The dynamic model of enterprise revenue management

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Abstract. The article presents the dynamic model of enterprise revenue management. This model is based on the quadratic criterion and linear control law. The model is founded on multiple regression that links revenues with the financial performance of the enterprise. As a result, optimal management is obtained so as to provide the given enterprise revenue, namely, the values of financial indicators that ensure the planned profit of the organization are acquired.

1. Introduction

The financial stability of the organization from the long-term perspective standpoint is normally assessed by the system of indicators that includes several main sections: assessment of property position; liquidity assessment; assessment of financial stability; assessment of business activity; and profitability assessment. In each group there are 6 to 12 different coefficients (with a total of 41) [1-12].

Apart from the coefficient analysis, a number of classification models that separate bankrupt companies from stable borrowers and predict the possible bankruptcy of the borrower company are used [6-16].

There are numerous proprietary methodologies for assessing the probability of bankruptcy, which operate on a wide range of indicators. Such factor models have been developed on the basis of a multi-dimensional (multiplicative) discriminant analysis.

The best-known models for assessing the probability of bankruptcy are:

- the Altman models [5-7];
- the four-factor Lis model which is suitable for Russian enterprises with such legal organization forms as CJSC and OJSC [8];
- the Fulmer model – a nine-factor model for bankruptcy risk assessment [8];
- the Springate model for predicting enterprise bankruptcy [10,11];
- the four-factor Taffler's bankruptcy model [12];
- the Sayfullin-Kadykov enterprise bankruptcy model – a medium-term rating model for bankruptcy risk prediction that has been developed by Russian scientists, which can be applied to any industry and businesses of various sizes [13, 14].
- in addition to these, the following models must also be mentioned: by G. V. Davydova and A. Yu. Belikov [15], O. P. Zaytseva [16], A. N. Makaryeva and L. V. Andreeva [17] and others.

Analysis of models has shown that there exists no universal model for assessing the bankruptcy risk of an enterprise. The limits of model applicability are related with the economic environment in which the models were obtained. [18] displays that foreign models are unsuitable for Russian conditions. Moreover, the models of financial sustainability for enterprises of different industries may also substantially differ from each other. For example, the performed analysis of financial stability of 30 oil and gas industry companies with the legal form of an open joint stock company according to the balance sheet for 2010, 2011 and 2012 has shown that the five-factor Altman model poorly reflected the real situations at the Russian enterprises and did not determine further development of the organizations. Thus, according to the Z-index outcome, 17 per cent of enterprises had a very high probability of bankruptcy, 30 percent – a high probability of bankruptcy, and 53 percent – a very low probability of bankruptcy. In fact, 100 percent of all businesses continued to operate in 2012; therefore, it can be assumed that 100 percent of enterprises had to have a very low probability of bankruptcy.

Nevertheless, the Russian models may not claim to be universal and suitable for businesses of any industry. For instance, though calculations according to the Sayfullin-Kadykov probability of bankruptcy model for the same 30 oil and gas companies showed high performance in the modern economic environment, this model is not deprived of disadvantages – there is room for some companies to vary between the R model key indicators, the degree of bankruptcy probability and the real state of affairs at the enterprises. This can be explained by the fact that both the model and its coefficients were calculated at the end of the 1990s, when Russia had other economic conditions and other development strategies for enterprises, as well as another tax climate. Therefore, we come to the following conclusion: for the oil and gas industry companies under consideration, the Altman model is pessimistic, whereas the Sayfullin-Kadykov model, on the one hand, allows assessing the current financial condition of the company; it still does not allow accurate assessment of the probability for the beginning of a crisis situation.

For enterprises of various branches, we have constructed proprietary models for assessing the enterprise revenues, which is the most significant indicator related to financial stability. [19] has already analyzed the issue of selecting factors that influence the main source of the enterprise's financial receipts – the revenue from product sales. The selection of factors is conducted by the principal component method. Based on the factors selected, an equation of regression that indicates the dependence of the revenues on those factors is formed. In this work, on the basis of the financial statements of 33 machine-building enterprises, there were selected 37 indicators. With the principal component method, 11 indicators were distinguished that had a significant impact on the enterprise revenues.

2. Model Description

Let us select n indicators as most critical for assessing the risk of bankruptcy that also affect revenues from product sales as the main source to form the financial resources of the enterprise. Let the values of these parameters exceed the lower boundaries of the permissible and let it be necessary to increase their values to avoid bankruptcy. This requires investments in the company.

As $x_i(t)$, $i = 1,...,n$, let us denote indices at time moment t, $t = 0,...,T-1$, where T is the planned time moment for the enterprise to leave the critical state; $V(t)$ – revenues from product sales that the company must have to lead itself out of crisis (it is in fact due to an additional investment into the company necessary to overcome crisis); $V^0(t)$ – planned revenues needed for sustainable functioning of the enterprise. It is assumed that part of the revenues is invested in production proceeds.

The dependence of the revenues on time is presented as a multiple regression:

$$V(t) = \sum_{i=1}^{n} a_i x_i(t), \tag{2}$$

where a_i denotes the regression coefficients.

The values of $y_i(t) = a_i x_i(t)$ may be considered as revenues conditioned by the i indicator of the industrial activity. Then

$$V(t) = \sum_{i=1}^{n} y_i(t) \tag{3}$$

The dependence of the planned revenues is presented in the form of:

$$V^0(t+1) = \left(1 + \mu_0(t)\right) V^0(t), \tag{4}$$

where $\mu_0(t)$ – the desired rate of the company's revenue growth. The revenue growth rate must be such that the planned revenues, at least, cover the inflation.

Let us present the dynamics of the $V(t)$ revenue in the form of:

$$V_i(t+1) = \left[1 + \mu_i(t)\right]\left(y_i(t) + u_i(t)\right), \ i = 1,...,n \tag{5}$$

where $\mu_i(t)$ is the parameter of the required revenue increase conditioned by the i indicator of the industrial activity; $u_i(t)$ is the management connected with the change of the $x_i(t)$ indicator (while $u_i(t) > 0$ denotes an increase in the indicator, and $u_i(t) < 0$ – its decrease). Let us introduce vector $z(t) = \left(y(t), \ V^0(t)\right)^T$. Then equations (4) and (5) can be rewritten as:

$$z(t+1) = A_0(t)z(t) + B_0(t)u(t), \tag{6}$$

where $A_0(t)$ is the diagonal matrix of dimension $(n+1) \times (n+1)$

$$A_0(t) = diag\left(1 + \mu_1(t),...,1 + \mu_n(t); 1 + \mu^0(t)\right);$$

and $B_0(t)$ is the diagonal matrix of dimension $(n+1) \times n$

$$B_0(t) = \begin{pmatrix} 1 + \mu_1(t) & ... & 0 \\ ... & ... & ... \\ 0 & ... & 1 + \mu_n(t) \\ 0 & ... & 0 \end{pmatrix};$$

Let us take the quadratic functional as management quality criterion

$$J = \sum_{t=0}^{T-1}\left[[V(t) - V^0(t)]^2 + (u(t))^T R(t)(u(t))\right] + [V(T) - V^0(T)]^2, \tag{7}$$

which characterizes the quality of the process, tracking the planned revenues of enterprise $V^0(t)$. By minimizing this functional, we hereby provide the company's access to the planned mode. Here, $R(t)$ is the diagonal matrix of weight coefficients.

Let us introduce vector $z(t)$ to expression (7). Value $\left(V(t) - V^0(t)\right)$ takes the form of $\left(V(t) - V^0(t)\right) = Cz(t)$, where $C = (1,1,...,1,-1) \in R^{n+1}$, and quality criterion J will take the shape of:

$$J = \left\{ \begin{array}{l} \sum_{t=1}^{T-1} z^T(t)C^T Cz(t) + \sum_{t=0}^{T-1}\left(u^T(t)R(t)u(t)\right) + \\ + z^T(T)C^T Cz(T) \end{array} \right\} \rightarrow \min_{u(t)}. \tag{8}$$

Thus, we have an optimal management problem in which the equation of the state is described by multi-step process (6), and the quality functional – by expression (8). Management is defined by vector $u(t)$.

It is necessary to find an optimal solution of $\left(\bar{z}(t), \bar{u}(t) \right)$, in which functional (8) takes the minimum value. The method of solving problems (6) and (8) may be found, for example, in [20, 21].

3. Simulation results

Based on the multiple regression, an analysis of the "KuibyshevAzot" financial condition was conducted, as well as an economic and mathematical model of the firm's profit was built. For the analysis of the "KuibyshevAzot" financial activity, which is specialized in the chemical industry [22], 33 coefficients (factors) were selected, including net income [23]. The values of the selected coefficients were determined by the financial statements according to the corresponding formulas [19]. Upon further selection of coefficients, one of the most common methods for reducing the dimension of the feature space under study was used, i.e. factor analysis [24]. This method has made it possible to reduce the number of the indicators under analysis to 15. As a result, the following model was obtained:

$$V = 1,16x_1 + 146,4x_2 - 300,68x_3 + 42,76x_4 + 226,73x_5 - 41,04x_6 -$$
$$7,86x_7 + 3401,59x_8 + 53,85x_9 - 3373,32x_{10} - 26,9x_{11} + 1,94x_{12} +$$
$$2,59x_{13} - 202,45x_{14} - 8,21x_{15} - 264,74.$$

(9)

Here the following notations are used:
- V – revenues from product sales,
- x_1 – net profit in rubles,
- x_2 – the index of the permanent (capital) asset,
- x_3 – the equity-assets ratio,
- x_4 – the acid ratio,
- x_5 – the concentration ratio of the debt capital,
- x_6 – marginal liquidity ratio (of the intermediate coating),
- x_7 – the current assets to equity ratio,
- x_8 – the ratio of borrowed and own funds,
- x_9 – the debt capital structure ratio,
- x_{10} – the financial activity ratio (the capital leverage),
- x_{11} – the leverage ratio,
- x_{12} – the turnover of the equity capital,
- x_{13} – the turnover of funds in calculations (in turns),
- x_{14} – the profitability of the total capital,
- x_{15} – the return on assets.

The "KuibyshevAzot" enterprise under study does not belong to the category of bankrupt enterprises and was taken only as an example for building a business management model.

Graphs of the planned and actual revenues of the enterprise obtained as a result of solving optimization problems (6) and (8) are shown in Figure 1.
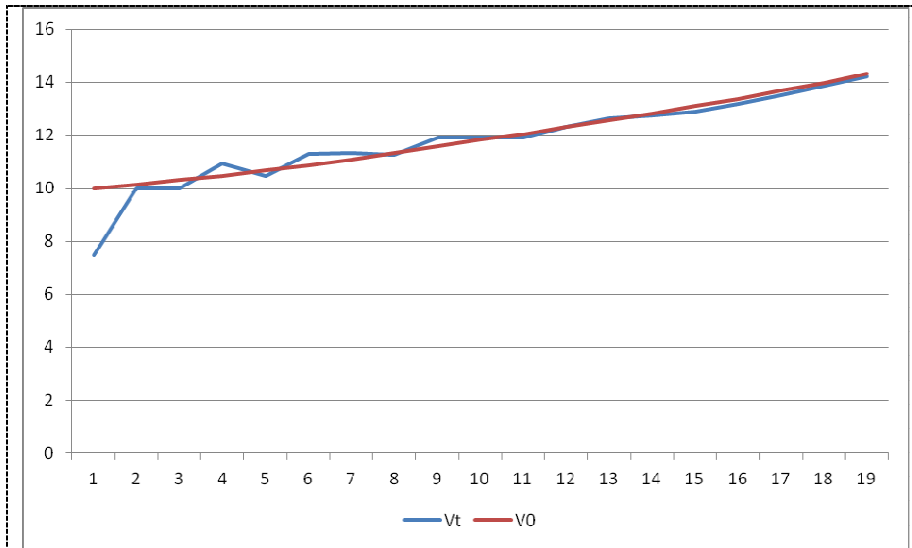
Figure 1. Planned $V0_t$ and actual V_t revenues of the enterprise.

The graphs show that over time the real value of the revenues is approaching the planned one. The values of indicators providing a given level of revenues are given in Figure 2.
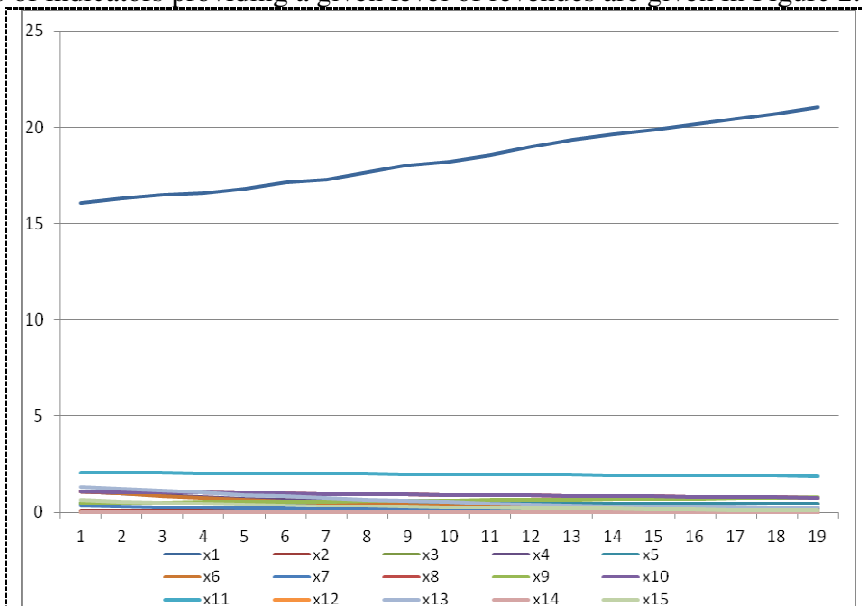

Figure 2. The optimal values of indicators for which the revenue reaches the predetermined level.

Analyzing the values of the indicators, we can conclude that in order to achieve the planned level of revenues it is necessary to reduce the following indicators: the first, second, ninth, thirteenth, fourteenth and fifteenth (i.e. the total amount of economic resources at the organization's disposal, the net fixed (capital) assets index, the debt capital structure ratio, the turnover of funds in the calculations (in turns), the profitability of the total capital, and the return on assets, respectively). At the same time, one of the indicators has adopted a negative value (the turnover of the equity capital), which conflicts with the economic sense. This is due to the fact that the optimal management problem was being solved without any restrictions on the permissible values of the controlled variables. Therefore, the value of this indicator should be set to zero, as shown in Figure 2.

4. Conclusion

On the basis of the regression model that relates to the dependency of the key indicator on the enterprise's financial performance, there was built a dynamic model of the enterprise revenue management. It is based on the quadratic criterion and the linear control law. As a result, optimal management was obtained to achieve the predetermined revenue, i.e. the values of financial indicators that provide access to the planned profit of the enterprise.

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