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ANALYTIC DECISION SUPPORT SYSTEM
FOR SMALL BUSINESS CREDITING

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ИНФОРМАЦИОННО-АНАЛИТИЧЕСКАЯ СИСТЕМА ПОДДЕРЖКИ
ПРИНЯТИЯ РЕШЕНИЙ О КРЕДИТОВАНИИ
СУБЪЕКТОВ МАЛОГО ПРЕДПРИНИМАТЕЛЬСТВА

The article develops the problem of credit process management and credit decisions support for small businesses. The official data on crediting and defaulted debt of small businesses is presented and analyzed. A higher growth rate of defaulted debt for small businesses indicates a lower efficiency of applied methods for credit risk assessment and management. For credit process management it is rational to apply (credit) decision support systems. The article systematized the specifics of small business crediting. The key feature is the high level of uncertainty in making credit decisions due to the frequent changes in the regulatory and legal information, a wide range of interpretation of the results of financial ratios analysis, incomplete information because of special (simplified) tax regimes. Taking into consideration specifics of small business crediting, the article proposes requirements for developing decision support systems and a group of tasks which are advisable to implement as system functions. The article systematizes the key decisions (tasks) to be taken at different stages of thr credit process for small businesses and contains a literature review of models and techniques developed and adapted to support decision-making on small business crediting. The majority of the models and techniques discussed in the study were designed or adapted for the Russian conditions and specifics of small business crediting. A composition of the major functional subsystems of the decision support system currently under development is proposed in the article. One of the distinguishing features of the decision support system is the application of hybrid techniques for adapting to both the expert-oriented credit departments and the departments focused on credit history information processing.

CREDITING; SMALL BUSINESS; CREDIT PROCESS; CREDIT RISK; DECISION SUPPORT SYSTEM.

Исследование развивает проблемы управления кредитным процессом и принятия кредитных решений для субъектов малого предпринимательства. Представлены и проанализированы официальные данные по объемам кредитования и просроченной задолженности субъектов малого предпринимательства. Опережающие темпы роста просроченной задолженности свидетельствуют о недостаточной эффективности применяемых методов оценки и управления кредитным риском. Для управления кредитным процессом целесообразно применять системы поддержки принятия (кредитных) решений. В исследовании систематизированы особенности кредитования субъектов малого предпринимательства. Ключевой особенностью является высокий уровень неопределенности при принятии кредитных решений в силу частых изменений нормативно-правовой информации, широкого спектра толкования результатов коэффициентного анализа финансовой отчетности, неполной информационной обеспеченности ввиду применения специальных (упрощенных) режимов налогообложения. На основе анализа содержательной специфики кредитования субъектов малого предпринимательства предложены требования к разработке систем поддержки принятия решений и комплекс задач, который целесообразно реализовать в качестве функционала. Систематизированы ключевые решения (задачи), которые необходимо принимать на различных этапах кредитного процесса для субъектов малого предпринимательства. Проведен обзор моделей и инструментов, разработанных и адаптируемых для поддержки принятия решений о кредитовании субъектов малого предпринимательства на различных этапах кредитного процесса. Преимущественно рассмотрены инструменты и модели, разработанные или адаптированные для российских субъектов малого или среднего предпринимательства. Предложен состав основных функциональных подсистем системы поддержки принятия решений о кредитовании субъектов малого предпринимательства. Одной из отличительных особенностей системы поддержки принятия решений является использование гибридных методов, позволяющих адаптироваться как экспертно-ориентированным кредитным отделам, так и на отделам, ориентированным на обработку массивов информации об исходах кредитных обращений.

КРЕДИТОВАНИЕ; МАЛОЕ ПРЕДПРИНИМАТЕЛЬСТВО; КРЕДИТНЫЙ ПРОЦЕСС; КРЕДИТНЫЙ РИСК; СИСТЕМА ПОДДЕРЖКИ ПРИНЯТИЯ РЕШЕНИЙ.

Introduction. Small business, which is seen as a way for the development of the national economy, is one of the priorities in the current economic conditions. Against the background of creating an economic environment conducive to the development of small business, crediting
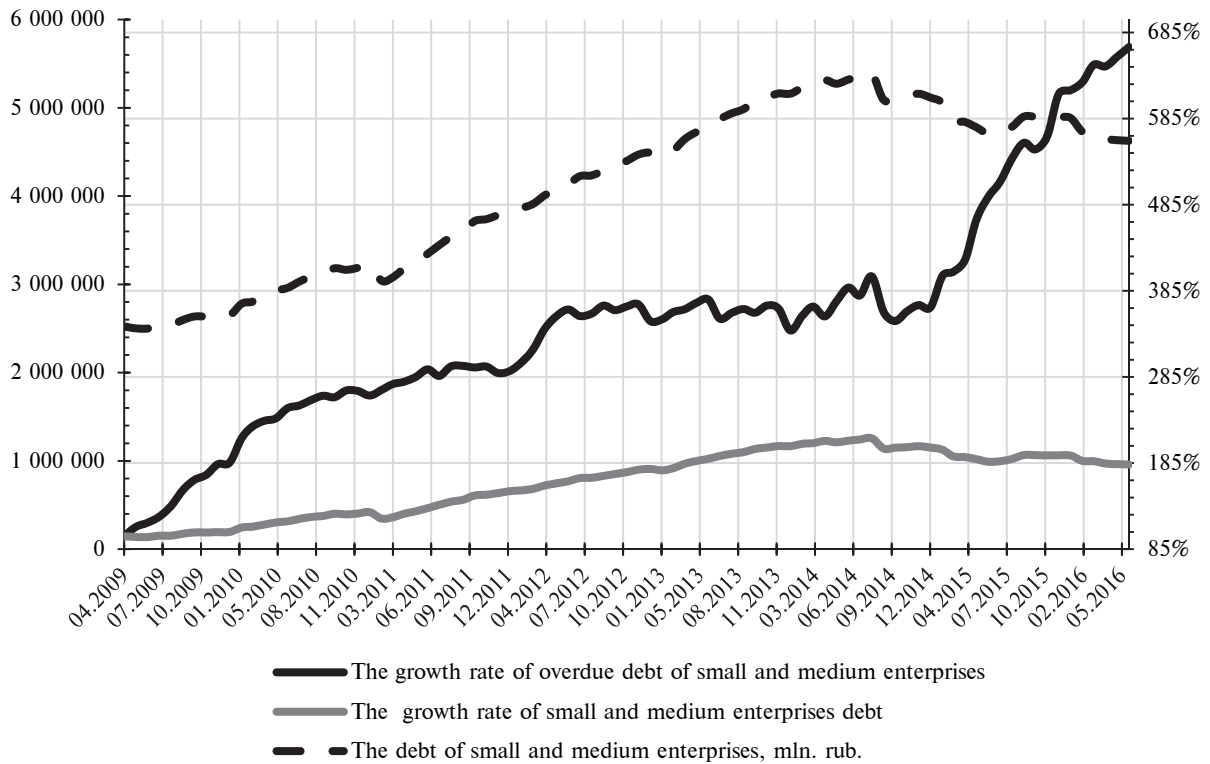
Fig. 1. Data on small and medium enterprises debt
Source: Our calculations were based on data of the National Bank of Russia

remains a constantly relevant issue, as evidenced by the desire of banks to increase credit portfolios and offer a variety of credit products. There is a trend of growing interest in the issues of the validity of the credit and investment decisions for small businesses.

According to the National Bank of Russia[1], the credit portfolio of small business for the first half of 2016 lost about 250 billion rubles (Fig. 1). During this period, negative trends remained in the market of small business crediting: the credit portfolio continued to decline, while the level of defaulted debt has exceeded 15 % of the credit portfolio (Fig. 2).

The deterioration of the situation is most evident in the segment of small and medium-sized banks: the level of defaulted debts in banks not included in the ranking (TOP-30) calculated by total assets value has grown almost by 2 times over the last 12 months and on June 1, 2016 exceeded 16 % of the credit portfolio. On the contrary, after declining for almost the entire year

of 2015, the share of the thirty largest banks in the portfolio of small business credits remained fairly stable for the first half of 2016 and accounts for about 56 % of the portfolio. A higher growth rate of small business defaulted debts shows a lack of efficient applied methods for credit risk assessment and management. Problems arise due to the specifics of small business crediting, so banks need specially designed models and approaches to credit process management.

For the assessment and selection of borrowers, as well as for credit process management, it is rational to apply the (credit) decision support systems, based on different groups of methods, the difference between which lies in the nature of the data, its accuracy and completeness, the method of factor aggregation and comparison of alternatives.

The aim of the study is to propose the architecture and requirements for (credit) decision support system based on the analysis of the distinctive features of small business crediting, as well as to make an overview of the models and tools developed and adapted to support the decision-making process on crediting at different stages of the credit process.

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[1] Information about the outside and placed funds. URL: http://www.cbr.ru/statistics/?PrtId=sors (accused August 10, 2016).
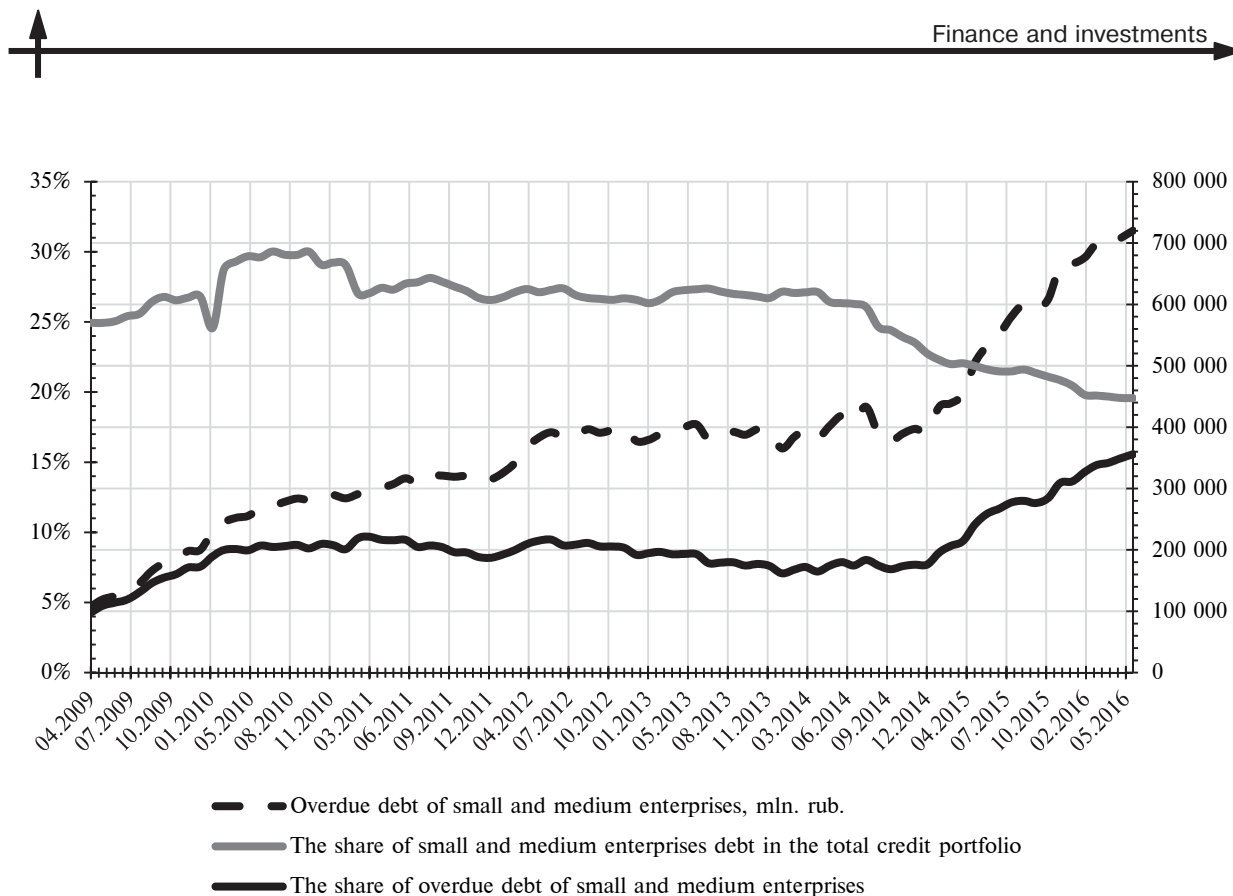
Fig. 2. Data on small and medium enterprises defaulted debt
S o u r c e : Our calculations were based on data of the National Bank of Russia

Methods and results. The simple credit rating procedure, which is regarded as the main stage of the credit process, is not enough for an effective credit policy of banks. Banks should use the complete credit process management system from credit product development to credit monitoring. The credit process is complex and multifaceted and involves a number of stages, each of which is designed to provide an effective credit decision. Each of the stages of the credit process should be viewed as a set of interrelated problems requiring tools (models) for the decision support.

Close integration of the banking information system with statistical software greatly expanded the possibilities to apply the credit-scoring models in practice and successfully use labor-intensive methods for constructing complex mathematical models to classify and monitor the borrowers at different stages of the credit process. For example, study [14] systematized the key groups of methods mentioned in the scientific literature for assessing the credit applications of different categories of borrowers, determining the credit conditions, monitoring the credit liabilities, decision-making at different stages of the credit process, such as statistical methods, neural networks, expert methods, logic and probabilistic methods, methods based on multiset theory, optimization methods, hybrid methods, fuzzy-set descriptions, ensemble modeling.

A decision support system for small business crediting should be developed taking into account the peculiarities of small business in terms of credit risk management. The scientific and practical literature has developed a strong opinion about the specificity of small business crediting in terms of credit application, information and analytical support, a high level of uncertainty associated with many changes in the regulatory and legal information, a desire for tax optimization, a wide range of interpretation of the results of financial ratios analysis, incomplete internal information base for credit risk assessment due to special (simplified) tax systems and other factors.

Chernov and Illarionov identified the following features of small business in Ref. [24]: 'the specificity of historical development of small business in Russia; the versatility of small enterprises; insufficient qualification of personnel which affects a company's performance; deformalization of the economic environment of

small business; high transaction costs associated with credit risk assessment and credit monitoring; lack of adequate security'.

Levchenko [13] described a feature of microenterprises which is that the owners do not share the costs of personal goals and the expenses for maintenance and business development, which is why different approaches to forming the information base for credit risk assessment need to be considered. Information on consumer credits of business owners is essential to assess the credit risk of microenterprises.

Zabolotskaya highlightedthe following issues in [9]: 'the information contained in the financial statements and provided on a certain date may not fully reflect trends in economic activity; financial information requires detailed examination on the reliability due to the generally insufficient level of qualification of entrepreneurs; frequent changes in the regulatory framework reduce the comparability of data for different periods. A high level of uncertainty also creates a low degree of formalization of economic activity that is often associated with the absence of a professional accountant and automation of accounting in companies, which leads to unintentional distortion of accounting and financial reporting'.

Biryukov also noted in Ref. [1] the high level of uncertainty and did not rule out the possibility of complete distortion of the true economic and financial situation of the company in all financial documentation. 'Most small businesses have a limited internal information base because of the application of the simplified taxation system or the unified tax on imputed income. This fact justifies the necessity to use both the official statements (declarations) and managerial reporting'.

Lukashevich claims in [14] that corporate crediting is accompanied by a significant document flow at all stages of the credit process due to the desire of banks to obtain as much information as possible for decision-making. The collected information is measured in different scales (qualitative and quantitative), contains a set of frequently contradictory parameters. A large number of input data has no clear boundaries, emerges from different internal and external sources and complicates the problem of credit risks assessment. The data obtained on the basis of experience, intuition and knowledge of credit analysts who can take into account important individual characteristics of borrowers play an important role for successful credit decisions. From this perspective, the problem of formalizing the acquired knowledge, their replication between other credit managers becomes more and more important. Based on the analysis of the scientific and practical literature concerning credit-scoring models, Lukashevich repeatedly stresses in [14, 15] that applying statistical models to corporate crediting is problematic. This limitation, on the one hand, is due to the stringent requirements for a sample, which determine the possibility of applying statistical methods and the availability of adequate models; on the other hand, different corporate forms, tax regimes, industrial specificity, a significant number of credit products for small businesses and other factors do not allow credit analysts to form a sample that meets all these requirements and is suitable for modeling.

Chernov and Illarionov [24] take the same position with respect to the limited application of statistical methods in credit risk assessment, arguing that the important factor is that the credit analysis process should be based on forming expert judgement. In this regard, applying fuzzy-set descriptions and fuzzy models allows working correctly with the originally qualitative or fuzzy evaluation data.

Exploring the problems of credit risk assessment of small businesses, Kemaeva et al. [10] and Krakovich [12] revealed that each industrial sector of small business is characterized by its balance sheet structure, the main items of expenses and income, normative or recommended values of financial ratios. Small business is characterized by using the simplest approaches to accounting, therefore, analyzing only the official accounting records does not allow obtaining reliable estimates of the financial standing of the borrower.

A considerable number of foreign methods for credit risk assessment are being actively integrated into Russian information andanalytical banking systems; to successfully implement these methods, it is necessary to take into account the peculiarities of the taxation system, the accounting system compared to international standards, the incompleteness and uncertainty of the significant part of the financial information

Thus, Lukashevich et al. presented in [15] the results on applicability of the traditional credit-scoring models including those developed based on foreign data and approaches, which provided a sufficient data variation proving the necessity of taking into account the Russian economic particularities.

Demeshev and Tikhonov [6] compared approaches to modelling the critical financial situation of medium-sized and small Russian private companies in different industries by using financial and non-financial indicators. In general, nonlinear algorithms yielded the best results. An important conclusion is the strong influence of some non-financial indicators such as the industrial sector, the federal district and the age of the enterprise upon the financial conditions. Profitability, leverage and liquidity were found to be the most significat financial ratios.

Bolshakova et al. discussed in [2] the problem of using traditional models based on ratio analysis for estimating the probability of default for Russian small and medium-sized enterprises. The authors concluded that using a single model for monitoring bankruptcy at different time horizons was not justified. For a year or two before the potential default, the key factors for a company to be declared bankrupt are the return on assets, the structure of current assets, the retained earnings as the main source of own funds and the ratio between revenue and variable costs.

The weak predictive ability of the traditional models based on financial ratios analysis to assess credit risks of small businesses remains a key focus for researchers. The main problem in this aspect is connected with selecting financial ratios, the second problem relates to the lack of recommended (normative) values of financial ratios for different industries, which complicates making the credit decision as credit analysts are unable to estimate the extent to which the calculated ratios are acceptable. This confirms the high level of uncertainty in making credit decisions. For example, the authors of [23] proposed a method for applying cluster analysis to identify the normative (recommended) values of financial ratios for companies with different levels of probability of default and offered a method for determining the values of financial ratios recommended or adequate to the current financial condition.

Having systematized the features of small business crediting, it is necessary to formulate the key requirements for the decision support system and suggest a set of typical tasks, solving which will ensure system functionality.

Firstly, taking into account the review of the literature, it is possible to assess the well-established traditional set of quantitative and qualitative factors of small business creditworthiness including financial indicators [1, 6, 10, 11, 16, 24−31]; credit history; experts estimation; factors reflecting the specificity of the region and efficiency of management in company and other factors which allow a wide range of interpretations of the influence on credit risk and do not have clear boundaries. Industrial particularities can be indirectly taken into account through the evaluation of financial ratios, the recommended (normative) values of which are totally different for each industry. In such circumstances, it is necessary to introduce approaches which could take into account the possibility of operating with multi-type quantitative and qualitative data, measured in different scales into the decision support system; formalization of knowledge and expert estimation. Many authors note that neuromathematics methods, fractal techniques and fuzzy logic methods [14, 24] are effective modern tools under highly volatile parameters of the external economic environment . Partial implementation of these aspects may be done as a transition to a common scale of measurement with the same meaning of parameters and application of some techniques based on expert opinions formalization, for example, by using fuzzy-set models, successfully investigated in studies [4, 9, 14, 22, 24, 25].

Secondly, the model laid down in the decision support system should identify the objective and significant patterns between different credit risk factors and minimize the impact of the subjective views of credit analysts for making decisions. As for applying fuzzy-set descriptions, the main drawback of this approach is the subjectivity in the construction of membership functions of fuzzy classifiers. This subjectivity can be partially eliminated by using the obtained credit history. An ensemble of models developed using different expert or statistical approaches can be used for this purpose. The results of the models are aggregated or 'averaged'. Using such a hybrid approach allows adapting decision support system for both expert-oriented credit departments, for example,

when introducing new credit products, and credit departments oriented to processing large volumes of statistic information.

Thirdly, the decision support system should be adaptive, that is, it should be possible to make adjustments to the model, for example, modify the parameters of factors or models, select the approaches to the decision-making process based on different types of input data. The system should not require the involvement of qualified experts for adapting to the new data structure.

Fourthly, the decision support system must allow to interpret the obtained decisions. The high level of ability to explain the credit decision leads to easy interpretation of the results and their visibility.

Fifthly, the decision support system should include only relevant factors (the factors should

not be too many and at the same time enough to make proper decisions) and provide the minimum of additional qualification requirements for credit managers and availability of specially developed information and analytical software.

Table systematized the key decisions (tasks) to be made at different stages of the credit process for small businesses and proposed different tools and decision support models described in the scientific literature. Tools and models designed or adapted for Russian small and medium-sized businesses are mostly considered.

Fig. 3 shows the configuration of the major functional subsystems and information flows in the decision support system for small business crediting.

Overview of decision support tools for small businesses at different stages of the credit process

Stage of credit process	Key decisions	Proposed models	Distinctive features
Borrower qualification	1. Assessment of conformity of the borrowers to credit policy 2. The assessment of priority for consideration of the credit application 3. Identification of the information base for risk assessment depending on the category of borrower and purpose of crediting 4. Preliminary risk assessment (pre-scoring) including stop indicators 5. Determination of the method for further risk assessment. 6. Assessment of credit portfolio return 7. Determination of the rational credit portfolio structure	Fuzzy-set model for rapid assessments based on Bellman-Zade principle and the analytic hierarchy process (Lukashevich, [14])	Reduction of the solution of multicriteria tasks to assessment of a complex metric that reflects the confidence in the expert judgements; the ability to take into account the collective opinion of experts and their importance in the assessment; obtaining an estimate of borrower priority.
		Fuzzy model for decision support in crediting (Fironov, [22])	Borrowers are divided into four groups of priority. As the parameters for ranking the following qualitative and quantitative indicators are used: commission; average monthly accounts balances; interest income; borrower loyalty to the bank.
Assessment of credit risk and credit conditions	1. Assessment of credit risk and probability of default. 2. Assessment of credit history 3. Assessment of collateral 4. Assessment of credit conditions 5. Assessment of investment attractiveness of the projects	IRB-oriented discriminant model for estimating the probability of default of small businesses (Efimova, [8])	The model uses traditional financial ratios and generates a probability of default and credit conditions. The model meets the requirements of Basel Capital Accord
		Fuzzy-set risk modeling system for investment and construction projects (Glushchenko and Dolzhenko, [4])	Fuzzy-set model contains 19 input linguistic variables, describing risk factors, and 14 output linguistic variables that characterize the risks of investment and construction projects. The model contains 14 data bases with rules and allows conducting linguistic (qualitative) analysis of the investment project risks.

Stage of credit process	Key decisions	Proposed models	Distinctive features
		Fuzzy production system (fuzzy inference system) of quantitative and qualitative risk assessment and credit conditions definition (Zabolotskaya andAristarkhov, [9])	Fuzzy production system for modeling credit rating of small business based on fuzzy data bases with 22 qualitative and quantitative indicators. The system allows to replace a set of financial indicators depending on the preferences of the credit expert, the specifics of the company or provided financial documentation. There is no dependence on the sectoral and regional origin. The system suggests the information-analytical database and expert guide (credit analyst) for fuzzification of the proposed indicators. The following groups of indicators are proposed: 1) industry-specific indicators; 2) region-specific indicators; 3) indicators of financial performance.
		Model of enterprises clustering based on neural networks (Biryukov, [1])	The model is considered as a tool to support decision-making on credit risk control. In the proposed concept the factors are linked to a specific sector of the economy and determined by using expert methods with 'additional experts training'. It covers the following groups of indicators: production process indicator; indicator of the financial condition; organizational indicator; the external economic environment indicator.
		Methods of assessing the creditworthiness of small enterprises based on a fuzzy-set mathematical model (Illarionov and Chernov, [24])	The method applies the following indicators: 1) the financial condition: indicators of solvency and liquidity; financial stability; business activity; profitability; 2) qualitative indicators: indicators of regional specificities; qualitative features of the borrowers; 3) industry-specific indicators: perspectives of industry development.
		Model of credit limit calculation, which determines the received individual credit risk of a particular credit application (Levchenko, [13])	Limit calculation is based on the financial and managerial reporting and takes into account the structure of the balance sheet and income statement.
		Methodology of credit rating assessment for small and medium-sized enterprises using fuzzy production system (Karamzin et al., [25])	The financial coefficients are calculated on the basis of the balance sheet and income statement presented in Excel format. The results are processed by fuzzy system by the following 10 fuzzy inference systems: liquidity, financial stability, business activity and profitability; forecasting the overall financial condition; modelling industrial indicators, regional specifics and qualitative characteristics and so on.

The rest of the table

Stage of credit process	Key decisions	Proposed models	Distinctive features
		Guidelines on the assessment of the creditworthiness of small businesses for different industries (Krakovich, [12])	The significance of various sectors for the credit portfolio is determined using statistical methods. The methods of comparative analysis are used to highlight industrial factors influencing on assessment of the creditworthiness of small businesses.
		Methods of aggregation of partial indicators for assessing the creditworthiness of small businesses in the service sector (Demina, [7])	The technique reveals the basic problem of selecting the key factors. The flexible model takes into account the feature of crediting in the service sector.
		Decision support systems for assessing the financial conditions of small and medium-sized enterprises [19]	The basis of the system is the integration of probabilistic and statistical methods of classification analysis (discriminant analysis, logistic regression, classification trees), neural networks in an interactive system using cloud technologies. The system solves the problem of small amount of data, quality of sample and unique samples.
		Mathematical model for credit parameters estimation taking into account the financial condition of small and medium-sized enterprises. (Pylypenko and Hafayan, [16, 17])	According to this technique, the software module has been developed that allows the user to quickly calculate the credit rating and credit conditions based on the individual financial status.
		Method of creating a virtual customer database, which is based on the revealed patterns in financial indicators (Shevchenko andHafayan, [26])	The method gives the linguistic interpretation of the levels of financial performance. There are five clusters of enterprises with different levels of creditworthiness. Database of enterprises can serve as a training sample for classification analysis methods for determining the risk level of real-life business.
		Set of models based on information and statistical approach for estimating the parameters of investment projects (Garanin and Lukashevich, [3])	A discrete-continuous model of investment project life cycle allows experts to obtain not only the probability of transition from one phase of the project to another, but also to determine the duration of the definite investment project stage. The distinctive features of the information and statistical approach to modeling the cash flow is that the possibility of estimating the probability of occurrence of the cash flow is not less than a defined planned value.
		Model of credit rating estimation for innovative companies (Angilella and Mazzщ, [27])	The model focuses on small innovative enterprises. To identify the risk, the following groups of indicators are proposed: technologic risk, market risk, financial position, innovation potential.
		Discriminant model (Z-score) for assessment of default probability (Lazovskaya, [30])	The approach proposes two models: on the basis of only traditional financial ratios and with the addition of non-financial variables (age and size of the company). The accuracy of the classification with a combination of financial and non-financial variables in the control sample amounts to 79%.

| Stage of credit process	Key decisions	Proposed models	Distinctive features
Credit monitoring and debt collection	1. Assessment of changes in credit risk 2. Management of credit portfolio 3. Assessment of credit portfolio quality 4. Selection of debt collection strategy 5. Evaluation of prognostic accuracy of credit-scoring models 6. Key performance indicators calculation for assessment of credit department effectiveness	Models developed for the stage of credit risk and credit conditions assessment can be used for on-going monitoring of credit risk. In this case, the models can be used repeatedly to monitor changes in the credit rating value.
		Guideline for credit monitoring (Ushanov, [21])	Guideline proposes a scheme of credit monitoring process that minimizes the risk of credit default
		Mathematical model for credit portfolio management (Timofeeva and Timofeev, [20])	Forecasting of credit risk and credit portfolio profitability are based on mathematical models of dynamics of credit portfolio structure by using a discrete-time Markov chain. The mathematical formalization of business processes such as organization of credit application approval, debt collection procedure and so on is presented.
		Model for selection of overdue debt collection strategies (Pika, [18])	The technique allows credit analysts to take against the debtor a reasonable decision based on five indicators: the sum of overdue debt; forecasted payments; planned costs for collection; workforce limitation.
		Model of credit portfolio structure optimization (Dem and Parominskaya, [5])	The developed model allows estimating the cumulative risk and credit portfolio return, as well as making credit decision in terms of its effect on the total risk and credit portfolio return. The model also provides the optimal credit portfolio structure.
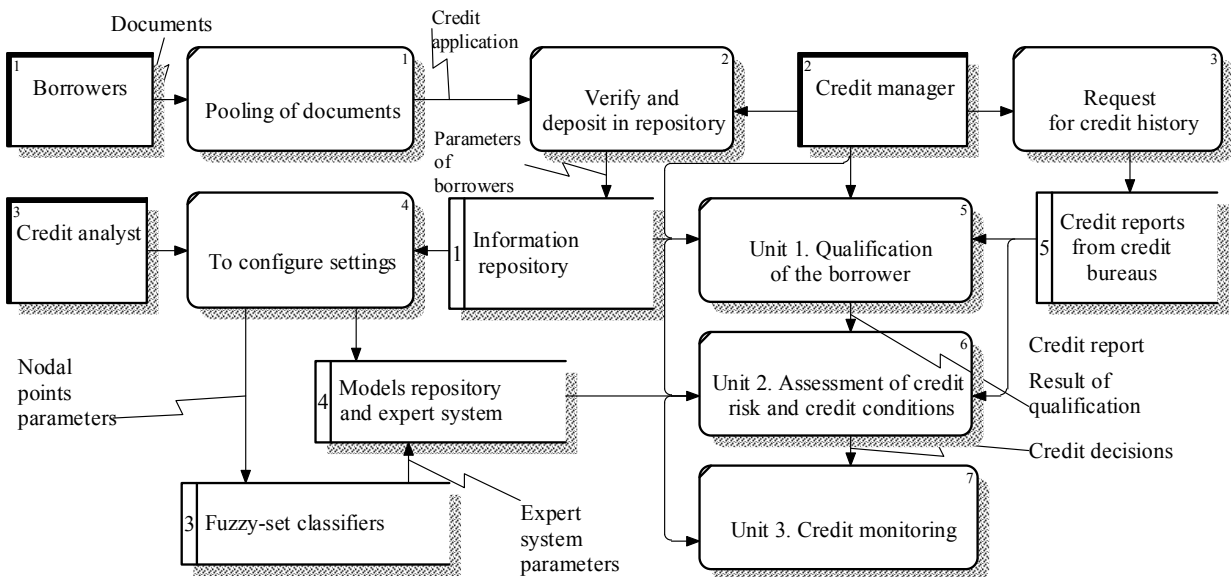
Fig. 3. Functional subsystems and information flows in the credit decision support system
Source: developed by the authors using DFD notation

Conclusions. The study analyzed the specifics of small business crediting. Based on this analysis, the article proposed the requirements for developing a decision support system for making credit decisions, a set of tasks which are advisable to implement as functionality, and a composition of the major functional subsystems defining the structure of decision support system. The distinctive features of the proposed decision support system are as follows: 1) the ability to take into account the specifics of small business crediting including the high level of uncertainty, the use of data in different types of scales for decision-making; 2) support for credit decisions for different types of credit products and categories of borrowers who use different forms of accounting and taxation regimes; 3) the ability to take into account industrial specifics of the borrowers to adjust the model parameters; 4) the ability to customize the parameters of the models with the accumulation of information about the outcome of credit applications and standard (recommended) values of the financial ratios.

For further research it is advisable to develop a standard business process of small business crediting for the proposed credit decision support system and a decision-making algorithm at different stages of the credit process.

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