STATISTICAL COMPANY'S CREDIT RATINGS AND THEIR ECONOMETRIC ANALYSIS

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Abstract

The system of statistical credit ratings (SSCR) of companies based on the financial report data as well as related software is proposed. The system includes three types of statistical creditworthiness indicators: individual ratings of companies, mean ratings by branch of the economy and mean integral creditworthiness indicator of the economy. The relations between the proposed creditworthy indicators and main economic indicators of Belarusian economy are investigated by means of econometric modeling and forecasting.

1 Introduction

The problem of assessing the creditworthiness of companies is one of the most important tasks in the system of bank risk management is governed by Basel Agreement [1]. In this agreement the need for an internal bank probabilistic, statistical models and quantitative methods to assess the creditworthiness of the bank borrowers and loan portfolio are strengthened.

The description of a technique for statistical evaluation of the credit ratings on the basis of data of the company's financial reports is provided in this research in the case, when information about defaults of the companies is not used. Proposed technique assumes transition from initial representation of sample in a form of panel data to sample of cross-sectional data. For classifications of cross-sectional data in the space of the informative features we apply the algorithms of cluster and discriminant analysis [2, 3]. The methods of multivariate statistical analysis, econometric modeling as well as financial analysis are used for verification and economic interpretations of the results. Suggested system of statistical credit ratings of companies SSCR is tested on statistical data of Belarusian companies from four main branches of the economy of the Republic of Belarus.

2 Mathematical models of the data and research problems

At the moment t ($t = 1...T$) we observe n objects relating to one of K types $G_1, \dots G_K$ in space $\Re^N$. For the given conditions t, k the object i (further – object (i, t, k)) is characterized by a casual vector of N-values analyzed indicators $x_{i,\,t}^{(k)} \in \Re^N$ $(i = 1, ..., n,\ t = 1, ..., T,\ k = 1, ..., K)$ with some probabilistic model determined by the conditional density of distribution for the given values (t,k) $f^{(t,k)}(u),\ u \in \Re^N (t = 1,...,T,\ k = 1,...,K)$.

For all objects samples of values of analyzed indicators are derived for the observation period T:

- $X_t^{(k)} = \{x_{i,t}^{(k)}\}$ $(k = 1,...,K)$ – sample of observations at the moment t for objects of type G_k,
- $X_t = \bigcup\limits_{k=1}^{K} X_t^{(k)}$ – sample of observations at the moment t for all objects,
- $n_t^{(k)} = |X_t^k|, \quad n_t = |X_t| = \sum\limits_{k=1}^{K} n_t^{(k)}$ – volumes of corresponding samples.

Depending on degree of expressiveness of some main property, which characterized by indicator $\nu \in S(L) = \{1,...,L\}$, objects can be divided in L classes $\Omega_1,...,\Omega_L$. For given t, k, i value of indicator ν is denoted by $\nu_{i,t}^k \in S(L)$. Thus, *the full information* about object (i,t,k) is defined by a compound casual vector

$$z_{i,t}^{(k)} = \begin{pmatrix} x_{i,t}^{(k)} \\ \nu_{i,t}^{(k)} \end{pmatrix} \in \Re^N \times\ S(L)\ (i = 1,\ ...,\ n_t^{(k)},\ t = 1,\ ...,\ T). \tag{1}$$

Under the assumption that indicator $\nu \in S(L) = \{1,...,L\}$ is not observable (latent) and it is described by the discrete random variable, concerning which for the fixed k and all possible values of i two types of assumptions can be considered:

π.1. $\nu_{i,t}^{(k)} \equiv \nu_t^{(k)} \in S(L)$ – independent random variables with a priori probabilities

$$\pi_l^{(k)} = \mathbf{P}\{\nu_t^{(k)} = l\} > 0, \quad \pi^{(k)} = (\pi_l^{(k)}) > 0(l \in S(\ L)); \tag{2}$$

π.2. $\nu_{i,t}^{(k)} \equiv \nu_t^{(k)} \in S(L)$ – the Markov's uniform chain (MUC) with parameters:

$$\pi^{(k)} = (\pi_1^{(k)},...,\pi_L^{(k)})', \quad P^{(k)} = (p_{rs}^{(k)}), \quad p_{rs}^{(k)} = \mathbf{P}\{\nu_t^{(k)} = s|\nu_{t-1}^{(k)} = r\} \geq 0,$$

which correspond to L-vector of probabilities of initial condition of MUC and $L \times L$-matrix probabilities of one-step transitions for one period of observation. Parameters of probabilistic models $\nu \in S(L) = \{1...\ L\}$ are not known.

The interpretation of model. We present the following substantial interpretation for the main notions of the considered problem:

– objects are the companies, related to one of K types of economic activity (branches) $G_1,...,G_K$ and characterized by vector of values of financial indicators $x_{i,t}^{(k)}$ $(i = 1,\ ...,\ n_k,$ $t = 1,\ ...,\ T,\ k = 1,\ ...,\ K)$;

– $\Omega_1,\ ...,\ \Omega_L$ – the classes of creditworthiness of the companies;

– $\nu_{i,t}^{(k)}$ – unknown number of a class of creditworthiness of the company i from branch k (further – company (i,k)) at the moment (quarter, year) t $(i = 1,...,n_k,\ t = 1,...,T)$.

The problem lies in classifying the observed objects to one of L classes $\Omega_1,...,\Omega_L$. In other words, there is the problem of statistical classification of objects (i,t,k), which consists in the construction of representation

$$d_{i,t}^{(k)} \equiv d(x_{i,t}^{(k)}) : \Re^N \to S(L)\ (i = 1,\ ...,\ n_t^{(k)},\ t = 1,\ ...,\ T,\ k = 1,\ ...,\ K).$$

3 The system SSCR: methods of construction and analysis

Taking into account described above data' features the process of the solution for a problem of statistical classification of the companies by degree of creditworthiness provides the following main stages of research: forming the set of informative characteristics on the basis of initial information; carrying out the preliminary statistical analysis of the sample; research of the correlation dependencies; normalization and censoring of variables; using factor analysis for construction of integral indicator of creditworthiness; classification of data on a basis of cluster analysis, and also integral indicator of creditworthiness; economic interpretation of results of factor and cluster analysis; discriminant analysis of the new companies; optimization of a statistical technique on parameters and conditions of application of statistical algorithms.

Taking into account the dimension of real data ($N = 43, n \approx 2000, T = 24, K = 4$) and using the assumption of independence on time t distribution of a casual vector $x_{i,t}^{(k)} \in \Re^N$ $(i = 1, ..., n,\ t = 1, ..., T,\ k = 1, ..., K)$ transition from panel data $X_t^{(k)} = \{x_{i,t}^{(k)}\}$ $(i = 1, ..., n,\ t = 1, ..., T)$ to cross-sectional sample is carried out

$$Y^{(k)} = \{y_j^k\}\ (j = 1, ..., m_k),\ m_k = n_k T.$$

We obtain the classification vector

$$g^{(k)} = (g_1, ..., g_{m_k})',\ g_j^{(k)} \equiv d(y_j^{(k)}) \in S(L) = \{1, ..., L\},\ j = 1, ..., m_k$$

as a result of classification of sample $Y^{(k)}$ $(k = 1, ..., K)$ with the help of statistical algorithms.

At the next step we realized transition from a vector of classifications of observation $g^{(k)} = (g_1, ..., g_{m_k})'$ to a required matrix of classifications $D^{(k)} = (d_{i,t}^{(k)})$ $(k = 1, ..., K)$ which taking into account dynamic character of basic data. Thus, it is necessary that $d_{i,t}^{(k)} \equiv g_j^{(k)}$, where for any given value $j = 1, ..., m_k$ index i satisfies a condition $(t-1)\ n_k < i < tn_k$ and for known values t, j it is calculated by using the formula $i = j - (t-1)n_k$.

Under the simplifying assumption that during whole period the same "through" sample of objects is observed we can put that $n_t^{(k)} \equiv n^{(k)}\quad \forall t = 1, ..., T$, result of the solution of the formulated research problem for all types of objects is $(n_k \times T)$ - *classification matrix* of objects

$$D^{(k)} = (d_{i,t}^{(k)}) = \begin{pmatrix} d_{1,1}^{(k)} & \cdots & d_{1,T}^{(k)} \\ \vdots & \ddots & \vdots \\ d_{n_k,1}^{(k)} & \cdots & d_{n_k,T}^{(k)} \end{pmatrix} (k = 1, ..., K). \quad (3)$$

Classification matrix $D^{(k)}$ allows representations on lines and on columns which have the substantial economic interpretation

$$D^{(k)} = \begin{pmatrix} d_1^{(k)\prime} \\ \vdots \\ d_{n_k}^{(k)\prime} \end{pmatrix} (k = 1, ..., K), \tag{4}$$

where $d_i^{(k)\prime} = (d_{i1}^{(k)}, ..., d_{iT}^{(k)}) \in S^T(L)\,(i = 1, ..., n_k)$ – vector of classification, reflecting dynamics of change for a class creditworthiness (rating) for company i from branch k

$$D^{(k)} = (\delta_1^{(k)}, ..., \delta_T^{(k)}), \tag{5}$$

where $\delta_t^{(k)} = (\delta_{1,t}^{(k)}, ..., \delta_{n_k,t}^{(k)}) \in S^{n_k}(L)(t = 1, ..., T)$ – vector of classification of objects for branch k at the moment (period) t.

On the basis of the results of the cluster analysis for the companies $\hat{D}^{(k)} = (\hat{d}_{i,t}^{(k)})$ $(k = 1, ..., K)$ the system of statistical credit ratings including the following types of ratings is offered:

$R_{i,t}^{(k)} \equiv d_{i,t}^{(k)}$ – statistical individual credit rating (statistical estimation $d_{i,t}^{(k)}$) for the company (i, k) at the moment t;

$\bar{R}_t^{(k)} = \frac{1}{n_k} \sum\limits_{i=1}^{n_k} R_{i,t}^{(k)} \in [1, L]$ $(t = 1, ..., T)$ – mean ratings by branch of the economy or statistical branch credit rating (BCR) for the companies belonging to branch k at the moment (period) t;

ICR_t – statistical integral creditworthiness indicator of the economy as the average value on shares of a value added of branch in GDP.

More over, the matrix of migration of ratings for one period observation for branch is estimated $P^{(k)} = (p_{rs}^{(k)})$ $(p_{rs}^{(k)} = \mathbf{P}\{\nu_t^k = s|\nu_{t-1}^{(k)} = r\} \geq 0)$ for each branch. Depending from interval of observation (quater or year) we deal with quarterly or annual ratings respectively.

Econometric models for ratings BCR and ICR have been developed and used for forecasting and economic analysis on the base of the given scenarios. These models include some significant for Belarusian economy indicators (prices on oil and gas, BLR/USD exchange rate, credit rate etc.) as exogenous variables. We established also the relationships between the indicators of output by branches and the economy in a whole with the constructed creditworthiness indicators by means of VARX models.

References

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