Bank's Credit Risk Modeling

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The article reviews the Bank's credit risk modeling issues. The substance of the article analyzes the credit risk structure and methods for measuring its components. Credit risk is measured as a loss, that is the function of several variables. The amount of open credit risk position in case of default, expected probability of credit default and recovery ratio after the default are the main variables of the given function presented in the article. These variables are reviewed as random values and methods are given for its evaluation and integration as one indicator.

The article also reviews the tasks of forming the bank's internal credit ratings and issues related to the use of these ratings in credit risk evaluation model.

Introduction

Recently, the size of the exposure has become a problem for banks throughout the world. Loans for majority of banks are the most vivid and primary source of Credit Risk. Credit Risk can be simply defined as the second party's failure to meet the obligations assumed as per to the agreed terms. Bank's Credit Risk Management aims at maximizing risk-weighted earnings by adjusting the exposure to the allowed level of control parameters. Banks have risks at two levels in terms of loans: at Credit Portfolio and at Individual Loans. Bank's Effective Credit Risk Management implies the both levels and ensures the achievement of short- and long-term goals. According to the Credit Risks Analysis, the main reason for banks' bankruptcy in most cases was large credit losses.

Given the Credit Risk's significance, a bank must be able to identify, measure, monitor, and control it. Besides, a bank must evaluate the capital adequacy of the assumed Credit Risk. The Basel Committee has set forth the main principles based on which it is recommended to build a reliable system for Credit Risks Management (Basel Committee on Banking Supervision, 2000). These principles require the following: (1) creating a

relevant Credit Risk Environment; (2) using reliable credit disbursement process; (3) adequate credit administration, evaluation and monitoring; (4) adequate Credit Risks Control.

As the task of the Credit Risks Modeling, we review the Credit Risk Evaluation and Aggregation by Credit Products. Modeling outputs can also be used in Risk Management and evaluation of activity outcomes, as well as in client's profitability analysis, pricing considering the risk factor and defining the recoveries linked to the results. Credit Risks Model has recently been used in Credit Portfolio Management and Capital Structure related decision-making. If the model is conceptually accurate, reliable, empirically tested and results in adequate evaluations for the Banks' Capital Requirement, Regulation could rely on it and define Capital Requirement based on it.

A Market Risk Model is widely used in practice. On the basis of it, risk equivalent requirement on capital is defined. Credit Risk Model can not be a simple expansion of the Market Risk Model due to two reasons. The first reason is the insufficiency of data. Majority of Credit Risk bearing instruments are not marketable, because of this the price forecast for these instruments based on the Model will not be the output of the statistical evaluation of the historical prices in full. Credit impairment cases are not distributed symmetrically. This is truly an random variable, but its distribution is shifted positively.

The second reason is Model validation. A Market Risk model includes only several days whereas the Credit Risl Model typically covers one year or more. This makes evaluation of the accuracy of the Model difficult. If we take the confidence level into consideration, the noted difficulty increases. Numerical validation requires a number of years, which is not practical, since it includes several credit cycles. However, the cycle component can be removed from the time-span (Hanke, Wichern, 2009), we will refer to this issue below.

Credit loss is an random variable, which has a distribution function. The main outcome of the Credit Risk Model should be the deriving of distribution function. Credit loss is divided into two components. One is the expected loss within the selected period or the average loss, which evaluates the amount of the expected credit loss for the concrete period. The second component is the unexpected credit loss, with this amount total actual credit loss exceeds the expected one.

The first component is covered by the bank's credit reserves, which is created according to the Bank's Reserve Policy and reflects the numerical and qualitative status of the Credit Portfolio within the specific timeframe. This part does not require the allocation of the Economic Capital. The latter is for the second component of the credit loss – the unexpected credit loss, so that the predefined rate of the bankruptcy can be achieved. This is shown graphically:
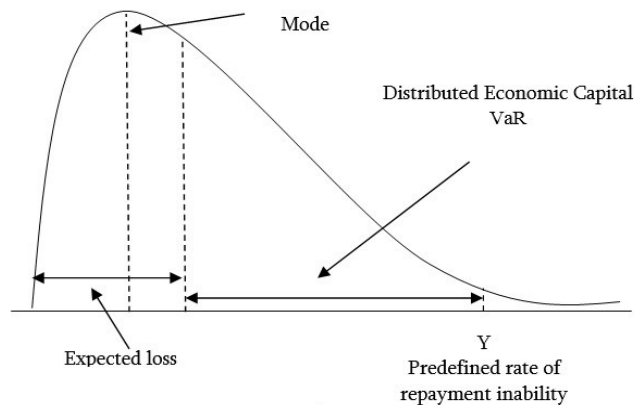
Chart 1

Unlike the market risk, this is not the normal distribution. It is skewed to the right and is the result of the repayment inability or lowering of the credit rating. Therefore, credit loss distribution modeling is necessary. Probability, that VaR exceeds the unexpected loss at the given confidence level equals to zero.

Apart from the Economic Capital, Bank has the Supervisory Capital Requirement (Lemonjava, 2009). Majority of banks review these capitals separately. If the Supervisory Capital is less than the Economic Capital, there is no problem, the used capital will be considered in pricing in full. But the problem arises, when the Supervisory Capital exceeds the Economic Capital. In this case, surplus is not distributed by Banking Products and the price does not include the recovery component of the regulation expense. Coming from the size of the bank and its business structure, this difference might be so big, that without its adjustment the bank's fair value will decrease significantly.

A Credit Risk Model, created and implemented on the basis of the relevant principles and methods, grants a reasonable privilege to the bank. With this model, bank can identify, measure and manage the risk promptly. Individual loans can be reflected in the model jointly, which makes it available to consider the composition effect and better reflects the concentration risk. As it is known, economic environment, market factors, bank's business structure is changing, which is reflected in the model and their results will be evaluated promptly. Finally, important model outcome can be the reduction of Regulatory Capital Requirement if the regulatory body is convinced in the reliability of Credit Risk Model and the bank's Risk Maangement System in whole.

Bank's Management is responsible for the Credit Risk identification, evaluation, management and monitoring, as well as launching the Internal Control Monitoring System. To fulfill these tasks, bank should have accurately and thoroughly identified credit risks and defined Risk Allowance Level. If we measure risk in two dimensions, in terms of output and probability, Management's tasks will be graphically presented as in chart 2.

Risk Allowance Level is approved by Top Management or Supervisory Board. A Credit Risk Model and Internal Systems of Credit Rating are a great assistance in fixing the Risk Allowance Level and its performance control. The Model connects Regulatory Capital Requirement, Capital with acceptable risk level and Economic Capital with Residual Risk. In case of the relevant management and control, a bank's Management can not exceed the acceptable Credit Risk Level. Herewith, Management has a chance to reduce the Regulatory Capital Requirement significantly, which will be positively reflected on the bank's profitability. Only for this it is necessary for the bank to have adequate Credit Risk Management System. Two interrelated components of this system are the Credit Risk Model and Internal Rating System. Given article aims for integrating these two instruments in the general Credit Risk Management Model.
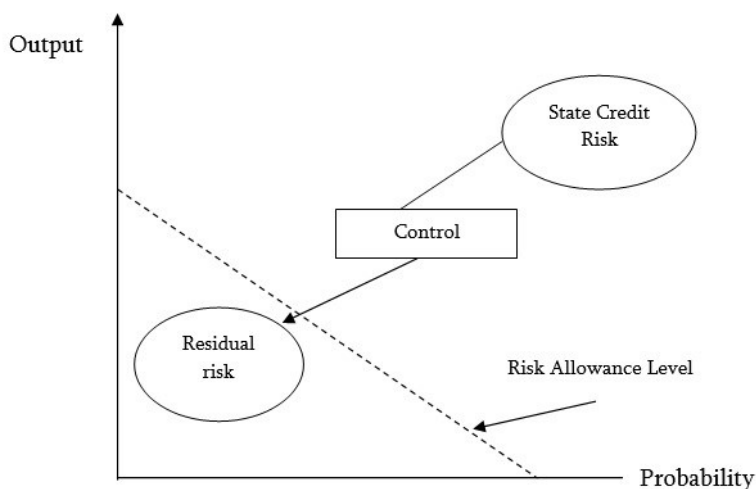

Chart 2.

Credit Risk Model

A Credit Risk Model includes several elements. These are the following: 1) time interval; 2) Credit Risk Measure - default or market method; 3) conditional/unconditional models; 4) Credit Aggregation Method; 5) Correlation among the default events. There is not any widely accepted standard for choosing a model. When making the selection, bank's Credit Portfolio features and its credit culture should be taken into account. Generally, it is necessary to analyze some conceptual issues, which are critical in selecting any model or method.

One principal output of the Credit Risk Model is the Credit Loss Distribution Function. Expected Credit Loss, Unexpected Credit Loss and Loss with targeted Confidence Level are determined within the scope of this function (see Chart 1.). It is true that the last section is characterized by low frequency, but the probability of their occurance is real and respective loss is equal to bankruptcy. Thus, shrinkage of the Confidence Level will increase VaR sharply and the latter will limit the business. VaR represents the Capital, which covers unexpected losses above the expected ones.

Credit Risk has several drivers, which are the Credit Risk Model variables. These are: 1) exposure; 2) migration risk; 3) default risk; 4) credit loss recovery risk.

Exposure equals the amount that can be directed to the other part. This can be measured by book value, which is client's balance liability or by market value, which implies the Migration Risk. Credit Risk Model, which implied the Migration Risk, evaluates the Credit Loss more accurately and thoroughly. However, it should be considered, that the Credit Risk component becomes harder to single out clearly.

According to the definition, only the future exposure is under risk. In this context, future exposure is not the predefined measure, it is a random variable, the source of which is withdrawals from Credit Lines.

When evaluating the Default Risk, default's deifinition is important. It has an impact on default's probability and its frequency. Default Payment can be considered if the payment is 3 months overdue. Bankruptcy and business restructurization can be considered as the default case. As for funds, default can be considered breaching the covenants breaching the terms (of a loan agreement?) may be considered a default .

Default-related loss equals to material loss with reduced recovery. Migration probability is calculated using the historical data. In any other class status rather than the default, Migration does not cause the Book Value impairment, even if the default probability changes. It is impossible to define the expected loss using the historical data, because of this data from Rating Agencies is often used. Agency ratings do not measure the

default probability of liability issuer, it measures the credit grade of the issued instrument. To overcome this issue, banks use Internal Ratings (IBR) frequently. The latter is envisaged by the new resolution of the Basel Committee, which is known by Basel II (Basel Committee on Banking Supervision). Credit Risk grade and significance increases if it relies on the smooth Internal Rating System of the bank. Bank's Internal Rating will be reviewed in details down below.

Credit Risk Model should give us the Credit Loss Distribution Function (PDF). Bank's Credit Risk Model should give the reliable evaluation of PDF. Probability of the Credit Loss exceeding Y equals to the area below PDF , right-side of Y. Credit Risk Portfolio grade is characterized with this interval/area: if it is high, Credit Risk Portfolio should be considered of high risk and if it is low-low risk. Bank reviews the unexpected part of the Credit Risk as a Credit Risk.

As it was said, given that the distribution will not be normal, we need to find a corresponding function. We consider the log-normal distribution (Lazrieva, Mania, Mari, Mosidze, et al. (2000) $X - Log(x, \mu, \sigma)$ as a good approximation for PDF. Its density is

$$f(x) = \frac{1}{x\sigma} \varphi(\ln x - \mu)/\sigma, x \geq 0$$

And parameters:

$$\mu \in (-\infty; +\infty), \sigma > 0.$$

To derive the function it is necessary to evaluate them based on the sample. Distribution Function accuracy will depend on sample representation and size, which is the function of two parameters (Robert, Mason, & Douglas, Lind , 1996):

$$n = \left(\frac{z \cdot s}{E} \right)^2$$

where:

E – allowable error

Z – respective z evaluation of selected Confidence Level

s - sample variance

We have mentioned about some difficulties of creating the model. One of them was the lack of data. Limited number of observations of smallsized banks is a general problem. Even in Georgia's largest Banks there are only several hundred medium- and large-sized business loans and mortgage loans. Consumer loans account for a comparatively greater

share of the overall loans. It is almost impossible in first two cases to take the sample size providing the accurate evaluation of the Distribution Function Parameteres.

The second problem is attributable to Managerial Information Systems, which are used by the banks. Along with the other necessary data, they do not record the credit default and losses. This is a problem characteristic to the beginning stage of the Credit Model implementation, which can be solved by postponing the model implementation or using expertise evaluations.

Using the Distribution (1) Function we can calculate expected and unexpected Credit Losses. Expected Credit Loss is:

$$EL = \exp(\mu + \sigma^2 / 2) \approx \sum EDF_i \cdot EAD_i \cdot LGD_i$$

Where: EDF is the expected probability of credit default; EAD- total credit balance of the default; LCG- impairment rate of the given default.

This part of the loss is covered by the Credit Reserves, which does not consider the default occurrence. This component is not involved in the distribution of Economic Capital, but the unexpected loss is. Credit Loss Distribution Function (1) includes two parameters, one of them evaluates the average component (μ) of the Credit Loss and the second- deviation (σ) of the unexpected loss. The size of the Capital to be allocated is determined by certain standard deviation multiple for Credit Loss:

$$UL = \gamma \cdot \sum_i \{\exp(2\mu_i + 2\sigma_i{}^2) - \exp(2\mu_i + \sigma_i{}^2)\} \approx$$

$$\gamma \cdot \sum_i EAD_i \sqrt{EDF_i(1 - EDF)LGD_i^2 + EDF_iVOL_i^2}$$

(Basle Committee on Banking Supervision, 1999)

Where: VOL is the standard deviation of the LDG , but γ - the coefficient of the standard deviation multiple, which is determined at the selected Confidence Level.

Formula (2) does not consider the correlation. If the correlation of one credit instrument is more important than the correlation of other instruments, it will be necessary to aggregate the individual credit loss risks with the respective coefficient of correlation (ρ_i). Considering the latter, formula (2) will be as follows:

$$UL \approx \gamma \cdot \sum_i \rho_i \cdot EAD_i \sqrt{EDF_i(1 - EDF)LGD_i^2 + EDF_i VOL_i^2}$$

Presented model is based on the following estimations: 1) Credit loss occurs only in case do the credit default; 2) time interval is the same for all credit instruments; 3) exposure for each credit instrument is known; 4) client default and loss for the given default (LGD) are independent variables; 5) LGD is a variable by clients.

Internal Credit Risk Rating System

The Rating System measures the credit risk, differentiates the individual credits and groups of credits according to their credit risk level. Using the Internal Rating System, the bank's Management can monitor the risk level fluctuation in an operative manner, assess and recognize trends promptly. Credit Risk Rating helps the bank to fulfill the following functions in an accurate and timely manner: 1) loan approval and disbursement; 2) loan pricing; 3) creation of loan reserves; 4) adequate capital coverage of credit risk; 5) Credit Portfolio management.

The bank makes concrete definition for the rating, designs the processes and sets criterias (Guidelines on Internal Credit Risk Rating Systems,2007), with the help of which the respective rating grades are assigned to each concrete credit risk. Rating grades should be differentiated sufficiently, so that each loan can be attributable to the rating class with respect to its risk. To avoid the concentration surplus, at least seven grades should be assigned for the current loans and one for bad debts (Basle Committee on Banking Supervision, 2004).

Retail loans are divided into baskets and are classified into the respective rating classes of assumed risk. Credit loass features (PD, LGD and EAD) are determined for each busket. Due to the number of this type of loans, given parameters of the model can be evaluated accurately even in the small sized banks.

Credit Rating is influenced by three factors: business risk, financial risk, and macroeconomic environment. We use three variables in business risk evaluation: 1) size of the firm, 2) systemic risk of the capital - Beta component and 3) nonsystemic risk of the capital-non Beta component.

Size of the firm can be evaluated by the market value of the firm's capital or the actual value of total assets. The second variable is evaluated by the Capital Market Model, the third – by the standard error related to the Market Model. Size of the firm is in negative correlation with the market risk, but the second and third variables are in positive correlation. In the countries with developed market economy, where capital market is

well-developed, β coefficients are available. But we shall use other variables in the countries with different situation. For instance, number of sales, raw material cost, competition, market share and other.

Financial Risks Analysis is based on the main financial ratios. For this reason, rating agencies use different number and type of financial ratios. For instance, S&P uses 8 main financial ratios, BLM – 4. First out of these four is 'interest expense coverage ratio'; second- operating income to sales; third- long-term loans to assets; fourth- total liabilities to assets. The first two are in positive correlation with the rating and the last two-in negative correlation. To exclude the impact of economic cycles, it will be reasonable to use several years of average for the given ratios. The above-mentioned rating agencies use the three years' average.

The Rating Agencies use different numbers of grades: Moody's has 9 different qualities (www.moodys.com), Standard & Poor's - 10 qualities (www.standardandpoors.com), Fitch - 12 qualities (www.fitchratings.com). Bank shall determine and use that number of qualities that will correspond to the existing and expected risk level. Slight differentiation of ratings will cause the concentration of loans with different risks at one rating class level, which will decrease the reliability of evaluating the credit loss parameters. On the other part, large differentiation of ratings will make it difficult to set clear criteria for assigning the ratings and different ratings will be assigned to the borrowers with the same risk. Clear definition and details of ratings is necessary also for the third party (Internal Audit, Supervisors and others), so that they can understand why that specific rating was assigned to the borrower. Criteria for assigning the ratings can not be dependent on the bank's internal credit standards and policies.

When the bank assigns rating to the borrower and the credit instrument, it uses all the essential information on hand. In case of the lack of information, which is frequent, the bank shall use a conservative approach. If there are external ratings and the bank is confident in its reliability, it can be used for assigning the internal ratings. But they should check the equivalency of their own ratings with the agency.

It is important, that a borrower's rating class shall be reviewed by taking the expected results of the borrower's future business into account, rather than using only the credit history. Rating shall measure the risk, which evaluates the probability of the borrower meeting the assumed liabilities for not less than one year. Generally, the results of the borrower's future business depend on the financial background, which reflects actual and budgeted financial accounts (Balance Sheet, Income Statement). Liabilities are met by money, therefore borrower's creditability is focused on available cash resources and its stability.

Credit Rating is not a fixed structure. It is characterized by certain fluctuations, which is reflected in the borrower's migration from class to class. Thus, it is necessary to create the matrix of rating migration and to update it periodically. The general structure of this matrix can be presented as follows:

	AAA	AA	A	BBB	BB	B	CCC	D (Default)
AAA	mp $_{1,1}$	mp $_{1,2}$	mp $_{1,3}$	mp $_{1,4}$	mp $_{1,5}$	m $_{1,6}$	mp $_{1,7}$	DP$_1$
AA	mp $_{2,1}$	mp $_{2,2}$	mp $_{2,3}$	mp $_{2,4}$	mp $_{2,5}$	mp $_{2,6}$	mp $_{2,7}$	DP$_2$
A	mp $_{3,1}$	mp $_{3,2}$	mp $_{3,3}$	mp $_{3,4}$	mp $_{3,5}$	mp $_{3,6}$	mp $_{3,7}$	DP$_3$
BBB	mp $_{4,1}$	mp $_{4,2}$	mp $_{4,3}$	mp $_{4,4}$	mp $_{4,5}$	mp $_{4,6}$	mp $_{4,7}$	DP$_4$
BB	mp $_{5,1}$	mp $_{5,2}$	mp $_{5,3}$	mp $_{5,4}$	mp $_{5,5}$	mp $_{5,6}$	mp $_{5,7}$	DP$_5$
B	mp $_{6,1}$	mp $_{6,2}$	mp $_{6,3}$	mp $_{6,4}$	mp $_{6,5}$	mp $_{6,6}$	mp $_{6,7}$	DP$_6$
CCC	mp $_{7,1}$	mp $_{7,2}$	mp $_{7,3}$	mp $_{7,4}$	mp $_{7,5}$	mp $_{7,6}$	mp 7_7	DP$_6$

Each non-diagonal element of the matrix (mp$_{i,j}$) shows the credit movement of one class rating into the other. Diagonal element (mp$_{i,i}$) shows the probability of the credit remaining in the same class. The last column shows the probability of credit defaults of each class.

This kind of matrix must be created for each credit product, wich requires the classification of large number of loans and takes minimum 5 years (Greg M Gupton, Christopher C Finger & Mickey Bhatia, 1997). Basel II (Basle Committee on Banking Supervision, 2004) gave a great stimulus to large international banks to implement the Credit Risk Model and Internal Credit Risk Ratings System. It took 5 years on average for them to implement this system and within the scopes of this process they had to restructure and develop the bank's Risk Management, Control and Managerial Informational Systems with respect to the requirements of new tasks.

And finally, it should be mentioned, that the creation and implementation of this difficult system is not the end of the process. The next step is the matter of its viability and sustainability, which is quite complex and requires resource and organizational support. For the activity of the model outcomes, it is important that the bank have the adequate system for its monitoring and outcome evaluation that will disclose the new trends and errors promptly, make recommendations for improvement and monitor their implementation. Constant testing of Internal Rating Systems is important as it evaluates the risk with default probability and expected

loss. Testing is based on historical data and shows if the model results correspond with the actual figures.

References

Basel Committee on Banking Supervision, , from htlp://www.bis.org

Basel Committee on Banking Supervision. (2000). Principles for the Management of Credit Risk, from htlp://www.bis.org

Basle Committee on Banking Supervision, (1999), Credit Risk Modeling: Current Practices and Applications, Basle, from htlp://www.bis.org.

Basle Committee on Banking Supervision. (2004). International Convergence of Capital Measurement and Capital Standards, Basle, from htlp://www.bis.org

Basle Committee on Banking Supervision. (2004). International Convergence of Capital Measurement and Capital Standards, Basle, from htlp://www.bis.org.

Greg M Gupton, Christopher C Finger & Mickey Bhatia. (1997). *Credit Metrics – Technical Document, Morgan Guaranty Trust Co*., New York, April .

Guidelines on Internal Credit Risk Rating Systems, 2007, from htlp://www.sbp.org.pk/bsrvd/2007/Annex-CB.pdf.

Hanke, J. E., & Wichern, D. W. (2009). Business forecasting. Pearson Prentice Hall.

Lazrieva N., Mania M., Mari G., Mosidze A., et al. (2000). Theory of Probability and Mathematical Statistics for Economists. Tbilisi: Institute of Mathematics.

Lemonjava, G. (2009). Banking loans: tendency and regulation. Economist, 4, 33-41

Robert, D. Mason, & Douglas, Lind, A. (1996). Statistical Techniques in

Business & Economics. Irwin/McGraw-Hill.