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Graduate School of Management

Master in Corporate Finance

THE CREDIT POLICY OF A COMPANY AND ASSESSMENT OF THE CREDITWORTHINESS OF COUNTERPARTIES

Master’s Thesis by the 2nd year student

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ЗАЯВЛЕНИЕ О САМОСТОЯТЕЛЬНОМ ХАРАКТЕРЕ ВЫПОЛНЕНИЯ

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STATEMENT ABOUT THE INDEPENDENT CHARACTER OF

THE MASTER THESIS

I, Beliaev Artem Alexandrovich, second year master student, program «Management», state that my master thesis on the topic «The credit policy of a company and assessment of the creditworthiness of counterparties», which is presented to the Master Office to be submitted to the Official Defense Committee for the public defense, does not contain any elements of plagiarism.

All direct borrowings from printed and electronic sources, as well as from master theses, PhD and doctorate theses which were defended earlier, have appropriate references.

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**АННОТАЦИЯ**

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| Описание цели, задач и основных результатов | Цель работы - разработка нового экспресс метода оценки кредитоспособности контрагентов.  **Задачи:**  Анализ существующих методов оценки кредитоспособности;  Разработка нового метода оценки кредитоспособности;  Проверка метода на реальных данных и формулировка результатов.  **Результаты:**  Предложен новый метод оценки кредитоспособности компаний и протестирован на реальных данных. Сделан вывод о том, что данный метод может быть использован на практике. |
| Ключевые слова | Кредитная политика, оценка кредитоспособности, опционы, модель Мертона, методы оценки. |

**ABSTRACT**

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| --- | --- |
| Master Student's Name | Beliaev Artem Alexandrovich |
| Master Thesis Title | The credit policy of a company and assessment of the creditworthiness of counterparties |
| Educational Program | Master in Corporate Finance |
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| Academic Advisor’s Name | Okulov Vitaliy Leonidovich |
| Description of the goal, tasks and main results | The main **goal** is to develop a new express way of counterparties’ creditworthiness assessment.  **Tasks:**  Analysis of existing methods of creditworthiness assessment;  Development of a new method of creditworthiness assessment;  Verification of the method on real data and formulation of results.  **Results:**  The new creditworthiness assessment method is created and tested on real data. It is concluded that this new method has can be used in practice. |
| Keywords | Credit policy, creditworthiness assessment, options, Merton model, assessment methods. |

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# **Introduction**

Nowadays, in a highly competitive environment, companies are forced to make concessions and create favorable conditions for customers to fight for their attention. One of the main conditions for customers are terms of payment. With regard to payment, companies create favorable conditions for their customers, granting them a deferred payment for a certain period of time with a certain size of credit limit. Deferred payment allows companies to pay their accounts to their suppliers after receiving funds from their core operations. Deferred payment in that sense is a kind of a loan provided by the company, which sells a good to the company, which buys this good. From the seller’s point of view, deferred payment is accounts payable on the Balance Sheet. According to the statistical data published on the official website of the Unified Interagency Information and Statistical System, the volume of overdue accounts receivable of all Russian companies over recent years is characterized by relatively stable growth[[1]](#footnote-1). As of 01.01.2013, it was 1 224 705 mln RUB, as of 01.01.2017 - 2 240 920 mln RUB. Thus, over 5 years the amount of overdue accounts receivable increased almost in two times.

It is evident, that the company that provides the loan is interested in its full payment on time from the buyer’s side. The buyer, as a rule, is also interested in paying, because non-fulfillment of the contract entails litigation. What is more, the buyer is always interested in the longest deferred payment period, because in fact this type of a loan, taken from the supplier, is non-interest bearing and it allows to use money for free.

Thus, both parties are interested in the execution of the contract, however, in practice, the terms of the contract are often not met. The buyer may have a great desire to pay money to his supplier, but simply do not have funds because of financial difficulties. A company that provides loans to its customers is interested in keeping the number of firms, which are incapable of meeting their obligations, as low as possible. To do so, at the decision-making stage on granting a deferred payment, the client must be carefully checked for its creditworthiness. The creditworthiness of the borrower is its complex legal and economic characteristics, represented by financial and non-financial indicators, which allows assessing the possibility in the future and in the period provided for in the loan agreement to settle on debt obligations to the creditor.

Counterparties’ creditworthiness assessment is an important component of the credit policy of every successful organization nowadays, and for that reason this topic becomes more and more discussed in the literature. One of the first authors, who started discussing the problem of creditworthiness assessment was E. Altman. In 1968 he developed the index of creditworthiness, which still remains one of the most widely used in the world, despite the fact that this index was developed on financial information of only US companies. In general, there are so many creditworthiness assessment methods nowadays, that the problem of their classification becomes an important one. Vishnyakov I.V. in his paper «Methods and models for assessing the borrower's creditworthiness» suggested dividing the methods of creditworthiness assessment into groups, and each group is also divided into subgroups[[2]](#footnote-2). Further in the paper nearly all the methods will be studied and compared. However, one of the conclusions of their comparison should be mentioned right now. Almost all methods of creditworthiness assessment require large amount of input data – quantitative and qualitative information about company. Of course, large amount of input data leads to more precise results – this is a rule for nearly all types of analysis. However, nowadays it is the speed and ease of use of the creditworthiness assessment method that is important. Companies need to make a decision at high speed and cannot wait for results of long complicated analyzes. As a rule, before signing a deal, counterparty should send its financial information (Balance Sheets, Profit & Loss Statements) to the seller in order to be checked for creditworthiness, but very often there is a problem of insufficiency and unreliability of the information provided by companies. Information on the quantitative and qualitative characteristics of companies is very often deliberately or undemandingly distorted. Moreover, when analyzing small companies, arises the problem of the availability of information. Limitations of currently existing creditworthiness assessment methods create a request to develop a new method of creditworthiness assessment, which would be spared from the minuses of current models. Thus, we can now formulate the main goal of the paper.

The main **goal** of my thesis is to develop a new express method of counterparties’ creditworthiness assessment.

To achieve this goal the list of the following **tasks** should be executed:

1. Analysis of existing methods of creditworthiness assessment;
2. Justification for the need to develop a new method of creditworthiness assessment;
3. Development of a new method of creditworthiness assessment;
4. Verification of the method on real data and formulation of results;
5. Comparison of the new method with currently existing methods and justification of its viability and possibility of use in practice.

The main **research question** can be identified as the following: «What is an alternative method of creditworthiness assessment previously never used».

The **relevance** of the paper is explained by the fact that counterparties’ creditworthiness assessment becomes more and more important component of a credit policy of every company. As it was previously mentioned, companies are trying to reduce risks associated with insolvency of customers. However, existing methods of counterparties’ creditworthiness assessment often require a large amount of input data or are extremely difficult to be developed. **Managerial importance** of the new method, offered in the paper, will be of high level due to this method ease of use and low need for company resources. Such a method is not used by companies nowadays and is not mentioned in the literature. In this regard, a study is relevant and can close currently existing practice gap.

The **object** of the study is the credit policy of a company. The **subject** of the study is the creditworthiness assessment of counterparties of a company. As research tools, the Black-Scholes option pricing model and Merton model for default probability are used.

Qualification paper has the following text structure:

1. Chapter 1. CREDITWORTHINESS

In this chapter main methods of creditworthiness assessment are described. Methods are analyzed for their advantages and disadvantages. Justification for the need to develop a new method of creditworthiness assessment is presented.

1. Chapter 2. MERTON MODEL FOR PROBABILITY OF DEFAULT

In this chapter a reader of the paper is introduced into the theory of options. Main principles and rules of options are shown. Merton model for default probability is described and analyzed in this chapter.

1. Chapter 3. NEW METHOD OF CREDITWORTHINESS ASSESSMENT

The main aim of this chapter is to introduce a new method of creditworthiness assessment and verify it on real data. Data, provided by the real Russian company is analyzed and used in calculations in the model. After that results are given and conclusions on new model’s viability and practical applicability are formulated. In the end new method is compared to currently existing methods of creditworthiness assessment. New method’s ease of use and low need for company resources are distinguished as its main advantages in comparison with currently existing methods of creditworthiness assessment.

# **Chapter 1. CREDITWORTHINESS**

## **1.1 Credit Policy**

Financial management of the company is the management of money (funds) aimed at accomplishing the objectives of the organization. One of the main components of financial management is the credit policy of the enterprise. There are different approaches to disclosing essence of the credit policy [[3]](#footnote-3):

1. Credit policy implies an answer to three simple questions: to whom to lend, under what conditions and how much[[4]](#footnote-4);
2. Credit policy is a system of measures and rules aimed at monitoring the implementation and use of loans provided by the company or bank. Among other things, it can include a system of rules for building relationships with customers, which includes the debt collection procedure;
3. Credit policy is a tool to achieve the company's strategic goals related to profit and the indicator of profitability of sales, by achieving current sales revenue targets, gross profit and the costs associated with lending. The credit policy that ensures the achievement of sales revenue targets (gross revenue of gross profit) and maximizing the profit associated with consumer lending is called an effective one[[5]](#footnote-5);
4. Credit policy is a set of principles that govern the provision of deferred payment to buyers.[[6]](#footnote-6)

According to the most common point of view, under the credit policy of an enterprise is understood a set of activities for managing receivables and payables and determining the optimal conditions for the provision and receipt of commercial loans. This approach is based on the interconnection of receivables and payables. Further in the paper, the credit policy of the organization will be referring to this definition.

From the company's internal documents point of view, the credit policy of the company should include:

* Thoughtful work with the client: rules of segmentation of types of customers and rules of work with each segment;
* Distribution within the company of works on interaction with debtors;
* Procedure of debt collection by internal forces;
* The description of situations in which the debt is transferred for collection to the collection agency;
* Description of situations in which the debtor is sued.

Formation of the credit policy of the enterprise in relation to the buyers includes: analysis of accounts receivable of the enterprise in the previous period; formation of principles of a credit policy in relation to buyers of production; determination of the possible amount of funds invested in receivables for commercial and consumer loans; forming a system of credit conditions, collection procedures, reduction of accounts receivable; control over the state and the ratio of receivables and payables of the enterprise.

**Types of the company's credit policy**

There are three main types of the company's credit policy in relation to buyers of products:[[7]](#footnote-7)

1. Conservative

Conservative (hard) type of credit policy of the company is aimed at minimizing credit risk. In this case, the enterprise does not seek to obtain a high additional profit by expanding the volume of sales of products.

1. Moderate

The moderate type of the credit policy of the enterprise is guided by the average level of credit risk when selling products with a deferred payment. This type can be attributed to most trading companies that are at the stage of stable development (not a new aggressive company, but not old monopolies).

1. Aggressive

The main goal of the company is to maximize additional income by increasing the value of the sale of goods on credit. However, the high degree of risk inherent in such operations is not sufficiently taken into account. The credit extends to more risky categories of purchasers of products, and the period for repayment of the loan reaches the maximum permissible (if it is possible to extend the period)[[8]](#footnote-8).

In the process of choosing the type of credit policy, the following main factors should be taken into account:

* The general state of the economy, which determines the financial capabilities of buyers, the level of their solvency;
* The current conjuncture of the commodity market, the state of demand for the enterprise's products;
* The potential ability of the enterprise to increase the volume of production with the expansion of the possibilities of its implementation by providing a loan;
* Legal conditions for securing collection of receivables;
* Financial capabilities of the enterprise in terms of diverting funds into current accounts receivable;
* Financial mentality of owners and managers of the enterprise, their attitude to the level of acceptable risk in the process of economic activity.

It is evident that for each company different type of credit policy is suitable. In general, the «ideal» credit policy should provide for the expansion of commodity (commercial) or consumer loans until the additional amount of net profit from the increase in the volume of sales of goods is equal to the amount of losses from diverting funds to accounts receivable, its servicing. This condition can be expressed as follows[[9]](#footnote-9):

Nps> CEar,

Where:

* Nps - additional sum of net profit from the sale of goods in the provision of commodity (commercial) or consumer credit;
* CEar - current expenses connected with service of accounts receivable and loss of the income at a diversion of means of the enterprise from it.

## **1.2 Creditworthiness assessment**

Formation of principles of a credit policy in relation to buyers of production begins with the process of an estimation of credit status (or creditworthiness) of buyers-debtors.

The creditworthiness of the borrower is its complex legal and economic characteristics, represented by financial and non-financial indicators, which allows assessing the possibility in the future and in the period provided for in the loan agreement to settle on debt obligations to the creditor, as well as determining the degree of risk lending to a specific borrower. This definition of creditworthiness takes into account, in addition to the financial, legal characteristics of the borrower (legal capacity, business reputation) and emphasizes the legitimacy and necessity of accounting for non-financial indicators in the analysis.

**Difference between creditworthiness and solvency**

At this moment, it is necessary to stop for a while and take a more precise look at definition of creditworthiness. In literature and mainly in non-professional articles, which can be found on the Internet, many authors make a mistake by mixing two different terms: creditworthiness and solvency. A lot of authors think that these terms are synonyms and have the same meaning, but it is not so. Solvency (of a company or a person) is the ability of the borrower to pay for its obligations for a certain period of time. It is about payments for a specific date or for a previous period. Solvency is evaluated as a solvency coefficient, which is equal to the ratio of available money to the amount of payments for the previous period or for a certain date. If the ratio is greater than or equal to one, then the borrower is solvent. Otherwise, there is a low level of solvency, which results in delinquencies in payments[[10]](#footnote-10).

Credibility (creditworthiness) is the ability of a company (or a person) to fulfill obligations under a loan agreement, timely repaying a loan and accrued interest. Unlike solvency, which assesses the past and current financial condition, creditworthiness assesses the future obligations of the borrower, including the risks of non-return of credit. To assess this important characteristic of the borrower, a much larger number of factors are used, and solvency is only one of them. If we are talking about the enterprise, then there is a quantitative and qualitative analysis of the entire business, the entire scheme of the company's activities. At the same time, the assessment of creditworthiness is built not just on the financial result of the enterprise for a specific reporting period, but also on the projected performance indicators for the whole crediting period. So, as it can be seen, one should not mix term of solvency and term of creditworthiness, as they have different meanings.

**Methods of creditworthiness assessment**

Nowadays there are a lot of different methods of creditworthiness assessment. Vishnyakov I.V. in his paper «Methods and models for assessing the borrower's creditworthiness»[[11]](#footnote-11) suggested dividing methods of creditworthiness assessment into two groups: Classification models and Models based on complex analysis. Both groups include a wide number of models of creditworthiness assessment. Derujinskaya M. P. in her paper «Methodological aspects of assessing the creditworthiness of the enterprise»[[12]](#footnote-12) suggested adding one more method actively used in the practice of Russian companies – Method (Technique) based on the analysis of cash flows. The scheme presented below reflects the separation of the creditworthiness assessment methods into groups. Further in the paper each method will be described in more detail.

*Picture 1. Methods of creditworthiness assessment*

*Source: made by author*

It is necessary to stop at the moment for a while and make it clear what is the difference between two words widely used in the paper: model and method. Generally, there is difference between these two words: model is a kind of a set of components of something, while method is more similar to a process of achieving something. For instance, if we draw an analogy with food, “model” is the recipe of a dish, while “method” is a process of cooking this dish. So, there is a difference between these two words. However, while studying papers and books of different authors on the topic of creditworthiness assessment, I noticed that authors do not pay much attention to the difference between “method” and “model”. In many papers “methods of creditworthiness assessment” and “models of creditworthiness assessment” are treated by authors as synonyms. For that reason, in my paper we will also not pay much attention to the difference between “model” and “method” and will treat these words as synonyms.

### **1.2.1 Classification models**

#### **1.2.1.1 Prognostic**

The first group of models, which will be analyzed is a group of “classification” models. Vishnyakov I.V. suggested dividing this group into two subgroups: Prognostic models and Scoring models. We will begin with prognostic models.

**Multiple Discriminant Analysis**

In the case of multiple discriminant analysis (MDA), discriminant function (Z) is used, taking into account some parameters (regression coefficients) and factors characterizing the financial condition of the borrower (firm). The coefficients of regression are calculated as a result of statistical processing of data on a sample of firms that either went bankrupt or survived for a certain time. If the Z-score of the firm is closer to that of the average firm-bankrupt, then, provided that its deterioration continues, it will go bankrupt. If the company's managers and the bank make efforts to eliminate financial difficulties, then bankruptcy may not happen. Thus, the Z-score is a signal to prevent the bankruptcy of the firm. The application of this model requires an extensive representative sample of firms in different sectors and scale of activities. The difficulty lies in the fact that it is not always possible to find a sufficient number of bankrupt firms within the industry to calculate the coefficient regression.

The most famous model of MDA is the model of Altman[[13]](#footnote-13). Organization is attributed to a certain class of reliability based on the values ​​of the Z-index of the Altman model. Five-factor Altman model is built on the basis of analysis of the state of 66 firms and allows to give a fairly accurate forecast of bankruptcy for 2-3 years in advance. In later works, the scientist studied such factors as capitalized lease obligations, applied data smoothing to eliminate random fluctuations.

The noted approach, developed in 1968 by E. Altman, was used by him himself in the same year as applied to the US economy[[14]](#footnote-14). As a result, the index of creditworthiness appeared:

Z = 1.2K1 + 1.4K2 + 3.3K3 + 0.6K4 + K5,

Where:

* К1 - own working capital / total assets;
* К2 - undistributed profit / amount of assets;
* K3 - profit before interest / sum of assets;
* K4 - market value of equity / borrowed capital;
* K5 - sales volume / total assets.

Interval assessment of Altman: at Z < 1.8 - very high probability of bankruptcy, with Z = 1,81-2,7 - high probability, with Z = 2,71-2,99 - possible probability of bankruptcy, for Z > 3 - very low probability of bankruptcy. Later this model was finalized for the analysis of non-public companies. The following changes were made to the calculation model:

for industrial enterprises:

Z = 0.717K1 + 0.847K2 + 3.107K3 + 0.42K4 + 0.998K5;

for non-manufacturing enterprises:

Z = 6.56K1 + 3.26K2 + 6.72K3 + 1.05K4,

Where:

* К2 - (undistributed profit + reserve capital) / amount of assets;
* K4 - book value of equity / borrowed capital.

At Z < 1.23, Altman diagnoses a high probability of bankruptcy, with Z = 1.23-2.9 - a zone of ignorance, with Z > 2.9 - low threat of bankruptcy.

The construction of MDA models in Russian conditions is quite difficult because of the lack of statistical data on the bankruptcy of organizations, the constant change in the regulatory framework in the field of bankruptcy and the recognition of bankruptcy of the organization on the basis of data that cannot be accounted for. Domestic discriminant models of bankruptcy prediction are represented by the two-factor model MA Fedotova[[15]](#footnote-15) and the five-factor model of RS Sayfulina, GG Kadykov[[16]](#footnote-16). The model of estimating the probability of bankruptcies of Fedotova relies on the current liquidity ratio (X1) and the share of borrowed funds in the balance currency (X2).

The following coefficients are used in Saifulin's and Kadykov's equations: the ratio of own funds (the normative value (X1 ≥ 0.1), the current liquidity ratio (X2 ≥ 2), the turnover rate of the advanced capital, characterizing the volume of sales per 1 ruble of funds, (Х3 ≥ 2.5), profitability of sales, calculated as the ratio of profit from sales to revenue (for each industry is individual), return on equity (Х5 ≥ 0.2). If the financial coefficients are fully consistent with the minimum regulatory levels Z = 1, the financial condition of the borrower with a rating number of less than 1 is characterized as unsatisfactory.

It is important to remember that none of the statistical methods is suitable for practical application without prior "tuning". Discriminant analysis is not an exception and is carried out in two stages. At the first stage, the selection of the most significant (from among the available) characteristics of the potential borrower, the criteria for "bad" and "good" borrowers are determined. The starting point for selection here is the data available to the bank for clients whose credit is closed with a known result of repayment (training sample). In the second stage, according to the training sample data, the classification of potential borrowers for "bad" and "good" is performed.

**System of indicators**

In addition to MDA models for predicting the probability of bankruptcy of a borrower, simplified models based on a system of certain indicators can be used. For example, the Beaver metric system[[17]](#footnote-17) includes: Beaver coefficient (KByver); return on assets; financial leverage; factor of coverage of assets with own working capital; coefficient of coverage of short-term liabilities of current assets. The ratio of Beaver is equal to the ratio of the difference between net profit and depreciation to the amount of long-term and short-term liabilities. The value of KByver ≥ -0.15 indicates a bad financial condition for the year before bankruptcy, as well as the value of the asset coverage ratio of net working capital is less than 0.06, and the coverage ratio of short-term liabilities is less than 1.

**CART**

CART is translated as "classification and regression trees"[[18]](#footnote-18). This is a nonparametric model, the main advantages of which are the possibility of wide application, accessibility for understanding and ease of calculations, although complex statistical methods are used in the construction. In the classification tree, borrowers are located on a particular branch, depending on the values ​​of the selected financial ratios. Then there is a branching of each of them, depending on the following coefficients. The accuracy of the classification when using this model is about 90%.

#### **1.2.1.2 Scoring**

The essence of scoring is to determine the total credit score of the borrower as a result of its assessment on a number of criteria. These criteria have different specific weights and are subsequently aggregated into an integrated indicator - the total credit score. The statistical methods underlying scoring systems are very diverse. In this part of the paper the most frequently used methods will be described in details.

**Linear regression**

Linear regression methods have become an essential component of any data analysis concerned with describing the relationship between a response variable and one or more independent variables. Linear regression used in credit scoring applications as the two class problem can be represented using a dummy variable. Using a Poisson regression model instead could be used to accommodate cases where the customer makes varying degrees of partial repayments. As such the proportionate repayments could be re-expressed as Poisson “counts”. Factors, such as customers’ historical payments, guarantees, default rates in a timely manner, can be analyzed by credit analysts, with linear regression to set up a score for each factor, and then to compare it with the company’s cut-off score. If a new customer’s score passes the company’s score, the credit will be granted[[19]](#footnote-19).

**Probit analysis**

Probit analysis is another conventional technique used in credit scoring applications for many years. Probit analysis is a technique that finds coefficient values, such that this is the probability of a unit value of adichotomous coefficient. Under a probit model, a linear combination of the independent variables is transformed into its cumulative probability value from a normal distribution. Under probit analysis, normal distributions of the “threshold values” are assumed, while multivariate normal distributions and equal variances are assumed under discriminant analysis; and using a likelihood ratio test, estimates of coefficients under a probit function can be tested individually for significance because of their “uniqueness”. But, this is not the case for discriminant coefficients, which cannot be individually tested, whilst this is possible in a regression as well as under a probit function, but the latter is much more difficult than that for a linear, logistic or Poisson regression model. Finally, multicollinearity can cause, under probit analysis, incorrect signs for coefficients, although the probability values from the likelihood ratio tests are not affected.

**Logistic regression**

Logistic regression is one of the most widely used statistical techniques in the field. What distinguishes a logistic regression model from a linear regression model is that the outcome variable in logistic regression is dichotomous (a 0/1 outcome). This difference between logistic and linear regression is reflected both in the choice of a parametric model and in the assumptions. Once this difference is accounted for, the methods employed in an analysis using logistic regression follow the same general principles used in linear regression. The simple logistic regression model can easily be extended to two or more independent variables. Of course, the more variables, the harder it is to get multiple observations at all levels of all variables. Therefore, most logistic regressions with more than one independent variable are done using the maximum likelihood method. On theoretical grounds it might be supposed that logistic regression is a more proper statistical instrument than linear regression, given that the two classes “good” credit and “bad” credit have been described[[20]](#footnote-20).

**Neural networks**

For quite some time the main area of ​​application of neural networks was the military-industrial complex. However, the wide possibilities of resolving banking and financial problems have led to a number of major developers of neural networks engaged in the creation of systems aimed at solving exclusively banking problems. In 1993, the organization "Equifax Europe New Technology Club" was established in Europe to study the possibilities of using the neural net in assessing credit risk. An analysis of existing software products on neural networks showed that some of them allow achieving much better results than when traditional methods of analysis are used.

The algorithm for the operation of artificial neural networks practically copies the essence of biological neural systems. An artificial neuron receives signals through several input channels. Each input signal passes through a junction (synapse) having a certain intensity (weight).

With reference to the analysis of the creditworthiness of the borrower, the training of neural networks is as follows: there is a set of enterprises with already assigned credit ratings. These ratings correspond to the values ​​of quantitative and qualitative indicators contained in the credit dossier. In the course of observations, the neural net calculates the weight of each indicator that is taken into account when calculating the credit rating. The obtained values ​​of the weights are corrected until the credit ratings of the whole initial set of borrowers calculated with the help of these weights coincide with the set values. In this case, the learning error will be reduced to zero, and the neural net will reproduce the exact type of connection between the performance indicators of the borrower and its credit rating.

The use of neural networks as a tool for assessing the creditworthiness of borrowers is also not devoid of shortcomings. First of all, the process of solving problems using neural networks, from data collection to application in practice, is rather laborious. At this stage, the most difficult is to determine the input parameters for neural networks, primarily because of the uncertainty of the connection between the predicted indicator and the available data. In order to avoid errors in the relationships, often the number of input data is redundant, resulting in overloading of networks, which complicates their operation. One solution to the problem is the genetic algorithm for selecting inputs, which is similar to natural selection in nature. The more informative parameters we choose, the more opportunities we can get a reliable result. Then, certain indicators change, and as a result they become more and more informative. The result of learning neural networks is the installation of an existing relationship between variables. Based on these dependencies, the further work of the neural network and its participation in the analysis of the borrower's creditworthiness are built.

The use of neural technologies is a promising direction in order to solve the problem of determining the level of creditworthiness of the borrower. The main advantages of neural networks are their ability to be effectively tuned by the method of back propagation of the error, which ensures high accuracy of the division of borrowers into classes, as well as the ability to combine both the capabilities of the artificial intelligence system and the possibilities of fuzzy-multiple algorithms[[21]](#footnote-21).

**Restrictions related to the use of scoring**

There are two main problems in scoring. The first is that the classification of the sample is made only on customers who have been given credit. It is never known how customers who were refused credit would behave: it is possible that some part would be quite acceptable borrowers.

The second problem is that companies change over time, and so do the economic conditions that influence companies’ performance. Therefore, scoring models need to be developed on a sample of the most “fresh” customers, periodically checking the quality of the system and, when the quality deteriorates, developing a new model.

### **1.2.2 Models based on complex analysis**

**"6C" rule**

"6C rule" method is based on the client's creditworthiness assessment according to 6 main criteria. Further, each of the criteria is described in more detail[[22]](#footnote-22).

1. **Character**

* Customer credit history;
* Experience of other creditors associated with this client;
* Credit rating, availability of persons placing a second signature or guarantors on the requested loan.

1. **Capacity**

* Authenticity of the client and guarantors;
* Copy of the charter, decisions and other documents on the legal status of the borrower;
* Description of the histories of the legal status of the owner; operations, products, main customers and suppliers of the borrower.

1. **Cash (money)**

* Profit, dividends and sales volumes in the past;
* Sufficiency of planned cash ceiling and availability of liquid reserves;
* Terms of repayment of accounts receivable and accounts payable, turnover of inventories;
* Capital Structure;
* Control over costs, coverage indicators;
* Dynamics of stock prices, quality of management;
* Contents of the audit report;
* Recent changes in accounting.

1. **Collateral**

* Ownership of assets, their service life;
* The probability of moral aging of assets;
* Their residual value;
* Degree of specialization in assets;
* Right of arrest, debts and limitation;
* Lease and mortgage obligations;
* Customer's insurance, guarantees, relative positions of the bank as a lender; legal claims and tax situation; possible future financing needs.

1. **Conditions**

* The client's position in the industry and the expected market share;
* Comparison of the client's performance with the performance of other firms in the industry;
* Product competitiveness, customer and industry sensitivity to changing business cycle stages and technology changes;
* Labor market conditions;
* Influence of inflation on the firm's balance sheet and customer cash flow;
* Long-term industry forecasts;
* Legal, political factors, factors related to the environment.

1. **Control**

* Appropriate documentation for controllers;
* Signed documents on debt recognition and properly drawn up documents for obtaining a loan;
* Information from third parties (economists, political experts) regarding the factors affecting the loan repayment process.

**CAMPARI**

The "CAMPARI" method consists of the sequential separation of the most significant factors determining the client's activity from the loan application and the attached financial documents in their assessment and specification after a personal meeting with the client. The name CAMPARI is formed from the initial letters of the following words: C (Character) - reputation, characteristic of the client; A (Ability) - ability to repay the loan; M (Margin) - margin, profitability; P (Purpose) - the purpose of the loan; A (Amount) - the amount of the loan; R (Repayment) - loan repayment terms; I (Insurance) - security, insurance of the risk of non-repayment of a loan[[23]](#footnote-23).

**PARTS**

The idea of this model is that "PARTS" is the key indicator in which the conditions for granting loans to borrowing enterprises are concentrated. The name of the model consists of the initial letters of the following words: P (Purpose) - purpose, purpose of obtaining a loan; A (Amount) - loan amount; R (Repayment) - payment, return (debt and interest); T (Term) - the term of the loan, S (Security) - to ensure repayment of the loan[[24]](#footnote-24).

**Evaluation system of analysis**

As for the last class of complex analysis models, in this case the following methodology can be cited as an example - a methodology developed by the specialists of the Association of Russian Banks (ARB)[[25]](#footnote-25). Within the framework of this model, the analysis of the borrower's activities and the requirements for its lending involves an assessment of its creditworthiness by the following parameters: “solidity” - management responsibility, timeliness of performance of obligations under previously received loans; “Ability” - the production and sale of products, maintaining its competitiveness; “Profitability” - the preferred investment of funds in this borrower; “Reality” of achieving the results of the loan project; “Validity” of the requested loan amount; “Recoverability” due to the sale of material assets of the borrower, if his project is not executed, namely by ensuring the loan project with the necessary size of the collateral; “Security” of the loan by the legal rights of the borrower.

### **1.2.3 Technique based on the analysis of cash flows**

Technique based on the analysis of cash flows is widely used in Russian practice. This method, unlike the approach based on financial ratios, allows to use not the data on balances on assets and liabilities, but the coefficients determined from the data on the turnover of liquid assets, stocks and short-term debt by calculating the net balance of various receipts and expenditures of cash for a certain period.

The difference between the inflow and outflow of funds shows the amount of the total net cash flow. A short-term excess of outflow over the inflow indicates a shortage of cash (a lower client rating). A systematic excess of outflow over inflow of funds characterizes the client as not creditworthy. The existing average size of the total cash flow can be set as the limit for the issuance of new loans, as it shows the amount of funds with which the client can repay debt obligations. Based on the ratio of the amount of the total cash flow and the size of the debt obligations of the client, its credit rating is determined.

### **1.2.4 Assessment of methods**

Having studied existing methods of creditworthiness assessment, now it is necessary to compare them, highlighting advantages and disadvantages of each class of methods.

**Prognostic models**

Prognostic models allow to take into account not only accounting data, reporting, but also additional information (for example, steadily low liquidity ratios, deterioration of relations with banking institutions, insufficient diversification of activity or loss of key contracts, etc.). In general, prognostic models have predominantly high prediction level. For example, CART (one of prognostic models) has the classification accuracy of 90%. What is more, results of prognostic models can be easily interpreted and used.

Concerning drawbacks of prognostic models, it should be firstly mentioned that the methodology of this class of models requires an extensive representative sample, i.e. to determine significant coefficients, there should be information about a fairly large number of enterprises of which about half are bankrupt and half are non-bankrupts. So, the difficulty lies in the fact that it is not always possible to find a sufficient number of bankrupt firms within the industry to calculate the coefficient of regression.

**Scoring**

Advantages of scoring models are: simplicity, the possibility of calculating optimal values for private indicators, the ability to rank organizations by results, an integrated approach to assessing creditworthiness.

Concerning drawbacks of scoring methods, these methods take into account only levels of indicators relative to the optimal values (whether or not it is fulfilled), while the degree of their fulfillment or non-fulfillment is not taken into account. What is more, it is important to justify the threshold values ​​of each of indicator used, but in Russia it is rather difficult to implement such an approach, since there is insufficient information on the actual state and levels of these indicators in the Russian economy. Moreover, it is commonly appearing that the same critical values are applied to all enterprises without specialization while using scoring methods for creditworthiness assessment.

**Models based on complex analysis**

Models based on complex analysis obtain the most reliable data on the financial position of the borrowing organization and qualitative characteristics of that organization. That allows to compare a lot of factors of potential risk of non-payment (or default) of the borrower and gives the high level of predictability.

Among drawbacks of models based on complex analysis is the high laboriousness of conducting evaluation procedures. What is more, wide use of the mathematical apparatus makes these models of creditworthiness assessment often very complicated. Also, very often the subjective opinion of experts prevails, which is not so good, because subjectivism can strongly influence the results of assessment.

Moreover, there is usually a problem with obtaining information when working with small business entities, because such entities give very low level of access to their internal financial and non-financial data.

**Credit assessment based on cash flow analysis**

Reliability of the method based on cash flow analysis is quite high since the cash flow determines the ability of the company to cover its expenses and pay off its debt with its own funds, which reflects the creditworthiness level quite reliable.

Concerning drawbacks of the method, high labor intensity of the method should be named. What is more, very often there is a lack of information on cash flows of the small business entities.

In the table below the main advantages and disadvantages of different classes of creditworthiness assessment methods are summarized for the better understanding and possibility of comparison.

*Table 1. Advantages and disadvantages of creditworthiness assessment methods*

|  |  |  |
| --- | --- | --- |
| **Class of methods** | **Advantages** | **Disadvantages** |
| Prognostic models | * Variety of analyzed company’s data * High predictive power * Simplicity of interpretation and use | * Model’s methodology requires an extensive representative sample |
| Scoring | * Simplicity * Possibility of calculating optimal values for private indicators * Ability to rank organizations by results * Integrated approach | * Degree of reaching optimal level is not taken into consideration * Threshold values ​​of each of indicator used are hard to be justified * Same critical values are applied to all enterprises without specialization |
| Models based on complex analysis | * Wide scope of company’s data is analyzed (quantitative and qualitative) – as a result, predictive power is high | * High laboriousness of conducting evaluation procedures * High complexity * High level of subjectivism * Problems with obtaining information from small business entities |
| Credit assessment based on cash flow analysis | * High reliability of the method | * High labor intensity * Lack of information on cash flows of the small business entities |

*Source: made by author*

To this point in the paper we have already studied various methods of creditworthiness assessment. It is obvious, that among methods presented in the paper there is no better in all characteristics. Each of the methods has its advantages and disadvantages.

Analyzing shortcomings of presented methods, it can be noted that there is one common drawback attributable to all of methods – the problem of insufficient amount of information for creditworthiness analysis. Indeed, many of the methods presented previously in the paper take into account a large amount of information in the aim of creditworthiness analysis. These methods have high predictive power and are very reliable. However, in real life very often there is a problem of insufficiency and unreliability of the information provided by companies. Information on the quantitative and qualitative characteristics of companies is very often deliberately or undemandingly distorted. Moreover, when analyzing small companies, arises the problem of the availability of information.

Thus, the new method of creditworthiness assessment is needed. This new method should be free from the shortcomings of existing methods and have a number of advantages over them. Having the purpose of this paper to develop a new method for assessing the creditworthiness of counterparties, we should pay special attention to the solution of the particular problem - insufficient information for the analysis. Perhaps reducing the amount of input data will reduce the predictive power of the model, but for many companies nowadays, it is the speed and ease of use of the model that is important.

## **Conclusions**

In this chapter we got familiar with a credit policy of a company. Creditworthiness assessment of counterparties is an important part of company’s policy. We got acquainted with various methods and models of creditworthiness assessment, which are used nowadays. Comparison of these methods was done in order to define common disadvantages, weak sides of these methods. Comparison showed that nearly all methods have common drawback - large (very often enormous) amount of inputs needed for creditworthiness analysis. This common drawback creates a request for the development of a new method of creditworthiness assessment, which will be spared from this minus. In the second chapter of the paper we will got acquainted with Merton model for defining probability of default. Further, in chapter 3, this model will serve as a basis for the creation of a new model of creditworthiness assessment. So, in second chapter a reader firstly will be introduced into the theory of options and after that will be met with a specific model – Merton model.

# **Chapter 2. MERTON MODEL FOR PROBABILITY OF DEFAULT**

## **2.1 Options theory**

As it was previously said, the main goal of the paper is to develop a method of creditworthiness assessment. The new method will be based on the Merton model. Reasons for choosing this model will be explained further in the paper, but for the beginning it is necessary to understand in detail what the options are, because they lie in the heart of the Merton model.

Option – is a contract whereby the buyer of the option (potential buyer or potential seller of the underlying asset - the commodity, security) receives the right, but not the obligation, to buy or sell the asset at a predetermined price at a specified time in the future or for a certain period time. In this case, the seller of the option has an obligation to sell the asset accordingly or buy it from the option buyer in accordance with its terms.

**Contract specifications**

Option contracts may be quite complicated; however, at minimum, they usually contain the following specifications[[26]](#footnote-26):

* whether the option holder has the right to buy (a call option) or the right to sell (a put option);
* the quantity and class of the underlying asset(s);
* the strike price, also known as the exercise price, which is the price at which the underlying transaction will occur upon exercise;
* the expiration date, or expiry, which is the last date the option can be exercised;
* the settlement terms, for instance whether the writer must deliver the actual asset on exercise, or may simply tender the equivalent cash amount;
* the terms by which the option is quoted in the market to convert the quoted price into the actual premium – the total amount paid by the holder to the writer.

**Option premium**

The option premium is the amount of money paid by the option buyer to the seller when concluding an options contract. In economic terms, the premium is a payment for the right to conclude a transaction in the future.

Often, saying "option price" implies an option premium. The exchange option premium is a quotation for it. The size of the premium is usually established as a result of equalization of demand and supply in the market between buyers and sellers of options. In addition, there are mathematical models that allow to calculate the premium based on the current value of the underlying asset and its stochastic properties (volatility, profitability, etc.). The premium calculated in this way is called the theoretical price of the option. As a rule, it is calculated by the organizer of the trades or the broker and is available together with the quoted information during the auction.

**Option type**

There are different types of options according to different classifications.

*According to the option rights*

* **Call options** give the holder the right, but not the obligation to buy something at a specific price for a specific time period.
* **Put options** give the holder the right, but not the obligation to sell something at a specific price for a specific time period.

*According to the underlying assets*

* Equity option;
* Bond option;
* Future option;
* Index option;
* Commodity option;
* Currency option.

**Option styles**

Options are classified into a number of styles, the most common of which are[[27]](#footnote-27):

* American option – an option that may be exercised on any trading day on or before expiration.
* European option – an option that may only be exercised on expiry.
* Bermudan option – an option that may be exercised only on specified dates on or before expiration.
* Asian option – an option whose payoff is determined by the average underlying price over some preset time period.
* Barrier option – any option with the general characteristic that the underlying security's price must pass a certain level or "barrier" before it can be exercised.
* Binary option – An all-or-nothing option that pays the full amount if the underlying security meets the defined condition on expiration otherwise it expires.
* Exotic option – any of a broad category of options that may include complex financial structures.

**Most popular option models**

* The Black-Scholes model;
* Binomial model;
* Heston model;
* The Monte Carlo Method;
* The Bjerksund-Stensland model;
* The Cox-Rubinshtein Model;
* Yats model.

## **2.2 The Black-Scholes model**

In the list presented above there are many option models. One of the most commonly used nowadays models is The Black-Scholes model. This model is one of the most important methods and foundations for the existing financial market. The Black-Scholes model will be used further in the paper as the basis for the creation of the new creditworthiness assessment method. Therefore, it is necessary to give a special attention to this model and tell about it in more detail.

The Black-Scholes Option Pricing Model (OPM) is a model that determines the theoretical price of European options, meaning that if the underlying asset is traded on the market, then the price of the option is implicitly already established by the market. This model is widely used in practice and, among other things, can also be used to evaluate all derivatives, including warrants, convertible securities, and even to assess the equity of financially dependent firms.

According to the Black-Scholes model, the key element in determining the value of an option is the expected volatility of the underlying asset. Depending on the fluctuation of the asset, the price for it increases or decreases, which directly affects the value of the option. Thus, if you know the value of an option, you can determine the level of expected market volatility.

To derive their option pricing model, Black and Scholes made the following assumptions:

* Trading in securities (the underlying asset) is conducted continuously, and the behavior of their price is subject to the geometric Brownian motion model with known parameters (in particular, these parameters are constant throughout the life of the option).
* For the basic asset of the option, dividends are not paid during the entire life of the option.
* There are no transaction costs associated with the purchase or sale of shares or options.
* The short-term risk-free interest rate is known and is permanent for the duration of the option.
* Any buyer of a security can receive loans on a short-term risk-free rate to pay for any part of its price.
* Short sale is allowed without restrictions, and at the same time the seller will receive immediately the entire cash amount for the uncovered security at today's price.
* There is no possibility of arbitration.

The derivation of the model is based on the concept of risk-free hedging. Buying shares and simultaneously selling call options for these shares, an investor can design a risk-free position, where the profits on stocks will accurately compensate for losses on options, and vice versa.

The risk-free hedged position should yield a return at a rate equal to the risk-free interest rate, otherwise there would be the possibility of extracting arbitrage profits and investors, trying to get benefits from this opportunity, would bring the option price to the equilibrium level, which is determined by the model.

**Formulas**

Below are the formulas for finding the price of call and put options in Black-Scholes model.

Call option price:

Put option price:

Where:

*C* - call option price;

*S0*- current price of the underlying asset (spot);

*N(x)* - cumulative distribution function of the standard normal distribution;

*K* - the strike price of the option (strike);

*R* - risk-free interest rate;

*T* - time to expiration of the option;

*σ* - volatility of the yield of the underlying asset;

*P* - put option price.

## **2.3 Merton Model**

In 1974, Nobel laureate Robert Merton presented a new approach to modeling and assessing the company's credit risk. In the model, the ideas embedded in the pricing model for the options of Black and Scholes (1973) were formalized and refined.

Model, proposed by Robert Merton is based on the following observation: the value of the firm's liabilities (debt and equity) at a certain point in time depends on the value of the firm's assets at that moment, as well as future forecasts for this value. Thus, debt and equity are conditional claims on the firm's assets.

The Merton model begins with the specification of the company's stochastic process of the company’s value (the economic value of all the firm's assets). The model assumes that this value varies according to the geometric Brownian motion.

Merton's model assumes that the firm has a simple capital structure, that is, equity and one corporate debt issue. Moreover, the debt is presented as a zero-coupon bond with a par value and a maturity date.

In Merton's approach it is assumed that the firm has no covenants, the violation of which can lead to default until the moment; a default can happen only at the time T. In addition, corporate debt holders have an absolute priority: settlements with them at the moment must be completed in full before shareholders receive something. The model also assumes the absence of costs in the liquidation of the firm and the transfer of property in case of default.

Using the above assumptions, Merton in his model makes a key conclusion: the corporate debt issued by the firm is an option to the value of the firm and can be estimated using known theoretical models for the valuation of options.

Let’s denote the value of the company at time T as **Vt**. Debt of the company is denoted as **D**.

On the maturity date, when the nominal of the debt must be repaid, there are two possible outcomes:

1. If the firm has sufficient funds to pay off debt holders (Vt > D), the debt creditors of the company will receive the amount due to them, while the shareholders of the company, respectively, will receive the residual value (Vt – D).
2. If the firm does not have sufficient funds to pay off debt holders (Vt < D), the debt creditors of the company will receive the amount equal to the value of the company (Vt), and shareholders will receive nothing (0).

Value of the equity at time T (the benefit that shareholders will get) can be written in the following form: Max(Vt – D, 0). Shareholders will receive either zero (in case Vt < D), or Vt – D (in case Vt > D).

So, as we can see, from equity holders’ perspective, the value of the equity is similar to European Call Option on the value of the firm with the maturity period T and strike price equal to Debt (D), that has to be paid at time T.

Also, we can look at this situation from debt investors’ perspective. Debt investors will get at time T: Min(Vt, D). Debt investors will receive either Vt (in case Vt < D), or D (in case Vt > D).

The price of call option can be determined using the Black-Scholes formula, since all the conditions and prerequisites of the model are fulfilled:

* Call option is European, with strike and execution date;
* The price of the underlying asset (in this case, the value of assets) follows a geometric Brownian motion with constant volatility;
* The risk-free rate is a constant.

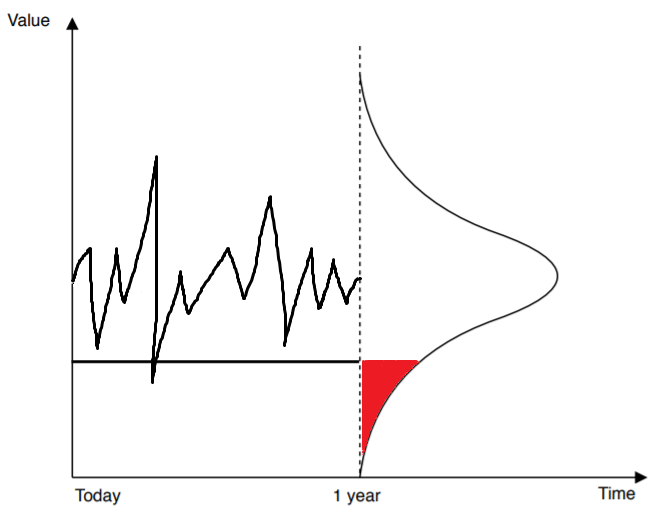
Applying the Black-Scholes formula, the price of the call option is determined by the following formulas:

Where:

* Vt is value of the company at time T
* D is face value of Debt
* r is risk free rate
* Sigma ( is the volatility of company’s assets.
* T is time

It should be recalled here, that the aim of Merton’s model is to estimate the likelihood of a company’s default. Risk neutral probability of default is the same as the chance that value of the company will be less than value of Debt at time T – the company will not be able to pay for its obligations. So risk neutral probability of default is Q(Vt < D), and this is nothing but 1-N(d2) in Black-Scholes formula.

The picture presented below can help to understand concepts and formulas described above.



Default Probability

Liabilities

Assets

Distribution of asset value

*Picture 2. Merton model*

*Source: made by author*

## **Conclusions**

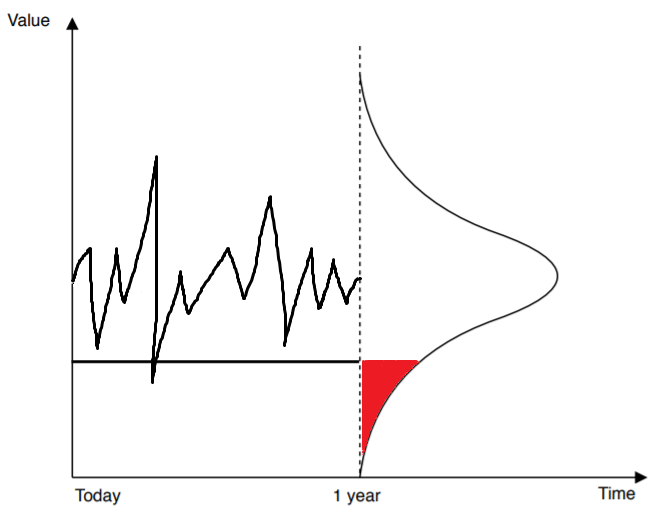
In this part of the paper we got acquainted with options in general, understood main principles and components of options. Different types and styles of options were studied. The Black-Scholes Option Pricing Model was also deeply studied. Merton model for default probability was also analyzed in the chapter as it serves as the basis for the creation of a new method of creditworthiness assessment. In the next chapter the detailed process of the new model creation will be shown. It is evident that it is not enough just to offer a new model of creditworthiness assessment – this new model must be tested on real data to conclude on its applicability and reliability. So, model will be used for defining probability of payment delay using real data provided by real Russian company. Finally, in chapter 3 we will compare new created model with currently existing models and will conclude on whether the model can be used in real life and whether the desired goal of the paper is achieved or not.

# **Chapter 3. NEW METHOD OF CREDITWORTHINESS ASSESSMENT**

## **3.1 New method**

Above we got acquainted with Merton model, aimed at defining the probability of company’s default. One of the main ideas of the model is that value of assets of a company is not a constant number and that it varies from period to period depending on variety of factors. We can look at the company’s operational profit and notice some similarities with the value of assets. Operational profit of a company varies from period to period depending on many factors, and in a sense, reflects how well the company is doing. Now let’s look at a specific line in a company’s financial statement called “Interest to be paid”. “Interest to be paid” reflects the amount of money which a company must pay every period to debt providers (banks) for the ability to use credit. Company is obliged to commit such a payment in any case, and in the case of non-payment, the company may be considered a bankrupt, as it is not able to pay for its obligations. It is evident, that if a company cannot pay for its obligations of paramount importance, it means that the suppliers of that company will also not receive any payments from that company. So, I suppose that Merton model can be used not only for defining the default probability of a company, but also for defining the probability that it will not be able to pay for its obligations to suppliers in time. To use Merton model for defining the probability of payment delay we need to introduce important changes to the model.

Value of the company (Vt) is substituted by operational profit of the company (Pt). Debt (D) is substituted by “Interest to be paid” (I). Operational profit is used here because in “Financial results” statement this profit is the last before the line “Interest to be paid”. So, actually from this profit “Interest to be paid” is paid. The graphical representation of the model with the changes introduced is shown on the picture below.



Distribution of Operational Profit

“Interest to be Paid”

Operational Profit

Probability of payment delay

*Picture 3. New model*

*Source: made by author*

At time T, on the maturity date (in one year, for instance) , when the “Interest to be paid” must be paid, there are two possible outcomes:

1. If the firm has sufficient funds (operational profit) to pay “Interest to be paid” (Pt > I), the credit organization, which gave credit to the company, will receive such a payment in full, and the residual value, the difference (Pt – I) will be used for other needs of the organization - including the payment of vendor bills.
2. If the firm does not have sufficient funds (operational profit) to pay “Interest to be paid” (Pt < I), the credit organization will not receive such a payment in full but will receive at least money that a company has. Credit organization will receive an available amount of operating profit (Pt). At the same time, other interested parties (including suppliers of the firm) will not receive anything (0), since all the money will be spent on repayment of interest on the loan.

At time T, when “Interest to be paid” must be paid, the credit organization, which lend a loan to the company, will receive either amount of money equal to “Interest to be paid”, or an amount of residual operational profit in the company. So, it can be written as: Min(Pt, I).

Other interested parties in the company (including vendors) will receive at time T either zero, or an amount of money left after “Interest to be paid” payment. So, it can be written as: Max(Pt – I, 0).

So, as we can see the situation described above is similar to situation described in Merton model, and we can use the same formulas for calculating price of an option and probability of payment delay.

Price of the call option is determined by the following formulas:

Where:

* Pt is operational profit of the company at time T
* I is “Interest to be paid”
* r is risk free rate
* Sigma ( is the volatility of company’s operational profit.
* T is time

To find the probability of payment delay, we need to define the chance that operational profit of the company will be less than “Interest to be paid” at time T – the company will not be able to pay for its obligations. So, probability of payment delay is Q(Pt < I), and this is nothing but 1-N(d2) in formulas.

One important thing that should be discussed is the difference between non-payment at all and delay in payment. The model, which I propose to use, defines the probability that a company will have payment delay in the coming period. In the next period (next year for example) when the financial situation of a company will change, it may (or may not) pay off its previous obligations, but this is a question of the future. For me it is important to create such a model, that will predict probability of payment delay of a company in coming period and will help its user in deciding whether to give a credit to that company or not. Moreover, results of the model can be used not only for making final decisions whether to grant a credit or not, but also for creating credit groups of counterparties. For instance, companies with very low probability of payment delay (according to my model) will receive greater credit limits and longer deferred payment periods, while companies, having high probability of payment delay will fall into “worst” credit group and will receive the smallest credit limit and the shortest deferred payment period.

Up to now we have a model, which can predict the probability of payment delay. So, the next step is to test the model on the real list of companies and to find out whether the model gives higher probability of payment delay for the companies which actually had delays, or not. So, the task is to test applicability and reliability of the model. We will begin with the description of the data, which will be further used for testing the model.

## **3.2 Data description**

Last summer a was interning in “Gazprom Neft”. One of the everyday tasks of my department was the analysis of possible new counterparties – companies, which want to deal with “Gazprom Neft” and for that reason, should be analyzed for their creditworthiness. My bosses wanted to create a new creditworthiness assessment methodology, which would help them to make decisions on whether to provide a counterparty with a credit limit or not, in what size and for how long. In order to test the developed methodology for creditworthiness assessment, the real data was needed. I was asked to collect information about financial (mainly) and non-financial characteristics of 100 companies-counterparties of “Gazprom Neft”. The aim was to test the created methodology on the real data and conclude whether methodology can or cannot be used further for counterparties’ creditworthiness assessment.

Data was collected using two sources: “Spark” (spark-interfax.ru) and internal database of “Gazprom Neft”. The problem with “Spark” is that it usually receives information on the companies’ financial statements in the end of the year. Information about a lot of companies was obsolete, that is why I mainly collected information using internal deal documents of the company. Before making a deal with “Gazprom Neft” counterparty sends to “Gazprom Neft” its latest financial statements – it is a rule. So, I got access to these documents and used them for the data collection.

After I had decided to offer a new approach to creditworthiness assessment in my thesis, I asked “Gazprom Neft” to provide me with a file that I was creating during the internship. The company agreed and provided me with this file.

Now let’s take a look at data itself. “Gazprom Neft” provided me with excel file, which contains information on 100 companies-counterparties. File includes information about financial characteristics as well as non-financial characteristics of each of 100 companies. There are balance sheets, P&L Statements for each company, as well as financial coefficients and qualitative characteristics. What is more, in this file there is information about payment discipline of counterparties – whether each of the companies has a late payment for the last year (2017) or not. For clarity, the structure of the file is presented on the picture below. Besides the main list with the short description of all 100 companies, in the Excel file there are 100 lists, each of which contains wide information of a company: Balance Sheets, P&L Statement and so on.



*Picture 4. Data provided by the company*

*Source: made by author*

A small note should be made here: in the file, provided by “Gazprom Neft”, there are no real names of companies - names are substituted by numbers. It is done for the purpose of non-disclosure of the business information of “Gazprom Neft”. However, all financial and non-financial characteristics of companies are real, so this anonymity does not interfere in any way with tasks of my paper.

*Type of data*

Now a few words about type of data used in the paper. Data which is used in my paper was provided to me by “Gazprom Neft”. From this side, data is secondary. The truth is, that this data was collected by me when I was interning in the company this summer. For that reason, data is primary. It took me nearly one week to collect data, that is why I cannot say that the process of data collection was very fast– which is the characteristic of secondary type of data. On the other hand, while I was collecting it, I didn’t even know that my paper would be somehow connected to or rely on this data, so, it cannot be said that data was collected special in the aim of my research. It was collected also for counterparties’ analysis, but in the interests of the company, not my interests. Anyway, it was collected by me almost manually, and the process took me long time, so I can characterize data as the primary one.

## **3.3 Forecasting**

In the previous part of the paper, devoted to the new model of creditworthiness assessment, it was described that the two main inputs of the model are: Operational Profit of a company and a line in a Balance Sheet called “Interest to be paid”. In the file provided by “Gazprom Neft” there is information on Operational Profit and “Interest to be paid” for each of 100 counterparties for last 5 years (2012-2016). It should be recalled here that the main idea of this part of paper is to test the new model of creditworthiness assessment on real companies. There is information on payment discipline of each of 100 counterparties of “Gazprom Neft” for the year 2017 – it is mentioned whether a counterparty had delay in payment to “Gazprom Neft” in 2017 or had not. So, the idea is the following and similar for each of 100 companies: I am going to forecast Operational Profit and “Interest to be paid” for the year 2017 for a company, after that insert these numbers in the new creditworthiness assessment model and get the result in the model. Result in the model will be the probability of payment delay for the year 2017 for each of 100 companies. After that I will juxtapose these results with real data (provided by “Gazprom Neft”) about delays in payments. If the model will give higher probabilities of payment delays to companies, which actually had delays in 2017, and will give lower probabilities of payment delays to decent companies, which had not payment delays in 2017, it will mean that the model has a predictive power and can be used for creditworthiness assessment.

At the picture below, it can be seen how data on Operational Profit and “Interest to be paid” for each of 100 counterparties for the last 5 years (2012-2016) looks like. Each line represents counterparty. In the Excel file there are 100 lines, representing information for 100 companies, while here in the text the information given in the shorter form in the aim of the space economy. Having an information for the years from 2012 to 2016 I had to forecast numbers, which would be in the year 2017. For the purpose of forecasting I used the function “FORECAST.LINEAR” in Excel as I seem it the most suitable in the situation of a limited number of observations by year. So, using this function I forecasted Operational Profit and “Interest to be paid” for each of 100 counterparties for the year 2017 and was able to move forward using these numbers in the new model.



*Picture 5. Operational profit and “Interest to be paid” prediction*

*Source: made by author*

## **3.4 Сalculations**

Having forecasted “Operational profit” and “Interest to be paid” I could go over to the calculations in the model. It should be straight said, that calculations for all companies are done using the same algorithm. I will show detailed explanations for one company now, and for other companies I will show only results further in the paper, because the process is similar.

On picture 5, presented above, we can see the list of counterparties. As it was previously said, this is not the full list – the full one is presented in Appendix 1. So, let’s take the company from the line 5 from this list and calculate the probability of payment delay using our new model. The chosen company is highlighted by red color on the picture 5, so that its Operational Profit and “Interest to be paid” for 5 years can be seen, however in table 2 below the same numbers are repeated for the better view.

*Table 2. Operational profit and “Interest to be paid”*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **2012** | **2013** | **2014** | **2015** | **2016** | **2017 Forecast** |
| **Operational Profit** | -54661 | -68184 | -110862 | -15071 | 18012 | 13385 |
| **“Interest to be paid”** | 3387 | 2949 | 2233 | 1975 | 1793 | 1219 |

*Source: made by author*

Operational profit and “Interest to be paid” for the year 2017 are forecasted using the function “FORECAST.LINEAR” in Excel.

Next step is the calculation of implied volatility of Operational Profit. We calculate volatility (sigma) of Operational Profit for years 2012 – 2016 using the following formula:

*(Maximal Operational Profit – Minimal Operational profit) / (2\*(3^0,5))*

Such formula is used to calculate volatility when the sample is not so big. For this particular company, which we analyze, volatility of Operational Profit in absolute terms is equal to 37203. To calculate volatility in percent we divide 37203 by Operational Profit forecast in 2017, which is equal to 13385 (table 2). So, implied volatility in percent is equal to 278%.

Another component, that is used in formula for calculating the probability of payment delay, is risk-free rate. For calculations I supposed that risk free rate is the average monthly yield of the index of 5-10-year government bonds for the period from January 2017 to December 2017[[28]](#footnote-28).

Concerning the time period of planning, it is one year - as I predict the probability of payment delay occurrence in 2017.

So, till the moment, we have all components needed for calculations in the new model: Forecasted Operational Profit and “Interest to be paid” for 2017, Risk-Free rate for the year 2017, Timeframe (1 year) and Sigma for 2017 (implied volatility of Operational Profit).

On the picture below, which is the screenshot from Excel spreadsheet, calculations can be seen.



*Picture 6. Calculation of probability of payment delay*

*Source: made by author*

In the upper block of the table there are numbers, which we have already discussed.

**D1** is calculated using the following formula:

Where:

* S0 is Operational Profit
* I is “Interest to be paid”
* R is Risk-Free rate
* T is Time
* is volatility of Operational Profit

**D2** is calculated using the following formula:

N(d1) and N(d2) are normal distributions of d1 and d2 respectively.

Price of call option is calculated using the following formula:

Probability of payment delay is equal to 1-N(d2).

From calculations we can see that the probability of payment delay for that particular company in the year 2017 is 69,12%. This is quite high probability, which is mainly explained by high volatility of Operational Profit. If we refer back to the table 2, it can be seen that despite the forecasted Operational Profit in 2017 is many times larger than forecasted 2017 “Interest to be paid”, the historical behavior of Operational Profit says not in a favor of the company. Operational Profit was negative in 2012, 2013,2014 and 2015, and only in 2016 became positive. It means that this particular company is quite risky and should be given money to with caution. If we look at information provided by the company, it occurs that this particular company actually had payment delay in the year 2017, which perfectly confirms results of the model.

The fact that the model takes into consideration historical volatility of Operational Profit is quite positive because it reduces the probability that the credit limit will be given to the company with bad historical Operational Profit, but good positive numbers in a moment.

Next step consists in calculation of probabilities of payment delay for all companies from the list. The truth is, that we live not in “ideal” world perfectly suitable for conditions of the model. As it has already became clear, one of two main components of the model is “Interest to be paid”. However, in reality companies may not have borrowed funds from creditors (banks) and are not obliged to pay interest on debt. That means that the forecasted 2017 “Interest to be paid” for such companies equals zero – and this is not applicable for calculations in the model, because we cannot divide by zero. What is more, some companies have negative forecasted Operational Profit for the year 2017. This is also a negative fact for calculations, because we cannot calculate natural logarithm of negative number. Thus, from the initial list of 100 companies 43 were excluded out of calculations because of their negative forecasted Operational Profit or zero “Interest to be Paid”. For remaining 57 companies probability of payment delay was calculated. The same steps and formulas were used as were shown previously for one particular company. If we return back to detailed calculation for one company, it could be mentioned that we actually do not need to calculate price of the call option to know the probability of payment delay. The main component, which is needed for calculation of Probability of payment delay is N(d2).

D2 is calculated using the following formula:

So, we can calculate d2 using this formula or can easily calculate it knowing d1. Detailed calculations are presented in Appendix 1.

## **3.5 Results**

The main result is that the model works and predicts the probability of payment delay. Depending on the Operational Profit and “Interest to be Paid” model gives corresponding probabilities of payment delay to companies. Important feature of the model is that it takes into consideration historical volatility of Operational Profit. Company may have positive big operational profit, and low “Interest to be paid” and the situation may be seemed as perfect. However, the volatility of Operational Profit of this company may be high through years. In such a situation model will not give such a counterparty low evaluation of its probability of payment delay – the probability will be quite high. Another important advantage of the model is, of course, its ease of use and low need for input data. It should be recalled here, that initially the idea was to create an “express” creditworthiness assessment method, which will require small amount of inputs and will be easy in use. Created model meets these conditions and for that reason is preferable to many of currently existing models of creditworthiness assessment.

Concerning results, which I got after calculation of payment delay probabilities for all companies from the dataset, it should be said that the results are quite expectable. In Appendix 1 information can be found on whether a company actually had a payment delay in 2017, and the probability, which the new model gives. In many cases model showed high probability of payment delay and this delay actually occurred. Also, in many cases model showed low probability of payment delay and actually there was no delay in 2017. However, there are also results, which say not in the favor of the model. Sometimes model gave high probability of payment delay to the company, but in reality the payment delay did not occur. This situation can be explained by the following reasons. First of all, the sample of companies, on which the model was tested, is not so big. Even if all predictions of the model were right, it could not be said with absolute confidence that the model has 100 percent predictive power. To make such conclusions, a greater amount of data for verification is needed. What is more, results of the model verification could be better in case quarterly values were used instead of annual ones. Unfortunately, such a data is rare and hardly accessible. It should be recalled, that the main aim was to create the model and test it on the real data to conclude on its viability and predictive power. So, having tested the model it can be concluded that the model created in paper has a right to be used in creditworthiness assessment.

One of the main limitations of the model is, of course, its inability to calculate probability of payment delay for companies, which do not have borrowed debt and do not have interest on this debt. Another limitation is, of course, inability of the model to calculate probability of payment delay in case the forecasted operational profit of a company is negative. However, a mark should be made here. If a company has negative operational profit, almost no one will be considering to give such a company deferred payment. So, in that sense, such companies should be rejected at the initial stage, should be not analyzed using my model and should be dealt with only on a prepayment basis.

The table below summarizes advantages and limitations of the new model.

*Table 3. Advantages and limitations of the new model*

|  |  |
| --- | --- |
| **Advantages** | **Limitations** |
| Small amount of inputs required | Inability to calculate probability of payment delay for companies, which do not have “Interest to be paid” or have negative forecasted operational profit |
| Ease of use |
| Model takes into consideration historical volatility of Operational Profit |

*Source: made by author*

Concerning the ways of the model improvement, it should be first of all mentioned that a more thorough process of the model verification is needed. The sample, which was used in paper was not so large even from the beginning and in addition has decreased in the process of calculations. The problem is that not so many companies have more than 100 counterparties and can provide such an information of their payment discipline for the analysis. Anyway, the greater sample is required in order to test the model more precisely and in order to understand its precise predictive power. What is more, it should be repeated that, data, which is used in a model can also be improved in such a way: it is possible to use not annual values of operational profit and “Interest to be paid” for forecasting of future numbers, but quarterly values. It will increase accuracy of prediction and at the same time more up-to-date information will be used.

What is more, results of the model can be used by companies not only for making final decisions on whether to lend a deferred payment to client or not, but also for creating credit groups of counterparties. For instance, companies with very low probability of payment delay (according to my model) will receive greater credit limits and longer deferred payment periods, while companies, having high probability of payment delay will fall into “worst” credit group and will receive the smallest credit limit and the shortest deferred payment period.

# **Conclusion**

In this final qualification paper the new method of creditworthiness assessment was developed. The relevance of the paper is explained by the fact that nowadays more and more companies carry out their activities with counterparties using deferred payment. Companies are trying to reduce risks associated with insolvency of customers and for that reason an issue of counterparties’ creditworthiness assessment becomes more and more important. Currently existing methods of creditworthiness assessment have a list of disadvantages and this fact creates a request for suggestion of a new alternative method. So, the main goal of the paper is to develop a new way of counterparties’ creditworthiness assessment.

The paper consists of three chapters. In the first part of the paper we discussed a credit policy of a company: what it is, what are different types of credit policy and why in general credit policy is an important part of any company. After that, the concept of creditworthiness was introduced. The creditworthiness of the borrower is its complex legal and economic characteristics, represented by financial and non-financial indicators, which allows assessing the possibility in the future and in the period provided for in the loan agreement to settle on debt obligations to the creditor. There are a lot of methods of creditworthiness assessment created and used nowadays. In the paper the main groups and types were studied and analyzed. This was done not only for the purpose of understanding and meeting with various methods of creditworthiness assessment, but also for the purpose of identification of strengths and weaknesses of these methods. Quite wide range of literature was analyzed in the aim of identification of pros and cons of methods and as a result a table of comparison appeared. After comparison of these methods it became clear that nearly all of methods have a common weak side – the problem of insufficient amount of information for creditworthiness analysis. Indeed, many of the methods take into account a large amount of information in the aim of creditworthiness analysis. These methods have high predictive power and are very reliable. However, very often there is a problem of insufficiency and unreliability of the information provided by companies. Information on the quantitative and qualitative characteristics of companies is very often deliberately or undemandingly distorted. Moreover, when analyzing small companies, arises the problem of the availability of information. So, this common drawback created a request for the development of a new method of creditworthiness assessment, which would be spared from this minus.

In the second chapter of the paper a reader got acquainted with options in general, understood main principles and components of options. Different types and styles of options were studied. The Black-Scholes Option Pricing Model was also deeply studied. Merton model for default probability was also analyzed in the chapter as it serves as the basis for the creation of a new method of creditworthiness assessment.

In the third part of the paper there was suggested an idea that Merton model, initially created for the assessment of default probability, could be used for the assessment of the probability of payment delay. Probability of payment delay is a probability that a company could not pay for obligations to its suppliers on time and that overdue accounts payable would appear. Looking from the suppliers’ perspective, probability of payment delay is the probability of occurrence of overdue account receivable. To use Merton model for defining the probability of payment delay important changes were introduced to the model and these changes were discussed and explained in the paper.

It is evident that it is not enough just to offer a new model of creditworthiness assessment – this new model must be tested on real data to test its applicability and reliability. So, the next step was to test the model on the real list of companies, which was provided by real Russian company, and to find out whether the model gives higher probability of payment delay for the companies which actually had delays, or not. Results of calculations appeared as quite expectable. For many companies model showed high probability of payment delay and this delay actually occurred. Also, in many cases model showed low probability of payment delay and actually there was no delay in 2017. However, there are also results, which say not in the favor of the model. Sometimes model gave high probability of payment delay to the company, but in reality the payment delay did not occur. This situation can be explained by the small sample of tested companies. What is more, results of the model verification could be better in case quarterly values were used instead of annual ones. Unfortunately, such a data is rare and hardly accessible. Anyway, the main result is that the newly created model works and predicts the probability of payment delay. Comparison of the created model with currently existing models of creditworthiness assessment, shows that the new model has indisputable advantage over them – small amount of inputs required. Of course, reduction of the amount of input data can reduce the predictive power of the model, but for many companies nowadays, it is the speed and ease of use of the model that is important. Moreover, comparison of the prediction power of different models should be done on a much wider set of data, than what was used in the paper. Just after comparison of all models on the same dataset it can be concluded, which model of creditworthiness assessment has the highest predictive power. However, it is not a task for the current paper - it is an opportunity for research for future works.

Summing up, it can be stated that managerial importance of the new method, offered in the paper, is of high level due to this method ease of use and low need for input data. Tasks, which were set in the beginning for the achievement of the goal, were fully executed. The main goal of the paper is achieved.

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# **Appendix 1. Probability of payment delay calculation**



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