Theoretical bases of project management in conditions of innovative economy based on fuzzy modeling

I L Beilin, V V Khomenko

Institute of Management, Economics and Finance, Kazan Federal University, 8 Kremlyovskaya street Kazan 420008, Russian Federation

E-mail: i.beilin@rambler.ru

Abstract. In recent years, more and more Russian enterprises (both private and public) are trying to organize their activities on the basis of modern scientific research in order to improve the management of economic processes. Business planning, financial and investment analysis, modern software products based on the latest scientific developments are introduced everywhere. At the same time, there is a growing demand for market research (both at the microeconomic and macroeconomic levels), for financial and general economic information.

1. Introduction
Today fuzzy logic is one of the most promising directions of scientific research in the field of analysis, forecasting and modeling of economic phenomena and processes. Fuzzy-multiple models, often represented as software for personal computers, allow both managers of different levels and owners of enterprises to make economically sound decisions.

Although for the first time the mention of a new method of mathematical modeling appeared about half a century ago, this field of scientific research is still little studied in our country. To date, in Russia, consumers of scientific developments, based on a fuzzy-multiple device, are a fairly narrow range of government and a slightly wider range of commercial enterprises, and scientists who create and supply these products to the market are estimated by one to two dozen people.

Conditionally the period from the moment of the birth of this science to our days can be divided into three stages: the first - the stage of the formation of the main theoretical postulates (1965 - early 70's); the second - a stage of practical development in various areas of life based on fuzzy logic; the birth of a new scientific direction within the framework of fuzzy logic "Fuzzy Economics" (1973 - early 90's); the third is the stage of mass use of products based on fuzzy logic (1995 till today).

However, this division is relatively arbitrary because theoretical research in this field of knowledge does not stop, and still, with each year expanding the scope of this mathematical apparatus. In 1965, Lotfi A. Zadeh, a computer science professor at the University of California at Berkeley, introduced the notion of fuzzy sets, known as fuzzy logic, into science. The basis for creating a new theory was the professor's argument with his friend about whose wife is more attractive [1-5]. According to the story, they did not come to a common opinion. And this, in turn, forced the scientist to form a concept that expresses fuzzy concepts such as "attractiveness" in a numerical form.
2. Analytical review

Unlike the standard logic in which we are accustomed to two binary states (1/0, Yes / No, True / False, etc.), fuzzy logic allows us to determine intermediate values between standard estimates. Examples of such assessments are: "more attractive", "less attractive", "yes rather than no", "probably yes", "slightly right", "sharply left" as opposed to standard: "attractive" or "unattractive", "Right" or "left", "yes" or "no". With the help of this mathematical apparatus, it became possible to formulate the above-mentioned estimates mathematically and subsequently to process them with a computer [6-7]. Thus, with the help of this mathematical apparatus it was possible to maximally approximate the mechanism of computer processing and analysis of data to human thinking. The initial intention of the theory of fuzzy sets was the construction of a functional correspondence between fuzzy linguistic descriptions ("high", "warm", "attractive", etc.) and special functions expressing the degree of belonging to the values of the measured parameters (lengths, temperatures, etc.) to the above-mentioned fuzzy descriptions. So a classic example of such descriptions is the question of dividing the totality of people into old and young. Let there be many young people. How to define this concept in ordinary (Boolean) logic? For this it is necessary to set the interval of years for which it is possible to assume that a person is young. Let us say it is an interval from 15 to 35 years. Then, according to the standard logic, all people, who fall into this interval, are considered "young" and the rest - not included in the "young". However, a very obvious question may arise: "And what about a person who is 36 years old already; an old man, or a man who is 14 years old also does not belong to the category of young people?" This is the main drawback of clear (binary) logic. At the same time, fuzzy logic allows us to weaken such strict separation between the old and the young. Usually people think so - if a person is 36 years old, then "Ivan Petrovich is still young, but age will soon make itself felt" or about a man aged 14: "Oleg is too young", etc. If in the first case, for ordinary logic, the elements of the set were coded by the computer as 0 (old) or 1 (young), then intermediate values between 0 and 1 can now be used. For a person whose age falls within the interval from 15 to 35 years, one can say with a great deal of confidence that he is young, so the value of 1 will correspond to this statement. If a person is 36 or 14, let us put in correspondence, say, the value of 0.9. In other words, the closer a person's age to the interval from 15 to 35 years, the more confidently it is possible to say that he is young, i.e. the confidence rating (reliability of the statement) will be close to 1. If the distance from the specified interval of "youth" is increased both toward its increase and in the direction of decreasing age, the significance of the veracity of the statement will gradually decrease to zero.

This approach was very relevant in the economy [8] and management [9] of innovative projects. Numerous chemical innovation projects face significant difficulties in transferring from laboratory to production [10]. This is due to fuzzy conditions of synthesis [11] and investigation of product structure and their applied properties [12]. Thus, this mathematical apparatus allows us to formulate and mathematically describe any qualitative concept ("attractive", "young", "high") by some distribution function, and then use it as an exact one, not caring more about its "fuzzy" nature. According to the above-mentioned principle of fuzzy logic, a graphic description of the qualitative concept of "young" (the function of belonging to the fuzzy set "Young") is shown in Fig. 1. The distribution function has the form of a trapezoid. The upper base of the trapezoid corresponds to an interval of 20 to 30 years. The word "young" for this section will correspond to a certainty equal to one. Sections 1-2 and 3-4 illustrate the fact that if a person's age falls in the intervals from 14 to 20 and from 30 to 45, then the reliability of the statement that a person is young decreases or increases. A formal description of this function is as follows:
The next achievement of the theory of fuzzy sets is the introduction of the so-called fuzzy numbers - fuzzy subsets of a specialized type, corresponding to statements like "the value of a variable is approximately equal to a". Here, as an example, the so-called triangular fuzzy number was used, where three points are singled out: the minimum possible, the most expected and the maximum possible value of the factor. Triangular numbers are the most commonly used type of fuzzy numbers, and most often they are used as forecast values of a parameter.

As an example, let us cite the expected value of inflation for 2006. Let us assume that the most probable value is 14%, the minimum possible is 8%, and the maximum possible value is 22%, then all these values can be reduced to a kind of fuzzy subset - fuzzy number A:

\[ A = (8, 14, 22) \]

The next historical step in this science is the introduction of a set of operations on fuzzy numbers, which are reduced to algebraic operations with ordinary numbers when specifying a certain confidence interval (level of belonging), which later received the name soft calculations. Fundamental research in this field was undertaken by D. Dubois.

3. The discussion of the results

In parallel with the development of the theoretical foundations of the new science, Lotfi A. Zade worked out various possibilities for its practical application. And in 1973, these efforts were crowned with success - he managed to show that fuzzy logic can be put in the basis of a new generation of intelligent management systems. This is why it is logical to consider this date as the beginning of the second stage in the development of this science.

The results did not take long. Almost immediately after the publication of the fundamental report by L. Zade, a small enterprising company from Denmark applied the principles outlined in it to improve the blast furnace management system. Only after this, the scientists paid close attention to the young science; it is this logic which is practically devoid of a theoretical basis, is capable of solving various problems under conditions of uncertainty. Four years after the introduction of this
management system complex production process, the company’s profits were estimated at tens of thousands of dollars.

For thirty years of its development (the first two stages in the above-mentioned classification), fuzzy logic has undergone a number of significant changes and additions. First of all, thanks to the efforts of B. Kosko, the relationship between fuzzy logic and the theory of neural networks was investigated and a fundamental FAT-theorem (Fuzzy Approximation Theorem) was proved, which confirmed the completeness of fuzzy logic.

In the works of Maria Zemankova-Leech and Abraham Kandel, the foundations of the theory of fuzzy database management systems, capable of operating inaccurate data, processing fuzzy queries, and using qualitative parameters along with quantitative. Fuzzy algebra was developed - an unusual science that allows us to use both exact and approximate values of variables in calculations. And finally, the so-called fuzzy cognitive maps invented by B. Kosco, on which the majority of modern systems of dynamic modeling in the field of finance, politics and business are based, are widely used.

By the 90s, about 40 patents related to fuzzy logic had appeared (of which 30 are Japanese). Forty-eight Japanese companies formed a joint laboratory for LIFE (Laboratory for International Fuzzy Engineering), the Japanese government funded a five-year program on fuzzy logic, which includes 19 different projects - from systems for estimating global atmospheric pollution and prediction of earthquakes to automated control systems of factory shops and warehouses. The result of this program was the emergence of a number of new mass microchips based on fuzzy logic. Today they can be found in washing machines and video cameras, workshops of plants, engine compartments of cars, in control systems for warehouse robots and combat helicopters.

As an example, the pioneer in the application of fuzzy logic in household products was Matsuhita. In February 1991, she announced the first “intelligent” washing machine, in the control system which combined fuzzy logic and a neural network. By automatically detecting fuzzy input factors (volume and quality of the laundry, the level of soiling, the type of powder, etc.), the washing machine unerringly selects the optimum washing mode from 3800 possible options. And after a couple of years, the use of fuzzy logic in the production of Japanese household appliances has become ubiquitous.

In addition to basic operations on fuzzy sets in the management of innovative projects, special operations such as “concentration” and “stretching” are of great importance. The venture business market is extremely volatile [13]. In the case of an excess of good projects, special operations enable a potential investor to select “very” different projects on some basis:

\[
\mu^-_A(x) = \left( \mu^-_A(x) \right)^\alpha
\]

If there are not enough good projects, then there is always an opportunity to switch to "more or less" projects that satisfy any criterion (Fig. 2):

![Figure 2](image-url)

**Figure 2.** An example of the function of the distribution of the NPV spread from "more or less" to "very" acceptable.
Today, the foreign market of so-called fuzzy controllers (a version of which is installed in washing machines widely advertised LG brand) has a capacity, estimated in billions of dollars [14]. Fuzzy logic, as a model of human thought processes, is built into the systems of artificial intelligence and into automated means of decision support (in particular, in the control systems of technological processes).

4. Conclusions

Project management in an innovative economy based on fuzzy modeling provides a number of advantages in economic efficiency in comparison with traditional approaches. Innovative analysts can summarize fuzzy sets of profit or costs or the risks of individual projects. This makes it possible to build highly reliable forecasts for the whole portfolio of projects. And also, fuzzy logic in project management makes it possible to minimize the possibility of a shortage of investment, or vice versa, their excess that will not give the required interest at the discount rate. With this approach, it becomes possible not only to quantify the magnitude of the risk, but also to continuously regulate its acceptable level to the investor.

References:

[1] Zadeh L 2002 Toward a perception-based theory of probabilistic reasoning with imprecise probabilities Journal of Statistical Planning and Inference 105 233-264
[2] Inuiguchi M, Tanino T 2001 Portfolio selection under independent possibility information Fuzzy sets and systems 115 83-92
[3] Beilin, I.L., Arkhireev, V.P. 2006 Copolymerization of cyclic carbonates with isocyanates under anionic initiation conditions and structure of the new copolymers Russian Journal of Applied Chemistry 79(1) 133–136
[4] Beilin I L, Arkhireev V P 2009 New copolymer products from cyclic carbonates and isocyanate-containing compounds Protection of Metals and Physical Chemistry of Surfaces 45(4) 450–454
[5] Beilin I L, Arkhireev V P 2005 New copolymers of propylene carbonate with controlled complex of properties Plasticheskie Massy: Sintez Svojstva Pererabotka Primenenie 7 12-15
[6] Takafumi N, Fminori T, Kamran M N, Bernardino M C and Alessandro P F 2009 Practical Equations for the Elastic Modulus of Concrete ACI Structural Journal 5 106-108
[7] Erdal K, Candidate P 2009 Contributions to Type-2 Fuzzy Sets Theory and Applications in Control Engineering and Robotics 10 24-30
[8] Beilin I L 2016 Analysis of efficiency of the innovative project in the field of chemistry fuzzy logic Journal of Economics and Economic Education Research 17(4) 177 – 185
[9] Beilin I L 2017 Economic-mathematical modeling of the total costs of innovative chemical enterprise methods of fuzzy set theory Journal of Engineering and Applied Sciences 12(19) 4865–4869
[10] Crowther K G, Haines Y Y 2010 Development of the Multiregional Inoperability Input-Output Model (MRIIM) for Spatial Explicitness in Preparedness of Interdependent Regions Systems Engineering 13(1) 46-50
[11] Zobel C W, Khansa L 2012 Quantifying Cyberinfrastructure Resilience against Multi-Event Attacks Decision Sciences 43(4) 89-92
[12] Beilin, I.L., Arkhireev, V.P. 2011 Synthesis and structure of copoly(amide esters) based on cyclic carbonates and monofunctional isocyanates. Protection of Metals and Physical Chemistry of Surfaces 47(4) 478–483
[13] Beilin I L, Arkhireev V P 2011 The supermolecular structure of new copolymer products based on cyclic carbonates International Polymer Science and Technology 38(1) 37-40
[14] Malach-Pines A, Sheva B, Dvir D, Sadeh A 2009 Project manager-project (PM-P) fit and project success International Journal of Operations & Production Management 29(3) 268-291
[15] Turner J R, Ledwith A and Kelly J F 2010 Project management in small to medium-sized enterprises: matching processes to the nature of the firm *International Journal of Project Management* **28**(8) 744-755

[16] Vos J, Achterkamp M 2006 Stakeholder identification in innovation project: Going beyond classification *European Journal of Innovation Management* **9**(2) 161-178

[17] Pons D 2008 Project management of new product development *Project management journal* **39**(2) 82-97

[18] Beilin I L 2017 Economic Optimization in Chemical Enterprises *International Journal of Economic Perspectives* **11**(4) 670-677

[19] Cormos A M, Cormos C C 2014 Investigation of hydrogen and power co-generation based on direct coal chemical looping systems *International Journal of Hydrogen Energy* **39**(5) 2067-2077