanicheskaya str., Penza 440014 Russia
2 Penza State University, 40 Krasnaya str., Penza 440026 Russia

E-mail: vekont82@mail.ru

Abstract. The increasing practical significance of forecasting tools in the agricultural business arises from the requirements of legislation on strategic planning. Solving the problem of foreseeing bankruptcy in foreign practice is carried out through the use of a step-by-step discriminant analysis methodology. The most common solvency forecasting models developed by Western European and Russian scientists in scientific research have been systematized. Their analytical and functional capabilities are summarized, and the need for their application in domestic practice to supplement existing tools of bankruptcy diagnostics with the means of its prediction is shown. These models, along with the method of assessing insolvency, will allow for a comprehensive survey of agribusiness entities, improving the business reputation of agriculture and acting as instrumental support for issuing guarantees to free capital owners about the financial status of producers in the future.

1. Introduction

To date, the state has significantly strengthened its position on the resource supply of agriculture (more than 10 times) in comparison with the indicators 20 years ago. At the same time, a fundamentally different investment breakthrough is required for a radical turnaround and the transition to the path of innovative development, accompanied by significant financial investments and budget funds are not enough. Therefore, the format of state stimulation of investment activity of agricultural producers today is being modernized, and the tools for attracting free capital to the agricultural business are being introduced. The criteria for financial sustainability, which are the basis for the mobilization of credit resources, are becoming more distinct.

As part of the state program on agriculture for 2013-2020, a compensation is made for a part of the interest rate on loans attracted for its development. Moreover, from January 1, 2017, a preferential crediting mechanism was introduced, consisting in providing a subsidy to credit organizations for reimbursement of lost revenue on loans to agricultural organizations at a preferential rate of not more than 5%.

In 2017, budget allocations in the amount of 95795.3 million rubles were provided for the implementation of these activities in 2017 in accordance with the Budget Law for 2017. Compared to the volume of budget allocations provided in 2016 for the implementation of measures aimed at stimulating investment in the agro-industrial sector, budget allocations in 2017 were increased by 19871.5 million rubles (26.2%), including in connection with the implementation of the mechanism of concessional lending. As of January 1, 2018, the cash execution of the federal budget for measures aimed at stimulating investment activity in the agro-industrial complex amounted to 87972.7 million rubles. Due to this, according to the national report on the implementation of the state program in
2017, the volume of short-term loans issued for the development of the agro-industrial sector in 2017 amounted to 1,204 billion rubles, which was 3.5% more than in 2016 and 39.4% more than in 2015.

However, the needs of the agricultural business in the resources of the financial and credit sector are much wider. According to our research, only a small part of sustainable agrofirms is able to finance their investment needs at the expense of banks [1]. A significant part of farms and farmers is not able (because of financial circumstances) to attract the necessary credit resources for current and capital investments. The fact is that state crediting measures alone do not guarantee the approval of an application by a bank with insufficient creditworthiness indicators, the assessment of which is essentially the only tool to support investment decisions made by a credit institution regarding debt financing for agriculture. For this reason, it is necessary to analyze the current situation, identify shortcomings, and include new mechanisms for attracting investment in the economy of the agricultural sector.

2. Material and method

The need for systematization, synthesis, and development of foresight tools is dictated by the legislation on strategic planning of 2014. Moreover, in the memory of partners (suppliers, buyers, etc.), the plume of low business reputation of agricultural producers has not significantly decreased due to relatively recent court battles about their massive bankruptcies. That is why, the risk of default agrarian business becomes the subject of serious scientific research [2, 3, 4].

In the Russian practice, insolvency studies of agricultural producers are based only on the tools of arbitration management approved by a number of regulatory legal acts. The methodology is based on determining the ability of an agricultural organization to pay on its obligations on time. Solvency analysis is carried out by identifying the degree of liquidity of mobile assets of agricultural enterprises. As well as the Sberbank method for assessing the creditworthiness of borrowers [5], the method of assessing the financial condition provides information only about their current financial position of the agrarian business entities without timely predicting the probability of losing their solvency. At the same time, the experience of developed countries suggests the feasibility of such procedures.

Most of the breakthrough research on the diagnosis of solvency and predicting the risk of default, which are successful in developed countries, were carried out using step-by-step discriminatory analysis.

The most common are the Altman models (table 1), which are based on a selection of 66 companies (33 successful and 33 bankrupt ones). As studies by leading scientists [6] show, prediction accuracy using these models was obtained in 95% of cases.

Table 1. Altman models for predicting default.

| View and image of the model | Model parameters | Conditions of default |
|----------------------------|------------------|----------------------|
| Two-factor model:          |                  |                      |
| \( Z_2 = 0.3877 - 1.0736 \ast X_1 + 0.579 \ast X_2 \) | \( X_1 \) – current ratio; \( X_2 \) – debt to liabilities ratio | \( Z > 0 \) |
| Five-factor model:         |                  |                      |
| \( Z_5 = 1.2 \ast X_1 + 1.4 \ast X_2 + 3.3 \ast X_3 + 0.6 \ast X_4 + 0.999 \ast X_5 \) | \( X_1 \) – as well as in four-factor; \( X_2 \) – as well as in four-factor; \( X_3 \) – as well as in four-factor; \( X_4 \) – ratio of the market price of a share to borrowed sources; \( X_5 \) – ratio of sales revenue to assets | \( Z < 1.81 \) |
| Modified model:            |                  |                      |
|                           | \( X_1 \) – as well as in four-factor; \( X_2 \) – as well as in four-factor; | Just like in \( Z_5 \) |
\[ Z_m = 0.717 * X_1 + 0.847 * X_2 + 3.107 * X_3 + 0.42 * X_4 + 0.995 * X_5 \]

\[ X_3 - \text{as well as in four-factor;} \]
\[ X_4 - \text{funding ratio;} \]
\[ X_5 - \text{as well as in the five-factor.} \]

The experience of using Altman models by foreign experts in the practice of developed countries indicates a high level of accuracy of forecast estimates for bankruptcy prediction [7]. At the same time, the model based on two factors, as indicated by a number of authors [8], does not provide a comprehensive assessment of the financial situation of enterprises, including in agriculture. Therefore, foreign business analysts are more likely to use the five-factor model. Moreover, due to the consideration of the market capitalization factor in the first two models and their low applicability to non-public firms, E. Altman later derived a modified version of his functionality [9]. However, even under these conditions, a number of leading scientists propose using its models only in conjunction with other tools [10], which makes it necessary to diagnose a wider range of indicators using other models (Table 2).

**Table 2. Western models of bankruptcy prediction.**

| View and image of the model | Model parameters | Default condition |
|-----------------------------|------------------|-------------------|
| **Fulmer’s model:**        |                  |                  |
| \[ Z_{Fulmer's} = 5.528 * X_1 + 0.212 * X_2 + 0.073 * X_3 + 1.270 * X_4 - 0.120 * X_5 + 2.335 * X_6 + 0.575 * X_7 + 1.083 * X_8 + 0.894 * X_9 - 3.075 \] | \[ X_1 - \text{the share of retained earnings of previous years in the amount of balance;} \] | \[ Z < 0 \] |
| **Springite’s model:**     |                  |                  |
| \[ Z_{Springite’s} = 1.03 * X_1 + 3.07 * X_2 + 0.66 * X_3 + 0.4 * X_4 \] | \[ X_2 - \text{the ratio of EBIT profit to total balance;} \] | \[ Z < 0.862 \] |
| **Taffler’s model:**       |                  |                  |
| \[ Z_{Taffler’s} = 0.53 * X_1 + 0.13 * X_2 + 0.18 * X_3 + 0.16 * X_4 \] | \[ X_3 - \text{ratio of long-term liabilities to total assets;} \] | \[ Z < 0.2 \] |
Fox’s model:
\[ Z_{\text{Fox's}} = 0.063 \times X_1 + 0.092 \times X_2 + 0.057 \times X_3 + 0.001 \times X_4 \]

Lego’s model:
\[ Z_{\text{Lego's}} = 4.5913 \times X_1 + 4.5080 \times X_2 + 0.3936 \times X_3 - 2.7616 \]

The accuracy of forecasts for these functionals ranges from 92% according to the Springate’s model [11] and 98% according to the Fulmer’s model [12]. In all cases, the foresight period is not more than a year [13]; otherwise, the probability of coincidence decreases [14]. In addition, in foreign countries, such discriminatory factor models as the Fox’s model, the Tafler’s model and the Lego model are also widely used. The latter is popular for predicting the bankruptcy of industrial companies with an infallible forecast of about 83% [15].

Among the Russian models, a number of models by researchers such as Postushkov [16], Zaitseva, Saifullin, Khaidarshina, Kovalenko are of particular interest (Table 3).

### Table 3. Russian default forecasting models.

| View and image of the model | Model parameters | Default condition |
|-----------------------------|------------------|-------------------|
| Postushkov’s model:         | \( X_1 \) – current liquidity; \( X_2 \) – security of own working capital; \( X_3 \) – turnover; \( X_4 \) – profitability of equity; \( X_5 \) – profitability of equity | \( Z < 0.99 \) |
| \( Z = 0.125 \times X_1 + 2.5 \times X_2 + 0.04 \times X_3 + 1.25 \times X_4 \) | \( Z_{\text{fact}} > Z_{n} \) |
| Zaitseva’s model:           | \( X_2 \) – ratio of own working capital to total assets; \( X_3 \) – the proportion of retained earnings in the balance sheet; \( X_4 \) – the ratio of debt to equity; \( X_5 \) – the proportion of equity in total assets; \( X_6 \) – the ratio of sales revenue for the two periods to the amount of assets for the two periods | \( Z_{n} = 0.25 \times 0 + 0.1 \times 1 + 0.2 \times 7 + 0.25 \times 0.1 \times 7 + 0.1 \times X_6 \) last year |
| \( Z_{\text{fact}} = 0.25 \times X_1 + 0.1 \times X_2 + 0.2 \times X_3 + 0.25 \times X_4 + 0.1 \times X_5 + 0.1 \times X_6 \) | \( X_1 \) – the ratio of own funds; \( X_2 \) – current ratio; \( X_3 \) – asset turnover ratio; \( X_4 \) – profitability of sales; \( X_5 \) – profitability of equity | \( Z < 1 \) |
| \( Z_{n} = 0.25 \times 0 + 0.1 \times 1 + 0.2 \times 7 + 0.25 \times 0.1 \times 7 + 0.1 \times X_6 \) last year | \( 0.8 < Z < 1 \) - maximum bankruptcy |
| Saifullin’s model:          | \( X_1 \) – the indicator value depends on the term of activity of the legal entity, it is 0, with a term of 10 years and more, and - 1 – | \( 0.8 < Z < 1 \) - maximum bankruptcy |
| \( Z = 2 \times X_1 + 0.1 \times X_2 + 0.08 \times X_3 + 0.45 \times X_4 + X_5 \) | \( Z < 1 \) |
| Khaidarshina’s model:       | \( X_1 \) – share of working capital in assets; \( X_2 \) – ratio of sales profit to total assets; \( X_3 \) – the proportion of retained earnings in the balance sheet; \( X_4 \) – the ratio of debt to equity; \( X_5 \) – the proportion of equity in total assets; \( X_6 \) – the ratio of sales revenue for the two periods to the amount of assets for the two periods | \( Z < 0.037 \) |
\[ Z = \frac{e^y}{1 + e^y} \]

where

\[ Y = 13.5065 + 0.2753 \times X_1 + 6.6637 \]

\[ - 2.3915 \times X_2 - 1.0028 \]

\[ + 2.8715 \times X_{10} - 6.9339 \times X_{11} \]

\[ * X_2 - 7.0113 \times X_3 \]

\[ * X_5 - 0.29 \times X_6 \]

\[ - 1.5742 \times X_7 - 6.1679 \]

\[ * X_6 - 2.3624 \times X_9 \]

\[ Z_{\text{kriz}} = 16.36 \times X_1 - 0.51 \times X_2 - 7.99 \]

\[ \times X_3 + 18.97 \times X_4 \]

\[ - 56.81 \]

\[ Z_{\text{norm}} = -5.26 \times X_1 + 110 \times X_2 + 3.23 \]

\[ \times X_3 - 3.83 \times X_4 \]

\[ - 54.0672 \]

with a period of less than 10 years; risk;

\[ X_2 - \text{the value of the indicator depends on the credit history of the organization, it is } 0 \]

\[ 0.6 < Z <= 0.8 \text{ - for positive and 1 for negative credit history; high bankruptcy risk} \]

\[ X_3 - \text{current liquidity ratio; } X_4 - \text{ratio of EBIT earnings to interest paid; } X_5 - \text{natural log of equity; } \]

\[ X_6 - \text{key rate of the Central Bank of the Russian Federation; } \]

\[ X_7 - \text{the value of the indicator depends on the regional affiliation of the company, it is 0, when located in Moscow or St. Petersburg, and 1 - when located in other regions of the Russian Federation; } \]

\[ X_8 - \text{profitability of assets; } X_9 - \text{profitability of equity; } X_{10} - \text{equity growth rate; } X_{11} - \text{asset growth rate.} \]

\[ Z_{\text{kriz}} > Z_{\text{norm}} \]

Kovalenko's model:

\[ Z_{\text{kriz}} = 16.36 \times X_1 - 0.51 \times X_2 - 7.99 \]

\[ \times X_3 + 18.97 \times X_4 \]

\[ - 56.81 \]

\[ Z_{\text{norm}} = -5.26 \times X_1 + 110 \times X_2 + 3.23 \]

\[ \times X_3 - 3.83 \times X_4 \]

\[ - 54.0672 \]

The domestic models considered in the table as well as the foreign ones are based on the methods of multiplicative discriminant analysis [17] and logistic regression taking into account the industry factor [18].

Unfortunately, all these models are proposed in our country to be used only as an aid to financial diagnostics. At the same time, their use for a thorough assessment of agricultural enterprises will allow complementing the instrumental support for making investment decisions in the agricultural business.

As information resources, the default estimates were the data of the consolidated financial statements for agricultural producers of the Penza region for 2014-2016 in the context of farms. The data were obtained from the Russian State Statistics Service [22].

The visualization of the initial data for diagnosing a default in the agrarian business shows that certain fluctuations occurred in the property and sources of its formation. Basically, the studied indicators of the balance sheet and the statement of financial results increased. However, this does not mean an increase in solvency, which depends on covering the company's obligations with its assets. Since the growth of debt occurred without an equivalent growth of property, the ratio of current liabilities and current assets changed, which led to deterioration in the solvency of agricultural organizations.

3. Results and discussion

An assessment of the actual solvency status of commodity producers in the region led to the following results (Figure 1).
Interpretation of solvency ratios shows that producers of the region lack the ability to immediately repay current liabilities at the beginning of 2017 at the expense of the most liquid funds and the downward trend. Moreover, there is a low level of quick liquidity and a decrease in medium-term solvency. Not formed is also the level of current liquidity ratio. Agricultural enterprises do not have the reserve to compensate for losses incurred in the liquidation of mobile funds. At the same time, there is a decrease in time. The provision of own funds, which shows today the absence of such assets of agricultural organizations necessary for their financial stability, is also not optimal. The analysis of the possibility of a break-even activity also does not indicate a chance for the restoration of the normal solvency of the agrarian business entities in the near future after the end of the analytical period.

![Figure 1. Assessment of the current state of solvency of the agrarian business in the region.](image)
**Figure 2.** Assessment of factors changing the current liquidity in the agriculture of the region.

**Table 4.** The prediction of bankruptcy in the agricultural business.

| Models                  | Criteria for evaluation | 2016 Value | Estimate (1/0) | 2015 Value | Estimate (1/0) |
|-------------------------|-------------------------|------------|----------------|------------|----------------|
| Altman’s model          | x                       | x          | x              | x          | x              |
| two-factor              | > 0                     | -1.866     | 0              | -2.045     | 0              |
| five-factor             | < 1.81                  | 1.414      | 1              | 1.282      | 1              |
| modified                | < 1.81                  | 1.048      | 1              | 1.153      | 1              |
| Fulmer’s model          | < 0                     | 4.059      | 0              | 3.643      | 0              |
| Taffler’s model         | < 0.2                   | 0.578      | 0              | 0.619      | 0              |
| Springite’s model       | < 0.865                 | 1.251      | 0              | 1.056      | 0              |
| Lego’s model            | < -0.3                  | -1.836     | 1              | -1.802     | 1              |
| Fox’s model             | < 0.037                 | 0.042      | 0              | 0.036      | 1              |
| Postuskov’s model       | < 0.99                  | -0.198     | 1              | -0.677     | 1              |
| Saifullin’s model       | < 1                     | -0.091     | 1              | -0.482     | 1              |
| Zaitseva’s model        | Zф > Zн                 | 0          | Zф > Zн        | 0          | Zф < Zн        | 1     |
| Khaidarshina’s model    | 0.8 < Z < 1             | 0.015      | 9.28E-36       | 0          |                |
| Kovalenko’s model       | Zк > Zн                 | 1          | Zк < Zн        | 1          |                |
| Sum of criteria         | x                       | x          | 6              | x          | 8              |
A study of the factors of the low ability of commodity producers to respond by paying their debts indicates a number of reasons (Figure 2), among which are the following: (a) the negative change in short-term liabilities and (b) the change in financial investments, short-term loans, and payables.

For the purpose of confirming the findings, an assessment was made on the models of discriminant analysis and prediction of default, summarized and systematized above (Table 4).

As can be seen from the table, only 8 models in 2015 and 6 models in 2016 indicate a high probability of default of the agricultural business. Among such models are the five-factor and modified Altman’s functionals, the Lego’s formula, and the models of Postushkov, Saifullin, and Kovalenko. The remaining models testify to the good financial stability of agrofirms in the future. All this, on the one hand, indicates the presence of a risk of insolvency. At the same time, the probability share of a decrease in the business reputation of agricultural organizations, on the other hand, does not allow to form an unambiguous conclusion about the upcoming bankruptcy status for agricultural organizations.

4. Conclusion
So, the diagnosis of a default in the agrarian business makes it possible to identify the existence of negative aspects in the current solvency of producers and determine the presence of financial risks affecting the decrease in its level. However, this conclusion, which was formed on the basis of the assessment data according to the official methodology, is only partially confirmed by the results of the analysis of foreign models. Of these, only about 50% predict the onset of the state of impossibility to answer for their debts. Moreover, in some of these cases, the risk of loss of solvency is not great, its value is estimated at a low or medium level.

As a result, on the basis of domestic bankruptcy analysis tools, a general picture of the solvency status of agricultural producers was created, negative factors and the degree of their influence were revealed, an idea of the possibilities for changing the situation was given. At the same time, for the owners of capital, we are talking about a kind of issuing guarantees at least about the satisfactory balance structure for a number of years ahead. In principle, most of the tools used in Western practice can provide such guarantees. Based on the general results of the diagnosis, we can talk about the normal financial state of the agrarian business entities, despite the fact that for some indicators a certain lag was allowed.

The study was carried out with the financial assistance of the RFBR project 16-32-00015-OGH.

References
[1] Samygin D Yu, Baryshnikov N G and Mizjurkina L A 2017 Economy of Region 13(2) pp 591-603
[2] Sheremet A D 2018 Analysis and diagnostics of financial and economic activity of the enterprise (Moscow, Russia: INFRA-M) p 374
[3] Samygin D, Baryshnikov N and Shlapakova N 2017 Ponte 73(2) pp 344-351
[4] Sigidov Yu I 2015 Methods of analysis of the financial condition and assessment of the bankruptcy potential of agricultural organizations (Moscow, Russia: INFRA-M) p 120
[5] Kelejnikova S, Samygin D, Imyarekov S, Katajkina N, Abelova L and Artamonova Ju 2017 Ponte 73(3) pp 270-283
[6] Vinogradov S A 2014 Audit and Financial Analysis 1 pp 108-110
[7] Fedorova E A, Gilenko E V, Dovzhenko S E 2013 Problems of Forecasting 2 pp 85-92
[8] Chesser D L 1974 The Journal of Commercial Bank Lending 56(12) pp 201-214
[9] Altman E I 1968 Journal of Finance 23 pp 589-609
[10] Ohlson J A 1980 Journal of Accounting Research 18 pp 109-131
[11] Springate G L V Unpublished M B A 1978 Research project Simon Fraser University, 2 pp
215-231

[12] Fulmer J, Moon J, Gavin T and Erwin M 1984 *Journal of Commercial Bank Lending* 5 pp 25-37
[13] Postin K, Harmon K and Gramlich J A 1994 *Journal of Applied Business Research* 10 pp 41-56
[14] Lennox C 1999 Identifying Failing Companies: A Re-evaluation of the Logit-, Probit- and DA Approaches *Journal of Economics and Business* 51(4) pp 347-364
[15] Taffler R J Tisshaw H 1977 *Accountancy* 3 pp 50-54
[16] Postyushkov A V 2007 *Arbitration Manager* 6 pp 11-16
[17] Zaitseva O P 1998 *Siberian Financial School* 11-12 pp 66-73
[18] Haydarshina G A 2012 *Economic Sciences* 2 pp 67-69
[19] Bogoviz A V, Lobova S V, Alekseev A N, Shabarchina I V and Yankovskaya V V 2019 Transformation of the Russian labour market as a result of development of internet technologies *Advances in Intelligent Systems and Computing* 726 pp 972-979
[20] Bogoviz A V, Alekseev A N, Lobova S V, Telegina Z A and Barcho M K 2018 The human component of the process of improving productivity in the agrarian sector *Quality - Access to Success* 19(S2) pp 166-170
[21] Bogoviz A V, Chistov I V, Zakutnev S E, Shkodinsky S V and Prodchenko, I.A. 2018 Financial incentives for the creation of high-performance jobs *Quality - Access to Success* 19(S2) pp 67-70
[22] Rosstat 2018 *Collection of agricultural data* (Moscow, Russia: Government of Russia) pp 134-178