FUZZY FINANCIAL ANALYSIS MODELS

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Abstract: The business development in the context of information competition requires appropriate improvement of the company management. The globalization of markets and the liberalization of economic links strengthen the non-conservatism of financial success factors. The problem of information incompleteness in the financial analysis is being identified. Uncertainty represents a typical characteristic of modern economics. It is the result of the great rapidity of changes in the environment. It means lack, incompleteness, failure and asymmetry of economic information. Uncertainty is also an inability to measure with absolute precision. The variety of forms of indeterminacy can be summarized in two large groups – stochastic and linguistic. The stochastic uncertainty indicates the probability of realization of an economic phenomenon and is processed by the probabilistic-statistical approach. Linguistic uncertainty describes the power of realization of the economic phenomenon and is examined through transition from accuracy to controlled approximation. To integrate linguistic uncertainty among the objects of financial analysis, the fuzzy set of tools and the fuzzy logic associated with them are used. This is a concept of analysis in conditions of incomplete information, subjectivity and qualitative description of economic phenomena. In its development, three periods can be distinguished. During the first period (1965 – 1973), the concept of the Fuzzy Set was introduced and set forth the foundations of mathematical theory of the same name; a set of operations over fuzzy numbers (so-called soft calculations) is being developed. The second period (1973 – early 1990s) was characterized by the launch of fuzzy database management systems; there are numerous practical applications for corporate strategic management, forecasting of securities market, etc. During the third period (the beginning of the 1990s – nowadays), the use of fuzzy sets and fuzzy logic in the economy is being strongly developed; software products based on fuzzy sets and fuzzy mathematics are being created – FuziCalc, CubiCalc, Matlab. Modern fuzzy sets and fuzzy logic in financial management are fuzzy models (also called soft computing models or expert systems). These are applications of intelligent technologies in the methodology of financial analysis. They allow the processing of financial information in the context of a specific management policy, risk appetite, market situation, taxation. Blurred financial analysis models operate on a standard, three-stage algorithm. First step: Dissolving the input – transforming the input (financial, accounting and other accurately valued) information into fuzzy estimates. Second Stage: Calculating the rules – building a model of reasoning for the subject of the analysis, defining the connections between the inputs and outputs of the fuzzy model. Third Stage: De-dilution of the result – converting fuzzy grades obtained after the second stage into accurate values. Fuzzy financial analysis models are built and run in Matlab environment, using Fuzzy Toolbox and Simulink simulation tools. As a result of the use of fuzzy models, the flexibility, speed and effectiveness of financial analysis are increased.
Keywords: Fuzzy sets, Fuzzy logic, Expert systems, Business, Management

1. INTRODUCTION

The development of the economy in conditions of information competition requires adequate improvement of the financial management. Foremost is the expansion of the system in the study of accounting information. A need occurs for a complex study of the content of financial statements, an interrelated assessment of financial indicators and extra-accounting facts, appropriate reproduction of expert thinking. The problem with uncertainty of financial analysis occurs.

This report aims to present fuzzy financial analysis models as a methodological framework for processing information in conditions of uncertainty. With this regard, the nature of uncertainty and both its expressions – linguistic and stochastic – is clarified. The chronology of the concept of the fuzzy set approach is being developed. The process of building expert financial analysis systems is characterized.

2. UNCERTAINTY IN FINANCIAL ANALYSIS

In the specialized literature there is no commonly accepted definition of the Uncertainty concept. According to the authors [1, 3, 5, 6] this is "absence, incompleteness, insufficiency and asymmetry of information about the object, the process, the phenomenon". Uncertainty reflects the limitations in collecting and processing information. The consequence is the high speed and ambiguity with which the information change is realized. Other authors [3, 4, 8] explain uncertainty as impossibility and measurement with absolute precision. In the financial analysis, it is

manifested in four directions: information uncertainty (incompleteness of data), objectives and tasks (ambiguity, non-quantifiable definition), selection criteria (uncertainty of the criteria) and process of analytical judgement (individuality, subjectivity). The variety of forms of uncertainty may be classified into two groups – stochastic and linguistic.

Stochastic uncertainty. It characterizes the probability of realization (appearance) of an economic phenomenon. It shows the relative frequency at which an event is executed when a predefined factor occurs. It is formalized using the probabilistic-statistical approach – a combination of the theory of probabilities and the methods of mathematical statistics. Parameters of stochastic unspecified phenomena are presented as probability distributions. Objective and subjective probability are distinguished.

The objective probability shows the frequency of occurrence (appearance) of a phenomenon, evaluating the mathematical expectation and the dispersion. It embodies the understanding that probability may be measured by frequency or statistical interpretation. To that end, there must be long enough empirical tests. In conditions of limited experimentation, the credibility of the results obtained is questionable. Expert opinions are used for overcoming this shortcoming.

Subjective probability measures the frequency of occurrence of a phenomenon by interpreting expert judgements. However, the probability is considered to be a credible measure of uncertainty. When evaluating the likelihood based on logical considerations, a logical interpretation of the uncertainty is established, based on logical considerations.

Stochastic uncertainty is a function of the random nature of economic phenomena. It is objective in nature and implies sufficient information to qualify uncertainty factors as occasional. Stochastic uncertainty may change over time.

Linguistic uncertainty. It characterizes the power of realization (appearance) of an economic phenomenon. It embodies individual perception of information, inaccuracy of the language of communication, and subjectivity in expert thinking. Linguistic uncertainty is inherent in the so-called humanistic systems – systems where human is involved, and is characterized by a subjective nature.

In the financial analysis, linguistic uncertainty is manifested in an unlikely but also indefinite follow-up of the outcome of preconditions. It remains outside the subject of classical analytical methodology and requires a transition from precision to a controlled approximation of analytical means. Opportunities to realize this perspective offer fuzzy sets and fuzzy logic.

3. FUZZY SET APPROACH IN FINANCIAL ANALYSIS
The fuzzy set approach integrates linguistic uncertainty in the methodology of financial analysis crisis. This is a concept of analysis in conditions of incomplete information, subjectivity and qualitative description of economic phenomena. It proposes new business solutions in the context of the current economic crisis [7, 8]. In the evolution of the fuzzy set approach, three periods may be conventionally differentiated.

First period: 1965 – 1973 The concept of the Fuzzy Set is introduced in mathematics in the 1960s by Lotfi Asker Zadeh, who in a series of studies sets out the foundations of the complex theory of the same name [12]. The concept synthesizes key concepts of the theory of ordinary sets and non-classical (triple) logic. It proposes a tool for describing and presenting objects which affiliation "is not amenable to objective assessment or assessment of the type {yes, no}, but allows a subjective interpretation of a more general nature" [2, p. 21]. At this stage the nature of the so-called fuzzy figures is clarified. A set of operations over fuzzy figures – algebraic operations over normal values when setting a change interval – is being developed. Subsequently, this information processing becomes known as the Soft Calculations. The concept of the fuzzy set theory is formed and possibilities for its practical use are sought.

Second period: 1973 – Beginning of the 90s. The beginning of this period is considered the publication of the report devoted to the theory of fuzzy sets of L. Zadeh in 1973 [11]. In 1975 the work "Application of Fuzzy Numbers in System Analysis" by K. Negoita and D. Ralescu [10] was published. The development of intellectual management systems has begun. The scientific interest in fuzzy logic – practically devoid of theoretical foundations, but capable of offering solutions in a state of uncertainty, is affirmed. As a result of a study of the relationship between it and the theory of neural networks, the basic FAT (Fuzzy Approximation Theorem) by Bart Kosko is proved. The start of creating fuzzy database management systems has been launched that are capable of handling inaccurate data, finding answers to unclear posed questions, using qualitative indicators along with quantitative data. Fuzzy algebra is being developed. The so-called fuzzy cognitive systems ("Fuzzy Cognitive Maps"), which allow

for dynamic modelling in finance, politics and business, are being disseminated. Numerous practical applications occurred for corporate strategic management, forecasting of financial indexes in the securities markets and others

Third period: the beginning of the 1990s – at present. The use of fuzzy sets in the economy is being developed. SIGEF (International Association for Fuzzy Set Management & Economy) was established – it is an international association for the application of the inter-generational approach in management and business, with headquarters in Barcelona, Spain. The possibilities of fuzzy sets and soft calculations in finance are explored. Software products based on fuzzy sets and fuzzy mathematics such as FuziCalc, CubiCalc, Matlab were created, allowing for high-speed computing with inaccurate output data. The modelling of dynamic management in the economy is enhanced.

The fuzzy set approach in financial analysis is an evolving concept. Based on the idea of fuzzy sets and operations with them, it offers unparalleled processing of data, reproduction of human thinking and decision-making in close proximity. The use of the fuzzy set approach allows the integration of accounting information with intuitive assigned hypotheses.

4. EXPERT FINANCIAL ANALYSIS SYSTEMS

Expert financial analysis systems are specific applications of fuzzy sets and fuzzy logic. These are systems that operate on the basis of rules for factor and influence research. They may be defined as the application of intelligent technologies in the company's financial management methodology. They are also called systems operating in uncertainty, fuzzy models and soft-computing models [4, 6]. Expert financial analysis systems offer information processing with varying degrees of accuracy. Furthermore, accounting information with its inherent objectivity and quantitative judgement is taken into account in the context of a management policy, risk aversion, market situation, and taxation. The approach to information in the financial statements is individualized. Conditions are created for increasing flexibility, speed and efficiency of business management [9].

Expert systems for financial analysis are modelled on a standard, three-stage algorithm [4].

First stage: Fuzzing input information. Represents the development of inputs and outputs of the fuzzy system in the form of fuzzy variables. This means that the financial ratios (calculated on the basis of the financial statements) are transformed into fuzzy indicators, burdened with expert knowledge of risk pricing, expected performance, market situation, individual characteristics of the subjects of the analysis, etc. As a result of the fuzzy of inputs, estimates are transformed into inaccurate (fuzzy) estimates.

Second Stage: Defining rules. It consists of constructing a model of reasoning in each analysis, defining the connections between inputs and outputs of the expert system. Conceptual basis at this stage of modelling is the thinking of an expert or a group of experts. As a result, knowledge of what action should be taken when certain conditions are met [2].

Third stage: Defusing of the result. We convert the fuzzy estimates obtained after calculating the rules into accurate values. This processing of the information is inverse to the fuzzing (first stage) and takes place at the output of the expert system. A suitable method of degrading is the Centre of gravity method.

Expert financial analysis systems models are built and run in Matlab environment, using the Fuzzy Toolbox and Simulink simulation tools.

Expert financial analysis systems have entered into the practice of industrial giants such as Motorola, General Electric, Otis Elevator, Pacific Gas & Electric, Ford and IBM as early as in the 1990s of 20th century. Examples of effective expert systems include: Chizuko Yasuobu – Developed by Fuji Bank and designed to evaluate the securities market, NHS (National Health Service) – fuzzy cognitive healthcare system and social insurance in England; Fuzzy Relational Data Bases – Computer fuzzy database management systems. In Bulgaria, such systems are used primarily for creating crisis management software, analysing the political environment, researching financial markets.

5. CONCLUSION

Fuzzy financial analysis models are an intelligent opportunity for improvement of business management. They embody the divisive multiplication approach in the processing of economic information. They use the advantages of fuzzy sets and fuzzy logic, and offer a methodological framework for decision making in uncertainty. Fuzzy financial analysis models reproduce human thinking by integrating accounting information from financial statements and expertise in finance, management and microeconomics. They are imposed as a modern trend in the development of economic research.

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