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Research/Technical Note

Estimating Risk of Debt Instruments Using the CreditMetrics™ Method: On the Example of JSCMB 'Ipoteka-Bank', Uzbekistan

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Abstract

In the article, credit risk assessment metric of a debt financial instrument, in particular a corporate Eurobond, is studied within the framework of the relevance of risk assessment in the financial sector due to the dangers and complexities of time. Joint-Stock Commercial Mortgage Bank 'Ipoteka-Bank', operating in the banking sector of the Republic of Uzbekistan, which is considered one of the important links of the financial sector of the Republic, was selected as the object of analysis. As input data for the analysis, statistical data of the bank provided in its official web-site's open sources, in particular, data on Eurobonds issued and placed by the bank in London Stock Exchange, are used. At the same time, one of the advantages of the research is the described and disclosed in details and widely used global benchmarking data, published by Standard&Poor's rating agency, as part of the methodology requirement. According to the methodology, credit risk assessment analysis was performed following a strict and detailed calculation algorithm for debt instrument risk assessment. The calculation of credit risk assessment of one debt instrument, especially the Eurobond, according to this procedure followed with the authors' discussion, conclusion and recommendation is also reflected in the article.

Keywords

CreditMetrics, Credit Rating Migration, Default Recovery Rate, Rating Quality, Discount Rate, Variance, Standard Deviation

1. Introduction

Uzbekistan is implementing the process of rapid integration into the world economy with the principles of an open economy, liberalization of currency and customs policy, transformation of the national economy in line with international norms and standards. As a result, centralized investments such as foreign debt, international loans and Euro-bonds provide the country with foreign currency income.

Our country, which has chosen the path of economic development through investments in the conditions of globalization complications, economic shocks, cyber threats and challenges of the times, will inevitably have its influence on the banking sector, which is the core of the financial system. The relevance of preliminary assessment and

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forecasting of probable risks and dangers in banks is explained by the above remarks.

Banks have a risk management system for assessing and managing risks, especially for credit risks and they use traditional methods and models, such as implementing strict underwriting standards, setting mandatory limits and monitoring the counterparty in a certain way. At the same time, it is advisable for commercial banks to use credit risk assessment models that meet the requirements of the modern era.

2. Literature Review

CreditMetrics methodology is one of the methods recognized and widely used in developed countries for quantitative assessment of debt instrument risk. The methodology was presented by JPMorgan in 1997, and according to Gupton et al. "The data which drive this model are the default likelihood and credit rating migration likelihoods for each credit rating. We can compactly represent these rating migration probabilities using a transition matrix model. [1]."

The methodology as mentioned in technical document of CreditMetrics covers " … changes in value caused not only by possible default events, but also by upgrades and downgrades in credit quality [2]." The other study claims that the methodology "… calculates the volatility of value due to changes in credit quality using the example of a single bond: the probabilities of all possible transitions and the distribution of values within each gradation [3]." "Since the model recognizes a rating downgrade as a credit event, its probability is assessed using a given credit rating migration matrix [4]."

Therefore, "The model is based on the fact that the occurrence of default depends on the value of assets. If the value of assets falls below a certain limit, then default occurs. If the value is above this critical value, then the company continues to exist. [5]".

The methodology is built in the context of a VaR approach. "The main problem when creating models based on the VaR methodology is the insufficient amount or absence of historical data; absence or inconsistency of statistical data due to the specifics of the bank's activities or the peculiarities of its credit policy [6]."

The methodology is based on migration analysis. "… in the CreditMetrics methodology establishes the likelihood of migrations between any possible credit quality states during the risk horizon for each individual obligor [7]."

As mentioned in technical document of CreditMetrics "Morgan developed transition matrices for this purpose as early as 1987. We have since built upon a broad literature of work which applies migration analysis to credit risk evaluation. The first publication of transition matrices was in 1991 by both Professor Edward Altman of New York University and separately by Lucas & Lonski of Moody's Investors Service. They have since been published regularly [2]."

"In the CreditMetrics methodology, it is emphasized that the transition matrix determined based on the historical data of several thousand rated bonds provides a sufficiently accurate assessment of the probability of migration of a debt instrument from one rating class to another [8]."

The methodology assesses "… the volatility of value due to changes in credit quality, not just the expected loss. In our view, as important as default likelihood estimation is, it is only one link in the long chain of modeling and estimation that is necessary to fully assess credit risk (volatility) within a portfolio. [2]".

3. Methodology and Analysis

"Credit risk modeling is complex both analytically and practically. For example, many solutions have been researched for stock price risk using modern portfolio theory. However, the fundamental differences between credit risk and equity risk pose problems in applying equity portfolio theory to credit portfolios [9]."

According to CreditMetrics the bond's credit risk assessment procedure includes the following three-step algorithm:

Stage 1. Determining the probability of bond's credit rating migration.

Stage 2. Estimating the spread of losses due to default state or credit rating shift.

Stage 3. Calculation of credit risk based on the first two steps.

In assessing the risk of the JSCMB 'Ipoteka-Bank' Eurobond, the following additional information is used [10]:

1) Standard&Poor's rating categories and the transition matrix corresponding to them;
2) Eurobond belongs to BB rating category according Standard&Poor's agency;
3) Eurobond's face value equals to 100 dollars;
4) Eurobond's annually coupon rate is 5.5 percent;
5) Eurobond's maturity period is 5 years and the risk horizon is considered to be one year.

Stage 1. Credit rating migration. In case of credit event, the current rating value may develop according to the following scenarios at the end of the year:

1) remains in the BB rating category;
2) rises upto each of AAA, AA, A, BBB categories or falls to B, CCC categories;
3) becomes default.

The probability of occurrence of these scenarios varies, and information about this is obtained from available historical research data. CreditMetrics methodology recommends obtaining such information from official sources, particularly from sources periodically published by rating agencies. In particular, the official information of the S&P Rating Agency on the expectations of future rating migration based

on the global default cases and rating changes that occurred between 1981-2021 was used. Table 1 below presents these data and the according to this ranking transition probability is represented by the migration matrix. The percentage probabilities in the matrix represent the percentage of transitions in the studied 40 years of total observations. For example, instruments (issuers) with BB rating defaulted in 0.6% of total observations.

Matrix should be read as follow: the probability that the rating class listed from the left column along its rows by the end of the year, will move to the rating classes listed along the columns. To clarify, this table shows the migration of a Eurobond rated BB to one of 7 rating classes (from AAA to CCC) or default at the end of the year with certain corresponding probability levels. For example, the BB rated JSCMB 'Ipoteka-Bank' Eurobond at the beginning of 2021 may have the following migration probabilities at the end of 2021: a transition to AAA is 0.01 percent, while a default is estimated at 0.6 percent or rating level is maintained at 78.12 percent.

Table 1. *2021 average one-year global corporate rating transition matrix indicators[1], %.*

from/to	AAA	AA	A	BBB	BB	B	CCC/C	D	Number of defaults
AAA	87.09	9.05	0.53	0.05	0.11	0.03	0.05	0.00	0
AA	0.48	87.32	7.72	0.46	0.05	0.06	0.02	0.02	0
A	0.02	1.56	88.73	4.97	0.25	0.11	0.01	0.05	10
BBB	0.00	0.08	3.19	86.72	3.48	0.42	0.09	0.15	71
BB	0.01	0.02	0.10	4.52	78.12	6.66	0.53	0.60	182
B	0.00	0.02	0.06	0.15	4.54	74.73	4.81	3.18	1 102
CCC/C	0.00	0.00	0.09	0.16	0.49	13.42	43.91	26.55	2 940
Number of unrated defaults									143
Total									4 448

Conclusions determined from the data of the rating migration matrix:

1) the current credit rating is the most likely credit rating;
2) the second most likely state is the rating classes that differ up/down by one letter;
3) a low-rated asset issuer has a higher probability of default than others;
4) the sum of probabilities of rating migration is 100%.

Thus, in the 1st step, the probability of transition of the credit quality of the asset from the rating class to any other class during the one-year time horizon is determined. Because risk can have losses not only with the probability of default, but also with changes in the rating.

Stage 2. Assessment of the level of losses. In the previous step, it has been seen that the Eurobond can change at the end of the year according to 8 scenarios, and it has been seen that changes can be assessed with a degree of probability appropriate to each of them.

Revaluations are estimated using the following three-step calculation, and the present discounted value of the remaining future value of outflows is calculated:

1) loss coverage level is estimated by the levels of bond classes for the default situation;
2) the change in the bond spread as a result of rating migration to a higher or lower category is evaluated;
3) the present discounted value of the residual future value of outflows of the eurobond is reassessed based on the changed profitability generated by the new rating.

Evaluation in default state. In case when credit quality migration falls to default state, the recovery value is determined by the probable residual value after deducting the recovery amount, and it depends on the class levels of the debt instrument, that is, the value is determined by the default recovery rates by debt instrument class. In other words, if the issuer of the Eurobond defaults, it shows how much of the value of the investment made by the investor will be returned (repaid). To determine the repayment amount, the recovery rate for classes of the debt instrument is calculated by multiplying it by its nominal value.

Table 2. *Default recovery rates for corporate bond rating classes for 2021, in % of face value*[2].

Seniority of bonds	Mean (%)	Median (%)	Standard deviation	Variance (%)	Observations
Senior secured bonds	65.6	69.0	39.4	60.1	393
Senior unsecured bonds	51.3	47.1	38.9	75.8	1,400
Senior subordinated bonds	35.1	20.6	37.4	106.5	554
Junior subordinated bonds	28.4	11.5	37.7	132.8	471
All bonds	46.3	36.0	40.3	87.0	2,818

Available retrospective study data on recovery rate data will be used. CreditMetrics methodology recommends obtaining such information from official sources, particularly from sources periodically published by rating agencies. These data was obtained from official sources of the S&P Rating Agency. According to Table 2 above, information on how much of the nominal debt was repaid after the default of the debt instrument issuer in the period 1987-2021. Let's say a BB-rated bond is valued at a default recovery rate of "Junior subordinated bonds" category default. In this case, the value of losses in default state is 28.4 percent of the face value of the bond. The retrospective estimation of the BB-rated bond's default probability (according to Table 1) is 0.60%.

Table 3. *One-year forward corporate yield/discount rate data for 2021 by rating class*[3]*,%.*

Rating class	Year 1	Year 2	Year 3	Year 4
AAA	0.09	0.46	0.90	1.25
AA	0.31	0.68	1.13	1.47
A	0.50	0.87	1.31	1.66
BBB	0.77	1.14	1.59	1.94
BB	1.79	2.25	2.78	3.20
B	3.19	3.84	4.55	5.14
CCC	10.10	10.36	10.70	10.94

Estimating the change in bond spreads. In the next step, if the bond does not default, its probable end-of-year forward value is determined for each rating classes apart. As a result, the value of a BB-rated Eurobond at the end of the year is determined when it rises to BBB, falls to B, etc. Therefore, according to the new rating of the Eurobond, discounted value of the residual future value of outflows of the eurobond are determined, that is, the coupons and nominal value of the remaining year until maturity are discounted. In discounting, the Eurobond is revalued eight times.

As a discount rate, the methodology recommends obtaining information on the corporate forward discount rate for each rating class from official sources, in particular, from sources periodically published by rating agencies. In particular, the global one-year forward corporate yield/discount rate data on bonds for the period 2011-2021 was obtained from the official data of the S&P Rating Agency for the year 2021. The yield/discount rates for the 5 years remaining to maturity are presented separately for each rating class, as shown in Table 3 above.

Revaluation of the today's value of euro-bond. Here, the present value of euro-bond is determined with discount rates from Table 3 for situations where the quality of the debt instrument that has not reached the default state but migrates. Let's say that the rating of a bond with a BB category is recalculated by discounting the value of the bond for the remaining 5 years until maturity in the case of an upgrade to the BBB category as follows:

$$V = 5.5 + \frac{5.5}{(1+0.77\%)} + \frac{5.5}{(1+1.14\%)^2} + \frac{5.5}{(1+1.59\%)^3} + \frac{100+5.5}{(1+1.94\%)^4} = 119.28$$

Table 4. Values of JSCMB 'Ipoteka-Bank' Eurobond at the end of 2021 based on the discount rate[4].

Rating classes	Discount rate, %				Coupon payments, USD	Forward value, USD	Total value, USD
	Year 1	Year 2	Year 3	Year 4			
AAA	0.09	0.46	0.9	1.25	5.5	116.68	122.18
AA	0.31	0.68	1.13	1.47	5.5	115.74	121.24
A	0.5	0.87	1.31	1.66	5.5	114.94	120.44
BBB	0.77	1.14	1.59	1.94	5.5	113.78	119.28
BB	1.79	2.25	2.78	3.2	5.5	108.74	114.24
B	3.19	3.84	4.55	5.14	5.5	101.58	107.08
CCC	10.1	10.36	10.7	10.94	5.5	83.21	88.71
Default	-	-	-	-	-	28.4	28.4

Therefore, in the same way, it will be necessary to carry out a re-discounting assessment in connection with the transfer of the BB rating bond to all other rating classes. Our current five-year euro-bond matures in 5 years with a coupon rate of 5.5% per annum. Changes in discount rates of each year end are presented in Table 3.

Thus, the results of revaluation for all rating classes are reflected in forward and total values in Table 4. In step 2, the changed value of the eurobond at the end of 2021 by class is determined. First of all, the value of each migration gradation is calculated.

Stage 3. Debt instrument risk assessment. In the example of JSCMB 'Ipoteka-Bank' Eurobond, we have all the necessary information to evaluate the change in the value of debt instrument's quality. That is, in order to estimate the probability of all possible migration transitions and distributions of values within each gradation, the necessary value data were determined in the first and second stages, respectively. The values of calculation are presented in Table 5 (columns 2 and 3) below.

The data in column (4) of Table 5 below is found by multiplying the data in columns (2) and (3) and the sum of this column gives the average value. It has been seen that the migration probability and value of the Eurobond are calculated above. Now we will calculate the risk assessment using these value indicators.

Table 5. Risk value due to changes in the rating quality of JSCMB 'Ipoteka-Bank' Eurobond[5].

Rating at the end of the year	Migration probability, %	Face and coupon values, USD	Probability weighted value, USD	Difference of value from mean, USD	Probability weighted difference squared
(1)	(2)	(3)	(4)	(5)	(6)
AAA	0.01	122.18	0.01	19.62	0.0385
AA	0.02	121.24	0.02	18.68	0.0698
A	0.10	120.44	0.12	17.88	0.3197
BBB	4.52	119.28	5.39	16.71	12.6226
BB	78.12	114.24	89.24	11.68	106.4949
B	6.66	107.08	7.13	4.51	1.3561
CCC	0.53	88.71	0.47	-13.85	1.0170
Default	0.60	28.40	0.17	-74.16	33.0024
1.	mean=				102.5647112
2.	variance=				154.9210624

Rating at the end of the year	Migration probability, %	Face and coupon values, USD	Probability weighted value, USD	Difference of value from mean, USD	Probability weighted difference squared
(1)	(2)	(3)	(4)	(5)	(6)
3.	volatility=				12.44672898
4.	CreditMetrics modified risk=				11.57524650

Standard deviation is used as a measure of risk in this methodology. To determine it, the average value is first found. The average value is the weighted average value of migration probabilities for all rating categories. It is determined by the following formula:

$$\bar{\mu} = \sum_{i=1}^{n} p_i \mu_i$$

Here p_i, μ_i are the rating migration probability and nominal plus coupon values of the bond under consideration, respectively. That is, the values of columns (2) and (3) of Table 5 are used in the formula:

$$\bar{\mu} = 0.01\% \cdot 122.18 + 0.02\% \cdot 121.24 + 0.10\% \cdot 120.44 + 4.52\% \cdot 119.28 + 78.12\% \cdot 114.24 + 6.66\% \cdot 107.08 + 0.53\% \cdot 88.71 + 0.60\% \cdot 28.40 = 102.56.$$

The standard deviation means the variance under the square root and is determined by the following formula:

$$\sigma = \sqrt{\sum_{i=1}^{n} p_i {\mu_i}^2 - \bar{\mu}^2}$$

In this case, the defined value calculates the difference between the individual value of the standard deviation rating migration and the average value for all non-default cases, that is, it determines how much it deviates as follows:

$$\sigma = ((0.01\% \cdot 122.18^2 + 0.02\% \cdot 121.24^2 + 0.10\% \cdot 120.44^2 + 4.52\% \cdot 119.28^2 + 78.12\% \cdot 114.24^2 + 6.66\% \cdot 107.08^2 + 0.53\% \cdot 88.71^2 + 0.60\% \cdot 28.40^2) - 102.56^2)^{1/2} = \sqrt{154.92} = \pm 12.45.$$

The defined standard deviation value generally serves as a measure of risk, and this value dictates that each bond rating class accepts only the average value. In fact, each rating class of a bond may have its own distribution, which can create uncertainty about losses in the event of default.

To take this into account, according to the methodology, it is required to include the σ_i^2 component (standard deviations for each classes) in the calculation formula of the standard deviation. This component represents the compensation value of the default loss rate uncertainty i = {1;8}. So the formula for determining the standard deviation is adjusted as follows:

$$\sigma^* = \sqrt{\sum_{i=1}^{n} p_i(\mu_i^2 + \sigma_i^2) - \bar{\mu}^2} = ((0.01\% \cdot (122.18^2 + 0^2) + 0.02\% \cdot (121.24^2 + 0^2) + 0.10\% \cdot (120.44^2 + 0^2) + 4.52\% \cdot (119.28^2 + 0^2) + 78.12\% \cdot (114.24^2 + 0^2) + 6.66\% \cdot (107.08^2 + 0^2) + 0.53\% \cdot (88.71^2 + 0^2) + 0.60\% \cdot (28.40^2 + 37.7^2)) - 102.56^2)^{1/2} = \pm 11.575$$

It is noteworthy that for the first 7 rating classes, this component, i.e., risk (standard deviation) value equals to 0, means the uncertainty of the value of the increase (decrease) level during the rating migration, only for the 8th default case has the value of standard deviation because there is standard deviation information according to Table 2 and it is 37.7.

After the calculation, the value of the improved standard deviation is equal to 11.57, that is, it is a value lower than the previous value of 12.45 by 7.61%. Therefore, when the component, that estimates the uncertainty of the loss level, is included in the risk formula σ^* it leads to a decrease in the credit risk of the bond.

Thus, the uncertainty of the value for the bond's default means that the value of the rating change (upgrade, decrease) will also be uncertain. This leads to uncertainty in bond spreads for each bond rating class. The uncertainty of the bond spread is called zero, because it is uncertain in what proportion it belongs to systematic and unsystematic risks.

4. Conclusion

In conclusion, CreditMetrics, developed by JPMorgan & Co, is a credit risk assessment methodology for risk managers that incorporates the latest advances in portfolio theory and assessment methodology.

As an achievement, the methodology is convenient and effective in terms of understanding, application and interpretation of results for the investor or any practical user. The calculation algorithm is simple, the ability to perform analysis using Excel, as well as the availability of freely available sources of normative criteria used in the rating by rating agencies are recognized as its main positive aspects.

At the same time, it provides an opportunity to perform the analysis, removing the complexity of applying the requirement of normal distribution to the statistics of the results of the banking industry, which is imposed on the input

data in the analysis of the risk assessment.

In the end, it was found that risk assessment with the help of methodology rather than traditional risk assessment gives an opportunity to increase the attractiveness of the debt instrument for the investor by minimizing its risk, which is the main goal of our research.

So, while providing an opportunity to assess risk based on statistical assessment metrics, CreditMetrics has a huge practical value to make investors active by increasing their risk appetite with estimated lower credit risk and gaining a competitive advantage among investors in the evaluation of debt instrument credit risk taking into account migration analysis and default cases.

Abbreviations

JSCMB	Joint-Stock Commercial Mortgage Bank
S&P	Standard and Poor's
AAA, AA, A, BBB, BB, B, CCC/C, D	Letter Designations Used by S&P rating Agency for Assigned the Seven Credit Rating Classes (Categories) and Default Status, Respectively

Author Contributions

Mirzayeva Fotima Mirrakhimzhonovna: Formal Analysis, Writing - original draft, Methodology

Zokirzhonov Mukhammadsodiq Ravshanbek Ugli: Resources, Data curation, Writing - original draft, Writing - review & editing

Conflicts of Interest

The authors declare no conflicts of interest.

1 It was compiled by the authors based on the official data of the S&P Rating Agency for the years 1981-2021.
https://www.spglobal.com/ratings/en/research/articles/221212-default-transition-and-recovery-2021-annual-global-financial-services-default-and-rating-transition-study-12573274#:~:text=Three%20of%20these%20issuers%20were,down%20from%200.23%25%20in%202020

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3 It was compiled by the authors based on the official data of the S&P Rating Agency for the years 2011-2021.
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4 It was compiled by the authors.

5 It was compiled by the authors.

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