

RATING MODELING SYSTEM: METHODS AND TECHNOLOGY

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Abstract: The purpose of this article is to compare rating scales of different rating agencies and to offer methodological principles of multiple rating scales mapping. Based on the econometrical modeling (ordered probit models), our study investigates the distinctions in ratings assigned by the largest international agencies. Also we have suggested a simple algorithm of parametrical scales mapping. In our analysis we use set of banks from different countries including Russia for the period 1995-2009.

Keywords: rating, bank, financial indicator, econometric model, risk management.

JEL: G24, G21, G32, C35.

1. Introduction

Ratings have been an essential tool for risk evaluation throughout more than a 100 years and their range of use is still extending. In modern understanding rating is a discrete ordinal measure. It is a result of complex assessment of a company or financial instrument. The ratings carry out function of transformation of great volume of information into the rating agency's opinion on the financial stability of the entity. Though ratings costs are considerably low both for the issuer and the investor, it is a result of a deep professional analysis. Business development requires the involvement of new approaches that would improve and expand possibilities of rating usage.

Thus, the emphasis of this paper is made on the analysis of possibilities for the expanded rating use. A key question of research is to investigate the possibility and efforts of integration of risk evaluation for various rating agencies, both domestic (national) and international, using credit organizations as an example. We don't apply for completeness of our research, however we set some ways to solve mentioned problems and also consider using the decisions with reference to the Russian market conditions.

Among all the questions it is necessary to emphasize the development of modern methods of mapping for rating scales, also the usage of econometric models for the correspondence analysis between scales and for the forecasts of ratings of

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entities that are not rated yet. We are to construct econometric models for forecasting bank long-term credit ratings based only on the public information, including the financial reports of banks and other open statistical data. The analysis of such models allows studying various factors influencing process of rating formation for international agencies, to compare rating estimations of agencies with each other, and also to analyze predictive power of the obtained models. In practice such models can be used within the approach to a risk assessment on the basis of internal ratings (Internal Rating Based Approach), regulated by the Basel II agreement, and also by banking supervisor authorities as a component of Early Warning Systems. It can be more relevant for emerging markets because of the high level of their financial risks.

We assess the basic financial and macroeconomic indicators that have the greatest effect at bank credit ratings of the three largest international agencies: Moody's Investors Service (Moody's), Standard and Poor's (S&P) and Fitch Ratings (Fitch). We evaluate ordered choice (ordered probit) econometric models using the bank data from different countries for the period of 1995-2009. Also for Russian banks we examine data using both IFRS and Russian Accountings Standards.

Ratings in Russia

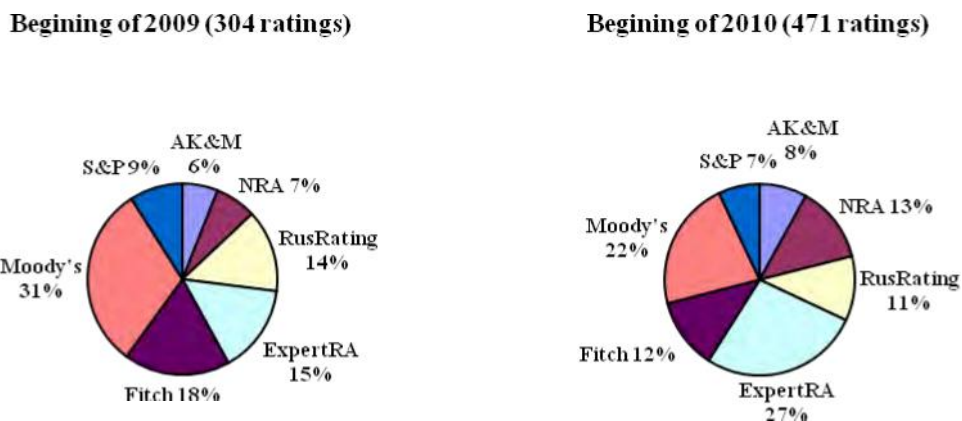
At the period of formation of market relations in Russia ratings were crazes, prevailed by rankings and mainly at bank sector. Rating business growth was highly stimulated by the entrance of international players from 1996 till 1998 when a number of banks from Russian Top-20 with international ratings went bankrupt. [7]. The following factors became the further stimulus for rating business development: first, is an access to foreign loans, including loans for companies from industrial sector, and second, is an upgrade of Russian sovereign rating to an investment grade. As the result the number of companies with ratings of international agencies exceeded 300. Thus, level of international agency's ratings of Russian banks and enterprises is still rather low: only a quarter of all companies have an investment grade rating, and the average level of ratings lies between BB- and BB for all three largest agencies.

Domestic rating agencies have begun to play a significant role lately. Of course, ratings for largest companies were assigned mainly by the international agencies, though some of these companies also received ratings from domestic ones. Distribution of number of bank ratings for international and Russian agencies is showed on fig. 1.

Rating services became more widespread in Russia due to the efforts of domestic and international agencies. At the same time the problem of integration of their ratings had become more and more relevant. In the middle of 2010 more than 300 banks had ratings; also about half of them were assigned by international agencies. Number of banks has ratings assigned by several agencies. Further

analysis of the Russian banking system will reveal problems and possibilities of integration of ratings.

Fig. 1. Distribution and dynamics of bank ratings in Russia



2. Credit rating models

Process of rating assignment is similar in general, but there are a lot of aspects for various rating agencies [1, 2]. Agencies publish their methodologies frequently; however they do not include detailed information but only general directions for rating assessment. Also in many respects they use expert judgment; still it is possible to analyze these features and to determine differences in methodologies [3, 7]. It is also possible to analyze results of rating process and to compare various ratings with use of the public information for the analysis of rating differences.

Theoretical aspects of rating models

Credit ratings are quantitative ordinal variables; therefore we use econometric models of a multiple choice (ordered probit models) to study ratings. Here we describe theoretical aspect of such models. There is an ordinal dependent variable y_i with numerical values 1, 2, 3 ... k (in our case –rating grades transformed to a numerical scale). Let there also be an unobservable (latent) variable y_i^* , specified by the equation:

$$y_i^* = x_i' \beta + \varepsilon_i, \quad (1)$$

where x_i is a set of explanatory variables for bank-year observation i . All errors ε_i are independent and have a normal function of distribution $F(z)$. Here y_i is related to y_i^* as follows:

$$\begin{cases} y_i = 1 & \text{if } y_i^* \leq c_1, \\ y_i = r & \text{if } c_{r-1} \leq y_i^* \leq c_r, \quad 2 \leq r \leq k-1, \\ y_i = k & \text{if } y_i^* \geq c_{k-1}, \end{cases} \quad (2)$$

where c_r and c_{r+1} are the lower and upper boundaries for the y_i^* to obtain rating grade r . Assuming equations (1) and (2) to be true, the probability that y_i equals r is specified by:

$$\begin{cases} P(y_i = 0) = F(c_1 - x_i' \beta), \\ P(y_i = r) = F(c_{r-1} - x_i' \beta) - F(c_r - x_i' \beta), \quad 2 \leq r \leq k-1, \\ P(y_i = k) = 1 - F(c_{k-1} - x_i' \beta). \end{cases} \quad (3)$$

All unknown parameters are estimated with a maximum likelihood procedure. Also the generalized Huber-White standard errors are computed, thus relaxing the homoscedasticity assumption and the assumption of independency among observations of the same bank.

Data

Financial data and credit ratings of banks for international study have been obtained from Bloomberg database, therefore almost all of banks have one or more traded security, and their financial reports are constituted under IFRS. Macroeconomic indicators of bank countries of domicile are taken from the GMID (Global Market Information Database). All financial indicators we have used in research are annual. Final sample consists of 5629 observations including data for 551 bank from 86 countries during 1995-2009. Each observation is defined by bank and year and comprises number of financial indicators, both for a bank, and country which it belongs to. Credit ratings of banks are included in observations with time lag. The majority of observations apply to banks from USA (622), Japan (526), France (189), Italy (188), Turkey (164), India (154) and Russia (145). Developing countries are represented by 30% of all observations and developed countries by 50% of the sample. We use financial data based on Russian Accountings Standards for the period 2006-2009 in Russian banks' ratings study. All the indicators are quarterly, total sample consists of 2686 observations for more than 150 commercial banks. Respective ratings were obtained from the databases and press-releases of rating agencies that are available in the internet.

Analysis of the model variables

Positive influence on agency-ratings has been shown by the size of a bank (natural logarithm of total book value of assets) and capital ratio as expected. Squared values of mentioned parameters have been insignificant for most models. Involving total risk-based capital ratio as explanatory variable has considerably improved statistical properties of rating models for most agencies in international study. The retained earnings-to-assets ratio has also shown a positive influence on

ratings in international ratings research because this parameter ensures bank financial strength.

Value of loan loss provisions reflects credit risk and non-returns from customers, as a consequence, possibility of bank default, because of failure to meet obligations. Therefore, this factor has a negative influence on ratings. Also it shows bank appetite to risk which is not welcomed by rating agencies. Negative effect is also provided by high borrowings (long-term debt-to-assets ratio), since rating agencies carefully follow the level of debt repayment. The increase in interest expenses-to-interest income ratio characterizes the low efficiency of bank' primary activity (intermediary in a money-market), that is also negatively evaluated by rating agencies.

Cash and near cash items-to-total liabilities ratio is used as a proxy of current liquidity but has a negative influence on ratings. Probably, it is connected with non-linear dependency (function is U-shaped), and the fact that high level of low-profitable assets reduces the financial strength of the bank.

Table 1. Rating models with financial indicators only

Variable	Expected influence	S&P – Issuer Credit	Fitch – Issuer Default	Moody's – Bank Deposits	Moody's – BFSR
Ln (Assets)	+	-0.517*** (0.024)	-0.548*** (0.020)	-0.481*** (0.023)	-0.318*** (0.019)
Equity Capital/ Total Assets	+	-2.887*** (0.291)	-2.012*** (0.428)	-2.814*** (0.265)	-1.811*** (0.260)
Total Risk-Based Capital Ratio	+	0.038*** (0.010)	0.008 (0.009)	0.016* (0.009)	-0.014* (0.007)
Loan loss provision/ Total Assets	-	43.641*** (6.020)	39.431*** (6.110)	14.768*** (3.308)	11.472*** (4.205)
Long Term Debt/ Total Assets	-	0.008* (0.005)	0.015** (0.008)	0.024*** (0.004)	0.022*** (0.004)
Interest Expenses/ Interest Income	-	0.288*** (0.046)	0.158** (0.073)	0.331*** (0.068)	0.122** (0.058)
Retained Earnings/ Total Assets	+	-9.148*** (2.548)	-5.247*** (0.826)	-1.193* (0.780)	-2.472*** (0.739)
Cash and Near Cash Items/ Total Liabilities	+	1.442** (0.641)	1.136** (0.486)	1.651*** (0.637)	1.904*** (0.440)
Corruption Perception Index	+	-0.325*** (0.017)	-0.268*** (0.017)	-0.387*** (0.015)	-0.337*** (0.014)
Annual Rate of Inflation, %	-	0.034*** (0.012)	0.050** (0.010)	0.025*** (0.006)	-0.012** (0.006)
Pseudo R²		0.265	0.242	0.277	0.183
Akaike Info Criterion		3.244	3.395	3.239	3.829
Number of Observations		1812	1991	1787	1897

*, **, *** signify 10%, 5% and 1% level of significance, respectively.

Country distinctions are characterized by several macroeconomic variables.

Corruption Perception Index (CPI) measures the perceived level of public-sector corruption and has been published by Transparency International organization

since 1995. This factor has shown high significance in all models. Thus, corruption is one of the major criteria showing external environmental conditions created for banks. The variable is also correlated with real GDP per capita, which has shown a smaller explanatory power in our rating models. Export-to-import ratio positively influences credit ratings of banks which means favorable economic circumstances in a country. It also has a strong correlation with the current account balance-to-GDP ratio and weak correlation with the inflation rate. We have chosen inflation to be added in final models.

Annual rate of inflation instinctively has a negative influence on ratings, since there are higher financial risks in countries with high inflation. Usually it is characterized by increased level of failures to deliver and perform obligations properly and general problems for financial assets accessibility.

In order to investigate other country distinctions we have added dummy variables to reflect relations of banks to different groups of countries and regions. Such dummies include developed countries, CIS, BRIC, emerging markets, etc. The effect of the developing markets dummies is negative, which is quite logical. It means higher rating "ceiling" for the developed countries that show better economic environments.

We should also note that ratings of Russian banks and the banks that operate in developed markets are different other things being equal due to the level of corruption and political risk.

Credit ratings of banks located in Central and Eastern Europe countries are higher than in emerging markets, BRIC and CIS. CEE is characterized by fast transition to capital markets and the big aspiration to enter EU. Their level of ratings is similar to developed countries.

The impact of ownership structure is examined in our Russian banks' ratings research. Two dummy variables were included in these models: for state-owned and foreign banks [4, 9]. In both cases the influence on ratings is positive.

3. Comparative analysis of rating agencies

Correspondence of banks' ratings assigned by different agencies is studied in this section. There are two suggestions that impact the ratings: on the one hand, if the gap between two ratings is large it can undermine agencies' authority, on the other hand, if there were no gaps there would be no sense to order rating of another agency [6].

Ederington [5] found the systematic bias between the ratings assigned by Moody's and S&P. However, Morgan [8] shows that bias is larger for less transparent issuers especially for banks and other financial companies.

Observations for all of three agencies were combined into one pooled sample to compare credit ratings of agencies with each other. Analysis was made by introducing dummies for agencies to our rating model. Such transformation allows to obtain a larger sample, because number of banks with credit ratings of several agencies is considerably small. Our models also consider financial condition of the banks (we have kept all financial explanatory variables used in previous models).

Table 2. Ratings correspondence models

Parameter	Model for S&P	Model for Fitch	Model for Moody's	Without dummy
S&P dummy	-	0,318*** (0,035)	0,450*** (0,040)	-
Fitch dummy	-0,318*** (0,035)	-	0,133*** (0,038)	-
Moody's dummy	-0,450*** (0,040)	-0,133*** (0,038)	-	-
Pseudo R ²	0,280	0,280	0,280	0,273
<i>Number of observations</i>	<i>5209</i>	<i>5209</i>	<i>5209</i>	<i>5209</i>

Table 3. Correspondence of S&P and Moody's ratings

S&P\Moody's	Baa1	Baa2	Baa3	Ba1	Ba2	Ba3	B1	B2	B3	Caa1
BBB+	3	18	0	0	1	0	0	0	0	0
BBB	14	3	0	0	0	0	0	0	0	0
BBB-	3	6	3	0	0	0	0	0	0	0
BB+	0	11	12	0	1	0	0	0	0	0
BB	0	3	2	23	2	2	0	0	0	0
BB-	0	0	0	5	16	9	9	0	0	0
B+	0	0	0	3	15	54	4	0	0	0
B	0	0	0	0	3	14	8	0	0	0
B-	0	0	0	0	0	6	13	3	43	4
CCC+	0	0	0	0	0	0	0	1	1	0
CCC	0	0	0	0	0	0	0	1	10	0
<i>K=0,137</i>										

Table 4. Correspondence of S&P and Fitch ratings

S&P\Fitch	A-	BBB+	BBB	BBB-	BB+	BB	BB-	B+	B	B-
BBB+	6	17	0	0	0	0	0	0	0	0
BBB	5	5	12	0	0	0	0	0	0	0
BBB-	4	8	0	0	0	0	0	0	0	0
BB+	4	5	0	1	0	0	1	0	0	0
BB	0	1	2	0	0	10	5	0	0	0
BB-	0	0	0	0	0	5	12	10	9	0
B+	0	0	0	0	0	0	13	22	4	0
B	0	0	0	0	0	0	0	5	11	3
B-	0	0	0	0	0	0	0	0	0	44
CCC+	0	0	0	0	0	0	0	0	0	10
<i>K=0,453</i>										

Another way to quantify the bias between the ratings of Russian banks assigned by the three international agencies is using the correspondence tables

(Table 3 and 4). Each element in the table stands for the quantity of the banks that have respective ratings as on the axes.

The results showed that the most conservative rating agency is S&P: its ratings are lower than ratings of other agencies; Moody's ratings on average are higher than Fitch ratings. The same results were obtained from the rating models for Russian study. The significance of all parameters remained at high level.

The results obtained can be used for comparison of credit ratings of Moody's Investors Service, Standard & Poor's and Fitch Ratings agencies. They are also important for the forecast of agency's rating, when rating of at least one agency is known.

4. Methodological approach for scales mapping

The efforts of rating scales mapping usually come to:

- pairwise comparison using limited data which leads to inadequate results;
- expert judgment and ratings correspondence tables;
- linear correlation and statistical analysis which requires an explanation of why the nonlinearities shouldn't be taken into account;
- econometric rating comparison of two agencies and estimation of distinctive factors.

An intensive study of multiple mapping considering problem statement and data restrictions are required due to the absence of recommendations on this matter.

Multiple rating scales mapping

The concept of multiple mapping is focused on creation of system of simultaneous rating mapping for all the agencies. It provides correspondence criteria validation by means of statistically grounded mapping to a base scale. The concept stipulates:

- Increase of mapping reliability by force of simultaneous use of all the available statistical data (across the agencies, time, scales)
- Creation of ratings, financial and macro coefficients database
- Determination of sufficient explanatory factors for ratings by force of econometrical analysis using the publicly available data
- Creation of base scale which all the scales will be mapped to
- Correspondence criteria setting which takes into account the explained component

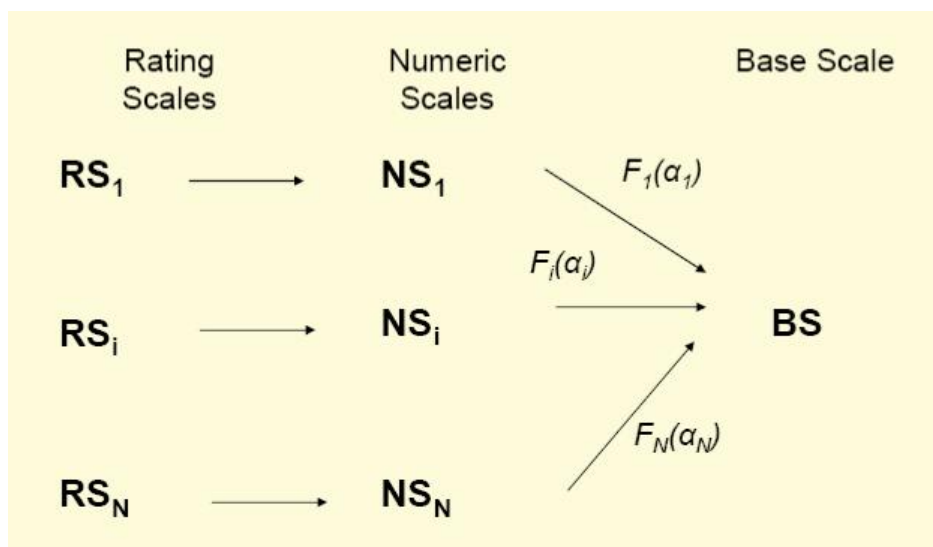
- Determination of scales mapping parameters by means of optimization algorithms. Rating scales comparison
- Validation of criteria and estimation of scales correspondence parameters
- Forming of methodical and practical fundamentals for regular monitoring, modeling and verification of rating models.

One of the important issues is choice of the base scale. One can take the digital scale that corresponds to one of the rating agencies' scale (S&P, for example, where 1 stands for AAA, 2 – for AA+ and so on). Besides the nominal base scale the respective exponential, ordinal and normalized scales can be used.

A simple algorithm of parametrical mapping can be the following:

1. Choice of base scale (BS)
2. Mapping of every rating scale RS_i to numerical scale NS_i considering synchronized principles (fig. 2)
3. Determination of parameters functional structure $F_i(\alpha_i)$ of mapping of i -th rating scale to the base one. The initial structure is supposed to be quadratic polynomial
4. Design of adjacency measure of generic estimates in base scale (SSE, for example)
5. Design of integral criterion in base scale (for instance, based on generic coefficients)
6. Mapping parameters estimation as the solution for the unified extremal problem based on integral adjacency criterion design.

Fig. 2. Basic algorithm of mapping rating scales to base scale



5. Conclusion

In this research we have examined the influence of financial indicators on banks' credit ratings assigned by international rating agencies. Positive influence on ratings is shown by such factors as bank size (natural logarithm of assets), capital ratios, the retained earnings-to-assets ratio and return on assets (ROA). High level of loan loss provisions, long-term debt and interest expense-to-interest income ratio have a negative influence on ratings.

Influence of external environmental factors on banks' ratings is also found and we have shown their high significance in econometric models. GDP and export-to-import ratio have positive effect on credit ratings, the effect of annual rate of inflation and corruption level is negative.

If a bank belongs to a group of developed countries or CEE, its credit rating is higher in comparison with banks from emerging markets. In addition to macroeconomic parameters developing countries have rating ceilings which means weak economic environment and high geopolitical risks.

Type of ownership does affect the ratings in Russia: foreign and state-owned banks are rated higher by the international agencies.

Comparison of credit ratings for three rating agencies has shown that S&P is the most conservative rating agency in banking sector. It assigns lower ratings all other things being equal. Moody's credit ratings are the highest.

General methodological principles of multiple rating scales mapping and basic algorithm of mapping are presented in the last section. Some steps of the concept are already accomplished: we have created ratings, financial and macro indicators database, also we have determined sufficient explanatory factors for ratings by force of econometrical analysis based on the publicly available data. Next steps should involve the development of mapping algorithms and profound research on agency-rating conformity.

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