Making Management Decisions in the Business Environment Based on Fuzzy Logic Methods

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ABSTRACT

The scientific research deals with the issues related to forming the structural component of ensuring managerial decision-making in business by using fuzzy logic in uncertainty and risk conditions. Improving the process of information support for management decision-making becomes possible by expanding the functional structure of expert systems (ES) in supporting services that adapt the ES functionality for the end-user – organisations' management. The article deals with further developing the information and analytical model for supporting the formation of management decisions in the conditions of constant changes and functional variability.

The scientific hypothesis is that management decision-making in the business environment with the help of expert systems can be implemented through the formation of a new approach to the construction of a system for presenting the tasks to be solved by modifying the knowledge base into a two-level system (methodological-analytical and experimental levels). The scientific novelty is expressed in the functional modification of the approach to the formation and provision of data to accept administrative decisions based on changes in the analytical structure aimed at various tasks.

Keywords: Expert systems, Business environment, Management decisions, Fuzzy logic, Uncertainty and risk conditions.

1. INTRODUCTION

The relevance of the scientific problem of the study. Making managerial decisions in the domestic business environment is a complex and ambiguous problem since decisions are formed, considering constant changes and risk conditions where their assessment and interpretation are still quite difficult. Therefore, the existing uncertainty of a sufficiently large number of environmental factors, the incompleteness of the information provided, and inaccurate expert opinions in making management decisions are motivators for creating expert systems adapted to the current business situation. Therefore, the development of appropriate tools based on a multi-factor presentation of cases using fuzzy logic methods is an urgent and practically significant task. The real and practically important problem of creating an information system that will allow you to correctly make an effective management decision based on its informed choice and encourage the manager (owner, manager) to properly manage the enterprise's resources (labour, material, etc.).

Analysis of the current state of research on a scientific problem.

In the methodology of the planned research as part of the "New" school of management will use the system approach within the concept of a learning organisation (learning organisation) and knowledge management (P. Senge, W.J. Forrester).

The mathematical theory that provides the management decision-making process is based on the main provisions of the theory of fuzzy sets (L. Zadeh) [1], which, in turn, will contribute to the development of new scientific areas of management theory: fuzzy systems for supporting management decision-making, fuzzy expert systems, data mining systems, integrated intelligent systems.

Accumulation, analysis, and systematisation of the bank of management decisions will be carried out based on economics' praxiological approach.

The study aims to study the theoretical and practical aspects of information formation and the analytical model of management decision-making based on fuzzy logic methods in the business environment under risk and uncertainty conditions.

Objectives of the study:

1) Analyse and summarise the existing problems in the scientific literature on the application of the theory of fuzzy sets for management decision-making (the use of information systems to support business decision-making);

2) To investigate the practical application of the theory of fuzzy sets for solving management problems in business;

3) Study and analysis of the ideas of small business managers about the problems, the range of the issues to be solved, the prospects for development, as well as about the technologies and products used by the programs (field research);

4) development of management decision-making models based on fuzzy logic using expert systems.

The scientific novelty of the research. The research aims to support (based on theoretical and practical developments and relevant field studies) the formation of information and analytical model for supporting managerial decision-making based on fuzzy logic methods that increase the efficiency of enterprises' functioning in conditions of risk and uncertainty. The scientific novelty is expressed in a functional change in the understanding of the concept of forming and providing data for making management decisions in conditions of uncertainty and risk based on the formation of appropriate information and analytical structure aimed at multi-variant and variable tasks, which, in our opinion, should take into account the constant changes in the external environment. Adequate analytical support for management decision-making in small and medium-sized enterprises requires introducing a new approach and new requirements for management tools [3]. To some extent, there is a need to standardise the management tools used.

Suggested methods, techniques and tools.

To achieve the set goals – the formation of an information and analytical (expert) model of management decision-making, - a corresponding economic and sociological study was conducted in the business environment of the Rostov region, where the following methods were used:

- interviewing;

- research in focus groups.

To develop and justify approaches to the classification of standard management decisions in the process of business functioning and the economic structure of the knowledge base of the expert system based on management functions:

- hierarchical structuring of the subject area of management based on the functional areas of management and the operational division of labour;

- functional modelling and representation of business processes of management (for example, through Integration definition for function modelling – IDEF methodology) to search and recognise fundamental management problems.

When developing a database of applied management solutions using fuzzy logic mechanisms for the methodological and analytical level of the expert system knowledge base, the following methods were used:

- scientific search in abstract and scientometric databases. Most of the research was conducted in the databases of EBSCO, Elsevier (ScienceDirect), Scopus, Web of Science, and elibrary in full-text mode (the authors ' team has access to full-text databases as part of their research and teaching activities). Studies of foreign (in English) and Russian scientists on this issue:

- cataloguing the results of scientific research for their registration, accumulation and storage;

- data analysis, structuring, and modification.

The practical significance of the study. Currently, applied solutions based on fuzzy logic methods in economics and management have been developed. Software products offered today in the information technology market have such functionality that presupposes a high user qualification; unfortunately, participants in business processes, especially in small businesses, cannot meet such requirements for user literacy. Thus, it is not enough to provide only functionality that provides direct management decision-making, but it is necessary to develop a sufficiently clear, adapted information and an analytical model that corresponds to the business community's expert opinions.

2. RESEARCH METHODOLOGY

The analysis of literary sources on the issues studied, and the analysis of practical aspects of expert systems in business leads to the conclusion that modern management approaches based on methods of fuzzy logic, focused on the creation of a Bank of common management problems, which will be the tools for decision support in the management of the company. Thus, L. Zadeh proposed a variant of calculating uncertainty based on a non-additive measure of

possibility, and, in particular, on the interpretation of a fuzzy set following the distribution of possibility [1]. In contrast to the fuzzy set, which expresses the inaccuracy of evaluating certain features, the measure of possibility describes the uncertainty, the lack of sufficient completeness of information associated with the occurrence of an explicit event. In fact, it is the method of quantitative description (representation of the meaning) of expert opinions that is a generalisation of interval analysis and error theory. Today, the measure of possibility and its dual measure of necessity serve as the primary means of modelling uncertainty in intelligent systems [2]. S.I. Prigozhin, G. Haken, R. Thom, B. Mandelbrot, Lotfi Zadeh can be attributed to the "ancestors" of the synergetic scientific paradigm.

On the one hand, in the synergetic methodology framework, uncertainty is no longer considered an external anomaly in the opposing system's behaviour, but rather as its inherent characteristic. In 1982, Holmblad and Ostergad developed the first industrial fuzzy controller based on fuzzy linguistic rules implemented to control the cement kiln process in a Danish factory and led to a renewed interest of mathematicians and engineers in the theory of fuzzy sets [3]. The need to use models and methods of fuzzy logic in solving problems in the business environment is due to the objective conditions of enterprises' functioning in a state of ambiguity, the uncertainty of the source data's provisions, and the existing risk situations.

3. STUDY RESULTS

Currently, applied solutions based on fuzzy logic methods in economics and management are being developed. Simultaneously, these solutions are little used in practice due to their academic nature and the previously mentioned problem of the economic situation's variability over short periods [4]. To solve the problem of creating a database, it is necessary to develop reasonable approaches to the structuring and classification of applied tasks that will provide the functionality required for using the database by the company's management. The structure of the data bank can be represented as a hierarchical diagram of management areas. The functional division of labour in

territorial subsystems can be used as the main direction for cluster management tasks [5]. In any case, structuring and clarifying management tasks is a scientific problem. The Japanese government funded a 5-year program for 19 different projects based on fuzzy logic in various fields (ecology, weather forecasting, control systems for factory workshops and warehouses, car engine compartments, etc.). [6] As a result, several new mass-produced microchips based on fuzzy logic appeared, which laid the foundation for creating many automated solutions based on fuzzy logic control algorithms, both in industrial diagnostics and in medicine. Developments in the financial sector (the system from YamaichiSecuruties Corporation, ASK, IThink) create software products using fuzzy logic [7].

The Russian market of such software is represented by CubiCalc, CubiQuick, RuleMaker, FuziCalc, QWL, and MatLab packages. The primary consumers of the programs already available on the market are large organisations of the banking and financial sector and institutions and funds engaged in political, macroeconomic analysis and forecasting of emergencies, and they are the points of purchase [8].

3.1. Application of the methodology for analysing management decision-making in the business environment based on fuzzy logic methods

Under the goal - to develop an information and analytical model of management decision-making in the business environment, expert analysis methods were used to determine business process participants' preferences using fuzzy logic methods.

The survey covered 150 respondents from among the heads of small enterprises and individual entrepreneurs from 18 city districts and the Rostov region's municipal districts. Business requirements for information products and systems are reflected in table 1.

According to the functionality of the expert model of management decision-making in small businesses, users' choice is presented in table 2.

Table 1. User Preferences by forecast financial performance

Indicator	Preferences, %
Value Added forecast	21
Available cash forecast	50
Payment forecast	50
Forecast expenditures (cost)	86
Revenue forecast (turnover)	86
Profit forecast	86

Table 2. Representation of users by the functionality of the expert model of management decision-making in small businesses

Indicator	Preferences, %
Entering information from other software: required	68
Graphical representation of data	67
Output reporting: Configurable	75
User training format	67
Clarification of positions: everywhere	52
Notification of a critical business situation	58

Conclusions based on the results of data analysis using fuzzy logic methods.

1. The main questions were about cash flow, income generation, the formation of the cost structure, their actual availability, and resource potential.

2. To create an expert model for supporting managerial decision-making in business, preferences of 1/3 are a significant threshold, since the absolute majority of questions received more than a third of the votes; therefore, these data should be taken into account as options when forming information and analytical model for managerial decision-making.

3.2. Formation of a functional model of management decisions made during business functioning

According to the study, it is necessary to determine the list of standard management decisions under the requirements of a specific business situation to form the parameters of the future expert model of management decision-making.

Next, we will present a general structural model of management decision-making in the business environment based on fuzzy logic methods using expert, information and analytical systems (fig. 1).
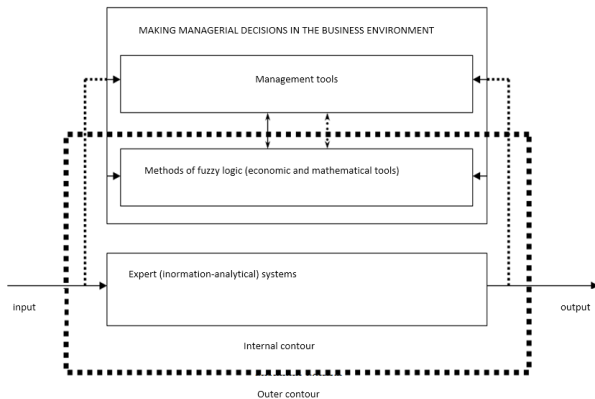
Figure 1 A general structural model of management decision-making in the business environment based on

fuzzy logic methods using expert (information and analytical) systems.

Next, we propose the following structure of the "ES Expertise Module" for making management decisions in the business environment (fig. 2).
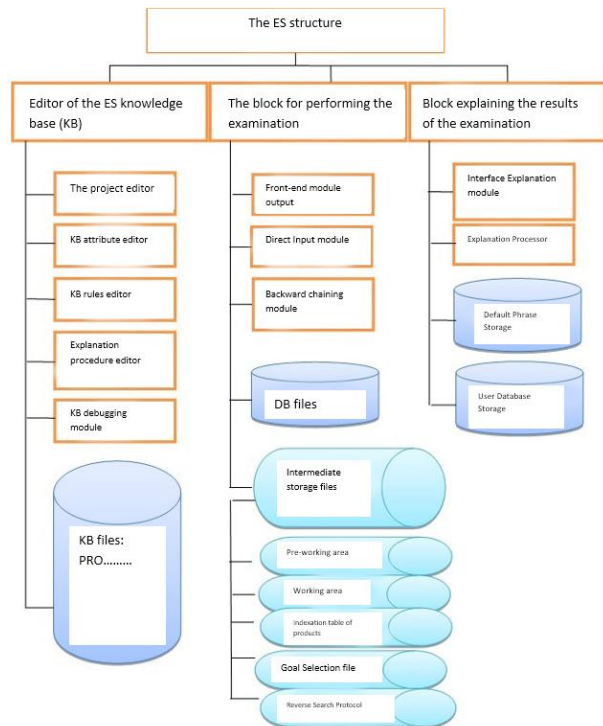
Figure 2. Structure of the "ES Expertise Module" when making management decisions.

The proposed examination module contains: an interface module, forward and reverse output modules. The interface module is used for "direct" interaction between the user and the expert system, which, based on the received data on the enterprise's economic activity, can recommend options for management decisions. This module was developed to execute the relevant grants of RSCI and RFFR by the author and a group of performers. When creating a specific examination, you can set both individual parameters for the examination, and a "set" of economic indicators, the more indicators -

the greater the variability of management decisions. Also, a block of explanation of the examination results was developed, which has its composition: the front-end unit and the processor is "explanation". The corresponding protocols for the output of data results allow you to present the analysis results in a visual form for any user and recommendations for eliminating "problem" points and directions for development.

In the future, it is planned to develop a module for "personnel evaluation", which will allow making management decisions, both about the optimal number of employees and making recommendations on their placement, up to the development of appropriate job descriptions.

The proposed approach to data analysis and the development of expert solutions for the business's functioning allows you to create a "*new"* generation of products that combine economic analysis and information technology, turning management decisions from an intuitive process into knowledge engineering.

4. RESULTS DISCUSSION

With the apparent advantages of the presented models (figure 1,2): the ability to analyse constant changes in the business environment and make appropriate management decisions with several development scenarios, some disadvantages need to be addressed, regardless of the management models being developed. Thus, experts-specialists working in a particular field, as a rule, cannot formalise their knowledge and often make the right decisions intuitively and cannot explain why they made the decision. In this regard, knowledge engineers need to be able to formalise the knowledge of experts in the form of a specific model of knowledge representation. To solve this problem, it is proposed to use systems and fuzzy logic methods, which formalise the presented disparate data and help provide variations (changes) in the external environment. Depending on the expected level of risk, the object of control at the enterprise is allocated, which is analysed using the presented modules (Fig. 2), and under the complexity of the tasks to be solved, a management decision is formed.

5. CONCLUSIONS

The effective use of information and analytical systems (experts - ES) based on the Fuzzy Logic Toolkit for solving management problems involves structuring the subject area based on the grouping of management tasks to search identify and standardise management tasks [9]. Considering the structural representation, the development of a systematised data bank - applied management decisions, implementation methods and decision-making models-can become a vital link that contributes to the development and promotion of ES.

The development of management decision-making support is achieved based on expanding the functional structure of the ES in the form of support services, adapting the functionality to the end-user - the management of organisations [10]. Adequate analytical support for management decision-making requires introducing a new approach and new requirements for the enterprise's information management processes, based on the appropriate economic and mathematical tools.

The solution of the problem of creating an information and analytical system for making management decisions based on fuzzy logic methods, considered in the article, will ensure the correct adoption of an effective management decision based on its informed choice and will tell the manager (manager, owner) how to manage the resources of the enterprise properly, is relevant and practically significant. Solving the problems of decision support in business management becomes possible with the correct definition of target settings and the availability of appropriate resources, including accurate information and analytical, expert systems.

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