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Intelligent computer decision support system for optimizing the control of investment analysis and projecting processes in the context of new industrialization

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Abstract—**The article discusses the issues of development and creation of an intelligent computer system for decision support that allows to optimize the control of investment analysis and projecting processes in the context of new industrialization. The development and creation of such a system is based on the technologies of computer expert decision support systems, neural networks, machine learning, as well as models and methods of network economical and mathematical modeling. The main stages of creating a computer expert system for optimizing the control of the processes of investment analysis and projecting by an economic entity are considered. Specific examples of the development of logical rules in the production and clausal forms for the knowledge base of the proposed computer expert system are given. The work analyzes the feasibility of selecting specific models and technologies suitable for creating the proposed intellectual system. Results are presented that testify to the effectiveness of its application in the practical activities of economic entities when optimizing the control of investment analysis and projecting processes.**

Keywords – intellectual systems; investment projecting; computer expert systems; production rules; clausal form; network models and methods

I. INTRODUCTION

The investment projecting process is an integral part of the functioning of any business entity and for its successful operation it is necessary to have as a tool a modern intelligent computer decision support system for optimizing the control of investment analysis and projecting processes. The system of support for making managerial decisions when implementing investment projects of an economic entity refers to a complex IT-system developed on the basis of relevant economic and mathematical models and methods.

Thus, the purpose of this work is to analyze the possible directions of using intelligent systems for the development and creation of a decision support system for optimizing the control of investment analysis and projecting processes.

To achieve this goal, it is necessary to consistently solve the following main tasks:

1) analyze existing software tools in the field of investment analysis and projecting;

2) analyze existing models and methods of developing and creating intelligent systems, namely computer expert systems, neural networks and machine learning methods, on the basis of which an intelligent decision support system can be created to optimize the control of analysis and control of investment projecting;

3) on the basis of the analysis of existing software tools, to create a software tool for the development and creation of an intellectual system;

4) based on the data of the analysis of models and methods of development and creation of intelligent systems, to develop a technology for the development and creation of an intelligent decision support system for optimizing the control of analysis and control of investment projecting.

Analysis of software tools in the field of investment design (FinModel Expert, FinEcAnaliz, Alt-Invest, Project Expert, etc.) showed that in this subject area in the Russian market there are companies that provide services in investment consulting and solutions for business development [1]. The software developed by these companies greatly simplifies the process of assessing the investment attractiveness of the business and with the help of such tools it is possible to perform detailed modeling of future cash flows, analyze possible alternatives and calculate various financial indicators. However, none of them provides for adaptation to a specific task of investment projecting, optimization of this process, and also does not use technologies for the development and creation of intelligent systems. Therefore, the development of a software system that takes into account all these factors could improve the quality of control decisions taken during the implementation of investment analysis and projecting processes.

Investment analysis and projecting is considered as an object of research by a large number of foreign and domestic authors. At the same time, the existing variety of methodological approaches to investment project control is based, first of all, on a significant number of factors affecting the implementation of investment activities. So some authors consider the volume of investments as a predicate of investment development of an economic entity [2]. A number of researchers focuses on studying the index of investment returns [3]. A significant number of authors consider and evaluate the factors of payback and discounting as the main ones for the analysis of investment projects [4]. At the same time, investment project control is studied both in the academic environment of Russian scientists [1-4] and their foreign colleagues [5-7].

II. METHODOLOGY

As a tool for economic and mathematical modeling of the solution of the problem of optimizing the control of the investment projecting process, it is proposed to use the results of work in the field of network modeling of economic systems, as well as models and methods of the theory of artificial intelligence, namely, technologies for the development and creation of computer expert systems for supporting control decisions, networks, as well as machine learning [1], [8-10].

To create an intelligent system for optimizing the control of investment analysis and projecting processes, it is necessary to develop a knowledge base that can be created in various ways (Fig. 1). One of them is the production logical rules that establish the relationship between data and facts in order to obtain logical conclusions [1], [11]. Another way is logical rules written down in clausal form. In addition, knowledge can be represented using linear models, neural networks, as well as decision trees, etc.

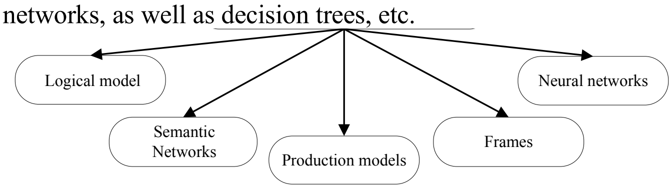

Fig. 1. Methods of data formalization in the knowledge base of investment analysis and projecting.

In Fig. 2 some models of data formalization are presented, in which the circles indicate the possible characteristics of investment projects.

An example of a knowledge base of a computer expert decision support system for optimizing the control of investment analysis and projecting processes is presented by the authors in [8]. The database presents the initial data and the main objectives for the implementation of a specific process of investment analysis and projecting. Taking into account the goals, available data, quality criteria for the implementation of investment analysis and projecting processes, formed in the knowledge base of facts and logical rules, an optimal or acceptable investment project is selected using the output subsystem that interfaces the database and the knowledge base.

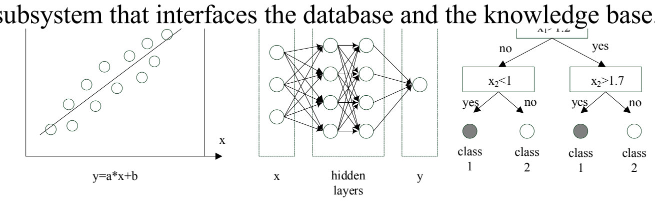

Fig. 2. Models of formalization of knowledge for the development of a decision support system for optimizing the management of investment analysis and design processes.

The database contains several hundred rules of investment analysis and projecting. For an example, we give some rules of the system in question in the form of “if-then”, i.e. in the form of production rules.

1. If the amount of investment is> $ 1,000; discount rate of 9.2%; the planned investment period is 3 years; internal rate of return 0 - 7%; payback period from 2 to 3 years; the discounted yield index is 1.02 - 1.07, then “Project 1”.

2. If the amount of the investment is> $ 1,000; discount rate of 9.2%; the planned investment period is 1 year; internal rate of return 0 - 7%; payback period is less than 1 year; the discounted yield index is 1.02 - 1.07, then “Project 1”.

2. If the amount of the investment is> $ 1,000; discount rate of 9.2%; the planned investment period is 1 year; internal rate of return 0 - 7%; payback period from 1 to 2 years; the discounted yield index is 1.02 - 1.07, then “Project 1”.

3. If the amount of the investment is> $ 1,000; discount rate of 9.2%; the planned investment period is 1 year; internal rate of return 0 - 7%; payback period from 2 to 3 years; the discounted yield index is 1.02 - 1.07, then “Project 1”.

4. If the amount of the investment is> $ 1,000; discount rate of 9.2%; planned investment period is 2 years; internal rate of return 0 - 7%; payback period is less than 1 year; the discounted yield index is 1.02 - 1.07, then “Project 1”.

5. If the amount of the investment is> $ 1,000; discount rate of 9.2%; planned investment period is 2 years; internal rate of return 0 - 7%; payback period from 1 to 2 years; the discounted yield index is 1.02 - 1.07, then “Project 1”.

6. If the amount of the investment is> $ 1,000; discount rate of 9.2%; the planned investment period is 3 years; internal rate of return 0 - 7%; payback period from 2 to 3 years; the discounted yield index is 1.02 - 1.07, then “Project 1”.

7. If the amount of the investment is> $ 1,000; discount rate of 9.2%; the planned investment period is 3 years; internal rate of return 0 - 7%; payback period is less than 1 year; the discounted yield index is 1.02 - 1.07, then “Project 1”.

8. If the amount of the investment is> $ 1,000; discount rate of 9.2%; the planned investment period is 3 years;

internal rate of return 0 - 7%; payback period from 1 to 2 years; the discounted yield index is 1.02 - 1.07, then “Project 1”.

9. If the amount of the investment is> $ 1,000; discount rate of 9.2%; the planned investment period is 3 years; internal rate of return 0 - 7%; payback period from 2 to 3 years; the discounted yield index is 1.02 - 1.07, then “Project 1”.

10. If the amount of the investment is> $ 1,000; discount rate 14.5%; the planned investment period is 1 year; internal rate of return 7 - 9%; payback period is less than 1 year; the discounted yield index is 1.02 - 1.07, then “Project 2”.

11. If the amount of the investment is> $ 1,000; discount rate 14.5%; the planned investment period is 1 year; internal rate of return 7 - 9%; payback period from 1 to 2 years; the discounted yield index is 1.02 - 1.07, then “Project 2”.

12. If the amount of the investment is> $ 1,000; discount rate 14.5%; the planned investment period is 1 year; internal rate of return 7 - 9%; payback period from 2 to 3 years; the discounted yield index is 1.02 - 1.07, then “Project 2”.

To optimize the control of the investment analysis and projecting processes, a general scheme of the network economic-mathematical model of investment analysis and projecting, presented by the authors in [1], was developed. We will describe the main stages / blocks of operations-work in the implementation of the processes of investment analysis and projecting:

1) collection of initial data for each of the investment projects under consideration;

2) marketing analysis of projects;

3) financial analysis (calculation of financial indicators) of projects;

4) analysis of uncertainty / sensitivity (impact of risks on projects);

5) building a financial model for each investment project;

6) the formation of alternative options for the implementation of projects;

7) analysis of the results obtained and selection of the optimal investment project / set of projects.

Note that the formation of product rules in a computer expert decision support system for optimizing the control of investment analysis and projecting processes is a long and time-consuming task, and the rules themselves are difficult to maintain in the current state. Therefore, if there is already collected statistics and a set of observations on implemented projects, then for this purpose it is possible to develop a model of an artificial intelligence system using, for example, the technology of neural networks [1, 12, 13].

The technology of neural networks involves processing in a special way on the basis of the corresponding model a set of input data and the formation of the output. How many incoming signals are formed in the outgoing, determines the calculation algorithm. At each input of the neuron, the values of the investment indicators are given, which then propagate through the inter-neuronal connections (synapses). In this case, each synapse has a corresponding numerical parameter - the weight by which the input information changes during the transition from one neuron to another. The information of that neuron, whose weight is larger, will be dominant in the next neuron (Fig. 3).

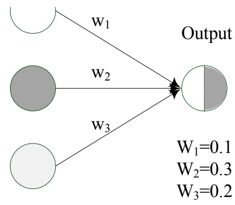

Fig. 3. Conversion of input information in a neuron into output information using weighting coefficients.

Note that the main advantage of neural networks over conventional mathematical algorithms for solving a particular problem is the possibility of their learning. Training a neural network is realized by forming a more precise coupling coefficients between neurons, as well as the data of the synthesis and identification of complex relationships between input and output signals. In fact, successful learning of a neural network means that its application allows to form a sufficiently accurate result of the solution of the problem under consideration on the basis of data not available in the training sample.

In the problem considered in the article there is a set of points on the plane (investment projects), some of which are dark - effective projects, and some - light - inefficient projects. Then, using a neural network model, these points must be divided. In Fig. 4 shows an example of the division of the set of investment projects under consideration, where the color of the dot denotes the corresponding quality of the project: “effective” / “ineffective” - “dark” / “light”.

Neural networks allow you to successfully model existing complex dependencies in data. In many ways, for this reason, today they are one of the most used models for the creation of artificial intelligence systems, since they show the high quality of the solution of various applied problems [14-16].

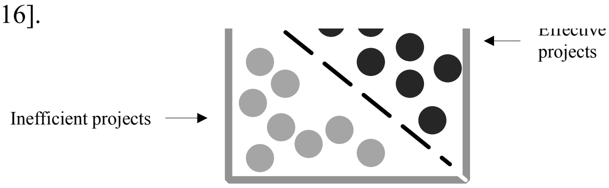

Fig. 4. An example of the separation of investment projects using a neural network.

III. RESULTS

The problem of searching for effective (optimal) investment projects among the whole set of available projects is considered.

The sequence of operations-works in the corresponding network model [1] can be represented as follows: selection of the investment objective, selection of the most important investment criteria, identification of possible additional functions for analysis of the projects under consideration, and the formation of a set of effective (optimal) projects.

For clarity, consider only two indicators for each investment project: the volume of investments - x_1 and the payback period of investments - x_2. Point-label of dark color indicates an effective investment project, light color - an inefficient investment project.

Note that in the computer expert system it is necessary to use all the indicators that the user deems necessary for the processes of investment analysis and projecting. In this case, all the initial information can be combined in any combination.

In Fig. 5 is a graph showing the amount of investment in the project and the payback period, and the corresponding point-marks - is the project effective or not.

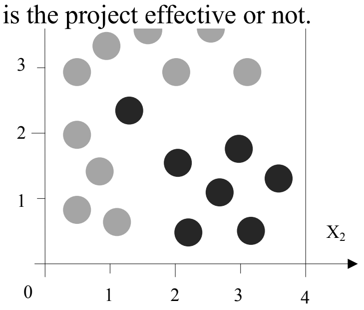

Fig. 5. Investment projecting data for training a neural network.

One of the main elements of development and the main difficulty of using neural network modeling is the learning process of a particular neural network. The operation of an object in a dynamically changing environment, for example, in a financial environment, is a big obstacle to solving related problems within the corresponding neural network. Even if the network is successfully trained, there is no guarantee that it will form an acceptable solution for all tasks from the subject domain in question. Financial markets are constantly changing, so the network can “break”. Therefore, it is necessary to either use a variety of network architectures and choose the best ones from them, or use a dynamic neural network. A description of the learning process of a neural network in fairly general cases is contained, for example, in [17, 18].

The neural network proposed for use in the computer expert system is an adaptive system capable of changing its internal structure on the basis of incoming information. In this case, the learning process of the network is realized by adjusting the values of the weights of neurons.

The weight of a neuron is a specific number corresponding to the degree of similarity of the processed information with the information stored in the computer program memory. As a result of data processing, a set of neurons is formed, each of which carries certain information about the degree of similarity. This information is described by the corresponding value of the weight of the neuron. Moreover, the greater the value of the weight of the neuron, the more likely it is that the fact (statement, judgment, utterance) corresponding to this neuron is true. Thus, based on the maximum weight of the neuron, the computer program will be able to determine whether the investment project is effective or inefficient.

In the initial period of use, the neural network will not be able to properly evaluate the investment project in question for its effectiveness, therefore, an appropriate network training algorithm is developed. The meaningful meaning of training a neural network is as follows. If the input permissible value of a specific indicator of the efficiency of the investment project in the memory of the corresponding neuron is absent, but it must be present, the computer program remembers it. When implementing further training of the neural network, the degree of influence of this indicator on the formation of the result of the evaluation of the effectiveness of the investment project will only increase.

A computer program that implements the algorithm for evaluating investment projects is part of an application that solves the problems of optimizing the control of investment analysis and projecting processes. This application is based on the knowledge base described above, which contains models of knowledge in the field of investment analysis and projecting in the form of appropriate product rules and a neural network.

In the database of the computer expert system being developed, all data are divided into two parts. The first part contains data from investment project indicators that are used as input data for production rules and for learning a neural network, and the second part contains test data, which contains the same indicators, but with different values. The second part of the data is used to test and evaluate the efficiency of the generated neural network.

All indicators of the processes under consideration are given by the corresponding input matrix describing the sequences of their possible values. In a set of input data, such a matrix is represented as a sequence of corresponding rows. The * character is used as a separator between the lines. For example, all allowable values of the investment volume indicator can be given by the following line:

50000 * 100000 * 150000 * 300000 * 450000 * 600000 * 750000 * 1000000 * 1250000 * 1500000 * 1750000 * 2000000 * 2500000 * 3000000 * 4000000 * 5000000 * 6000000 * 7000000 * 8000000 * 10000000, etc.

Then the problem of investment projecting assessment is the following: knowing effective investment indicators, training the neural network, and then, together with the existing set of product rules, use it to evaluate both test projects and the real projects under consideration.

To solve the problem of learning a neural network, for example, the method of back propagation of an error using the logistic function can be used [19, 20].

In our example, the trained neural network divided the projects under consideration into a dashed boundary, as shown in Fig. 6. All projects are divided into two classes - a class of effective investment projects and a class of inefficient investment projects, with errors - 0.

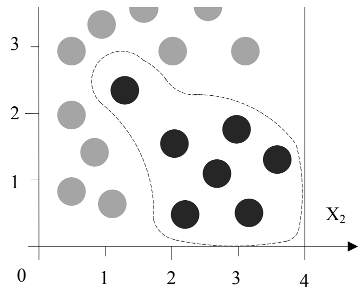

Fig. 6. An example of the result of a neural network for investment analysis and projecting.

Note that the use of neural networks requires a lot of effort. At the same time, for the development, training, and testing of neural networks, large computing powers are needed. Neural networks are just a tool for modeling intellectual activity. The proposed computer expert system can be implemented using high-level programming languages C ++, C #, Java, JavaScript, Python, PHP, Delphi, etc.

IV. CONCLUSIONS

Let's summarize the application of product rules and neural network modeling to develop an intelligent decision support system for optimizing the control of investment analysis and projecting processes in the form of a computer expert system.

The analysis showed that modern computer software systems designed to evaluate the results of investment design use only one specific algorithm and are not capable of self-learning. Therefore, when changing the market situation, we must abandon the use of such systems or modify the algorithms used in them. Moreover, even during the regular use of such a system, it can incorrectly evaluate many projects, since the market situation is very volatile and may not correspond to the algorithm used in the system.

In this paper, we analyze the possibilities of using product rules and neural network knowledge modeling to develop and create an intelligent decision support system for optimizing the control of investment analysis and projecting processes in the form of a computer expert system.

Thus, the work describes the development of a computer-based intellectual decision support system to optimize the control of investment analysis and projecting processes based on expert system technologies and knowledge modeling using production rules and neural networks. Approbation of the obtained results on model examples is carried out, the results of which prove the effectiveness of its creation and application. Use of the developed intellectual computer system will allow to have at the disposal of the economic subject an effective toolkit for an estimation of possibilities of realization of various industrial and commercial investment projects.

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