www.czasopisma.pan.pl PAN www.journals.pan.pl

jet INTL JOURNAL OF ELECTRONICS AND TELECOMMUNICATIONS, 2021, VOL. 67, NO. 2, PP. 163-168
Manuscript received August 7, 2020; revised April, 2021 DOI: 10.24425/ijet.2021.135959

Intelligent System in the Context of Business Process Modelling

Svetlana A. Yaremko, Elena M. Kuzmina, Nataliia B. Savina, Konrad Gromaszek, Bakhyt Yeraliyeva, and Gauhar Borankulova

***Abstract*—The article deals with the features and characteristics of intelligent systems for modelling business processes. Their classification was made and criteria for comparison were developed. According to the comparative analysis of existing expert systems for intelligent analysis, a reasonable choice of system for modelling business processes of a particular enterprise has been carried out. In general, it was found that the introduction of intelligent systems for modelling business processes of the enterprise and forecasting its activities for future allows management of the company to obtain relevant and necessary information for the adoption of effective management decisions and the development of a strategic plan..**

***Keywords*—business process, automation, simulation modelling, intelligent system, expert system, intelligent analysis, forecasting**

I. Introduction

IN submitted the current context, where the intensification of various political and socio-economic factors affects the state of the economies of many countries, the competitiveness of enterprises increasingly depends not only on existing production capacities but also on effective management efforts to respond rapidly to changes in the external environment. Nevertheless, the increase in the volume of input data, the importance of taking into account a large number of interrelated and interdependent factors and their transience determines the need to use of information technology that would ensure the rapid data mining in conditions of incompleteness, uncertainty, the ambiguity of incoming data. Therefore, the relevant and important direction of scientific research at present is the development and implementation of intelligent systems for modelling and forecasting business processes of enterprises and effective support for making management decisions.

Analysis of scientific works of such Ukrainian and foreign scientists as A.A. Barsegyan, M.Glibovets, E.A. Vlasova, R.V. Duma, B.V. Kuzmenko, G.F. Ivanchenko, J. Lyuger, D. Waterman, O. A. Chaikovsky and others have shown the necessity to continue research on systems development for simulation modelling of economic processes based on artificial intelligence and expert estimation technologies.

The purpose of the article is an analytical review of the areas of application and functional capabilities of modern systems of modelling management activities on the basis of data mining and expert assessment, the development of criteria for a reasonable choice of an intelligent system for modelling business processes of the enterprise and the implementation of simulation modelling of business processes of a particular enterprise, as well as conducting of intelligent analysis employing the chosen system.

II. Main Results

In modern conditions of continuous scientific and technological progress, enterprises should constantly improve their IT infrastructure for successful business development, image improvement and business reputation. At the same time, the conceptual stage in this field of development is the creation and implementation of expert systems (ES). Expert system refers to an intelligent information system that, unlike others, can be used as a consultant that helps to solve a specific task or as an expert that is directly evaluating the task. [1]. The expert system consists of a knowledge base, a logical output mechanism and a subsystem of justification (Fig. 1).

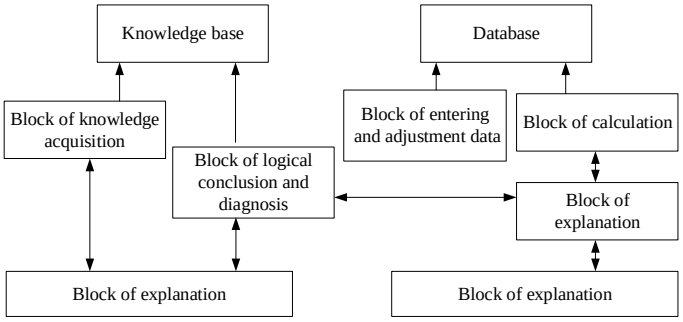

Fig. 1. Structural elements of the economic expert system

Expert knowledge can be described as a combination of theoretical understanding of the problem and practical skills of its solution, the effectiveness of which is proved by the practical work of experts in this area [2]. Today, the expert systems are used in various areas and sectors of the economy, in particular, for developing and evaluating enterprise development programs; formation of its investment portfolio; distribution of financial and other strategically important resources etc.

It should be mentioned that software based on the technologies and methods of data mining, greatly extends the range of

Svetlana A. Yaremko and Elena M. Kuzmina are with Vinnytsia Institute of Trade and Economics of Kyiv National University of Trade and Economics (e-mail: svitlana_yaremko@ukr.net, lenakuzmina@ukr.net).

Nataliia B. Savina is with National University of Water and Environmental Engineering, Rivne, Ukraine (e-mail: n.b.savina@nuwm.edu.ua).

Konrad Gromaszek is with Lublin University of Technology, Lublin, Poland, (e-mail: k.gromaszek@pollub.pl).

Bakhyt Yeraliyeva is with Taraz State University after M.Kh.Dulaty, Kazakhstan (e-mail: b_eral@mail.ru).

Gauhar Borankulova is with Taraz State University after M.Kh.Dulaty, Taraz, Kazakhstan (e-mail: b_gau@mail.ru).

complex professional tasks, the solution of which can be automated. At the same time, there are a number of requirements regarding the possibility of expert systems design in a particular area, in particular, it includes:

- the availability of experts in this field;
- the presence of a single assessment of the proposed decision on the developed expert system;
- the ability of experts to express in a natural language and explain the methods used by them;
- the possibility of solving the problem by considerations, not the actions;
- moderate complexity of the task;
- the clarity and structuring of the task (the basic concepts, relations and methods of solving the problems that are known to the expert should be distinguished).

The main requirement for the creation of the expert systems is to achieve high quality and speed in order to fulfil the desired objectives. To this effect, it must be monitored and updated throughout the life cycle of the expert systems. With this approach, the expert systems have already begun to function since the creation of the tool for the formalization of knowledge and are ready for practical application when introducing the first "portion" of expert knowledge, which allows finding a certain empirical solution to a specific task. At the same time the tasks must satisfy the following conditions:

- the possibility of a solution using symbolic considerations, and not manipulations with numbers, as it is implemented in mathematical and traditional programming;
- heuristic rather than algorithmic character (for the decision it is necessary to use the heuristic rules);
- the economic effect of fulfilling the task should justify the costs of developing the expert systems, but the task should not be excessively complex (the decision takes an hour for the expert, not weeks);
- practical significance of solving problems using the expert systems.

It should also be mentioned that the use of the expert systems is justified in that case when the use of a human expert is impossible or if there are not enough experts. Furthermore, it is important to take into account the aspects of the necessity of carrying out the examination at the same time in different places and the transfer of information to the expert, in which there is a loss of time or information that the company cannot afford. All this proves the expediency of developing and using the expert systems in various spheres and industries[2, 3, 4].

At present, a large number of expert systems has been developed, which it is customary to classify by type, instrumental means, purpose, functions, etc. (see Fig. 1) [5, 6].

It is essential to summarize the features of the expert systems, listed in the classification in Fig.2.

Independent expert systems work directly in the mode of consultation with the user for specific "expert" tasks, for which it is not necessary to attract traditional methods of data processing (calculations, simulation, etc.). Independent ones include, in particular, the expert systems Index, which supports the development of consulting systems [1, 2, 3].

Hybrid expert systems represent a program complex, aggregate standard application packages (for example, mathematical statistics, linear programming or database management systems and so on) and knowledge manipulation tools. This can be an intelligent superstructure over an RFP or an integrated environment for solving a complex task with elements of expert knowledge. The examples of hybrid expert systems are KEE, KnowledgeCraft, ART, etc. [1–4].

The surface expert system provides an opportunity to form knowledge about the field of expert assessment in the form of certain rules (condition action).

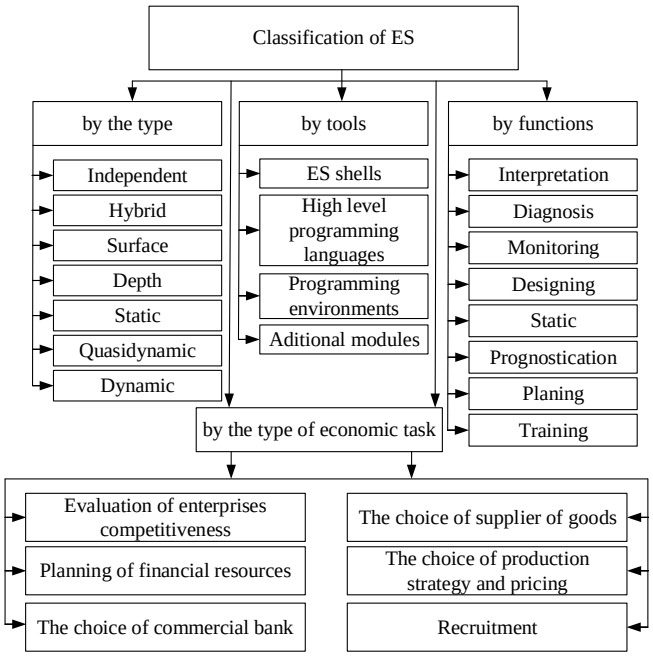

Fig. 2. The classification of expert systems.

The condition of each rule defines an example of a situation in which a rule can be fulfilled. Finding a solution means to execute those rules whose samples are compared with the current data. It is supposed that in the process of finding a solution, the sequence of situations shaped in such a way will not be broken until a solution is obtained, that is, there will not be an unknown situation that is not in line with any rule. An example is Fuzzy CLIPS 6.02, an expert system shell based on rules and used to represent and manage unclear facts and rules [1, 2, 4].

Depth systems include all the capabilities of surface systems, but in addition, when an unknown situation occurs, it is possible to determine with some general principles, actions for a particular area of expertise that should be performed. It is possible to attribute the CLIPS to the expert systems through the possibilities of mapping the facts and rules and determining which rules need to be activated.

Static expert system is often designed and implemented in subject areas where the knowledge base and interpreted data do not change over time (diagnosis of the technical state of devices and systems). An example of such a system is R1 / XCON (XCON – eXpert CON figurer [1, 2, 3, 5].

Quasidynamic expert systems interpret a situation that changes with some fixed time intervals. They include, in particular, the microbiological expert systems, where the laboratory measurements are carried out during the process with a certain interval and the dynamics of the obtained indicators towards the previous measurement was analysed. This type includes such expert systems as Mycin, STD Wizard and others.

Dynamic expert systems work in conjunction with object scanners in real-time with a constant interpretation of incoming data (management of flexible production complexes, monitoring in intensive care chambers, etc.). Among the modern commercial systems, it should be pointed out the G2 expert panel of the American firm Gensym (USA) as an expert commercial system for dealing with dynamic objects, as well as OMEGAMON – an expert multi-agent dynamic system that functions in real-time and monitors unusual circumstances for objects of the corporate information system, [1, 3, 5].

These types of expert systems can be implemented on the basis of such tools as software shells. The prototypes are certain applied expert systems, which have proven themselves to solve problems of a concrete type. The components that are specific to a certain subject area are removed from them. Examples of expert systems of this type are EMCYN and M.4 among others.

Using a high-level programming language for the development of the expert systems, in particular, OPSS, it is possible to realize the division of BK into segments; to manage data output; to provide the ability to connect to the system of any external functions implemented in C [5, 6].

Programming environments provide the developers with expanded capabilities through a set of software tools, they can combine in the expert systems development process. Based on this concept, there have been developed such products as BABYLON, MIKE, etc. [5].

Additional modules are independent software tools for solving specific tasks. A good example is a module for working with a semantic network of the VT system, which allows tracing the relationships between values of new and previously set parameters in the process of project development [5].

As for the expert systems classification of functions, one of the first is the interpretation, which implies the definition of the content of data, which must be consistent and correct. The expert systems, which implements this function, include SIAP, REACTOR, FALCON, and others [1, 2].

The diagnostic function in the expert systems is defined as the detection of deviations from the normality in a certain system. At the same time, an important feature is the need to understand the functional structure of the system to be diagnosed. The prime examples of the expert systems, that are responsible for the diagnosis, are, in particular, CRIB (used to diagnose errors in equipment and PC software) and ANGY (diagnoses the narrowing of coronary vessels) [1, 2].

The main characteristic of the monitoring function is the continuous interpretation of data in the real-time and timely notification about the deviation of system parameters from the norm. Problematic issues are the omission of an alarming situation and "false" activation. Qualitative monitoring of such complex systems as electric and nuclear power plants, as well as large systems of big industrial enterprises, allow the implementation such systems as SPRINT, REACTOR, FALCON, etc. [1, 7].

The design function in the EU is to prepare specifications for the creation of "objects" with predefined properties. In this case, the specification is defined as the whole set of necessary documents: drawings, explanatory statement, etc. Among the features, it should be mentioned the need for a structured description of knowledge about the subject of research. To organize effective designing, it is also necessary to form clearly both the design decisions and the motives for their adoption. In order to implement the designing processes, in particular, in the computer field, there are the ES XCON, CADHELP, SYN, and others [1, 2].

Forecasting in the expert systems allows deducing logically the probable consequences from the given situations. In a predictive system, a parametric dynamic model is usually used, where the value of the parameters are "fitted" for a given situation. Modelling results are the basis for forecasting with probable estimates. Among systems that realize forecasting in the economy today, the most popular are PLANT, ECON, Project Expert, etc. [1, 2].

The planning function in the expert systems means the development of an action plan for modelling the behaviour of real objects in order to eliminate logically the consequences of planned activities. The examples of expert systems for planning are STRIPS (robot behaviour planning), ISIS (industrial order planning), MOLGEN (experiment planning).

The expert systems, which implement the educational functions, provide a dialogue with a student during training and can diagnose mistakes in studying any discipline via PC and suggest the right decisions. A prominent example of the expert systems of this type is PROUST, which provides Pascal learning [11, 12, 13].

The above-mentioned types of expert systems and the functions they implement have been widely used nowadays to solve plenty of economic challenges. Thus, one of the most prospective areas of expert systems application in the economic sphere is the assessment of the company's solvency. The purpose of the expert systems is to determine the possibility of providing a loan to the company from the bank for the implementation of a certain project. The enterprise must provide feasibility studies and financial statements. As a result of the analysis of the aggregate rating of the company, which is calculated as a factor of confidence, as well as a comparison of the bank's ability with the terms of the lending (size, interest rate, term, etc.), the bank makes decisions about lending or refusing a loan.

The expert systems for planning financial resources of the enterprise can determine the sources of financial development of the company, depending on its strategic objectives, capital structure, the state of commodity, credit and stock markets. In case of lack of own funds, it is determined the possibility of obtaining loans, issuing shares or bonds and the most optimal result is chosen [14].

Nowadays, among the most popular expert systems are those, that allow selecting the banks for financial services of the enterprise, considering its needs for conducting cash-settlement, credit, deposit, trust operations. The foundation of building the expert systems is an economic analysis of the enterprise, which involves identifying requirements for financial services of the enterprise. For example, the dimension of production, marketing and procurement activities – requirements for the urgency and forms of cash payments; presence/absence of free funds – requirements for deposit/credit operations. According to the set of requirements, a choice is made from the database of the list of similar banks, which are additionally tested in terms of financial reliability and the possibility of transactions in certain sizes [15].

The expert systems for selecting a supplier of products allows making a reasonable choice of a reliable supplier, taking into account the required level of quality, prices, technical service

and delivery conditions. However, the quality and prices are determined by the features of the product strategy and delivery terms (delivery, payment) – by specificities of the financial situation of enterprise – recipient of products. According to the prevailing requirements of supplied products, the potential suppliers from the database are selected and tested about financial condition and assessment the reputation of the supplier (breaches of terms of delivery and reclamation) [1, 2, 7].

The choice of production strategy by means of expert systems is based on the analysis of industrial, scientific, technical, financial and marketing potential of the company and the competitiveness of its products [6].

TABLE I
ASSESSMENT CRITERIA
FOR BUSINESS MANAGEMENT INFORMATION SYSTEMS

The criterion	The description of the criterion	The grade of manifestation of criteria
Purpose	For solving tasks that do not require complex calculations, modelling and are realized in autonomous mode.	–+
	For tasks that require the implementation of applied modelling programs, the use of rules and conditions, that are changed with the certain fixed time-interval.	++
	For solving complex diagnostic and modelling tasks with input processing in real-time with permanent interpretation.	+++
Functionality	The standard set of functions.	–+
	The extended set of functions.	++
	The full range of functions for intelligent analysis, diagnosis, modelling and forecasting.	+++
Modularity and integration	The splitting into certain modules and inability of integration.	–+
	Providing the opportunity for integration of functions to be based on separated modules.	++
Prevalence	For one sphere or field.	–+
	For different spheres and areas.	++
Tools for creation	The programme envelopes.	–+
	The high-level programming language.	++
	The development environments with additional modules.	+++
Duration of development and implementation	The medium duration.	++
	The long duration of development and implementation.	–+
Difficulty in settings	Acceptable; it does not require special training.	++
	It requires training and attracting highly qualified specialists.	–+

The choice of pricing strategy in the expert systems is carried out with taking into account the effects of the type of market (various combinations of competition and monopoly), elastic demand, the level of costs in the company and its position in the market and so on. These qualitative parameters of the market state are derived from the database about the behaviour of competitors on the market and the state of production and sales of the company [1, 2, 6].

The expert systems, used for recruitment, allows forming a list of vacancies, which can be claimed by the candidate who has applied to the human resource department of the enterprise (employment service). The peculiarities of solving the problem are related to the fact that the expert system is configured to the requirements and characteristics of the applicant. Thus, on the basis of personal data, the calculation of the candidate rating for all relevant positions is carried out.

The professional, business and psychological qualities of the candidate are also tested. On the database of vacancies and satisfaction of the candidate's requirements is checked for selected positions [1, 2, 3]. Obviously, in this case, it is necessary to provide information security of confidential data on the basis of selected modes and the appropriate class of protection of valuable information [6].

The consideration and analysis of requirements for expert systems as well as expert systems types; tools for their development; the main functions and characteristics and, depending on the specifics of solving economic problems, according to the classification given in Fig. 1, allow developing of evaluation criteria for the possibility of improving their analysis and comparison, using the following symbols for the various degrees of manifestation of the criterion: "–+ "– the criterion is not fully reflected; "++" – the average degree of manifestation of the criterion; "+++" – the highest degree of manifestation of the criterion. The list of criteria, their features and degrees of manifestation are presented in Table I.

The assessment of the most commonly used intelligent systems for business process modelling was made using these criteria. The evaluation results are presented in Table II.

TABLE II
COMPARATIVE CHARACTERISTICS OF BUSINESS PROCESS MANAGEMENT
INTELLIGENT SYSTEMS

system name/ criterion	CLIPS	Mycin	OMEGAMON	ART	EMCYN	Project Expert
Purpose	+++	+++	++	++	++	++
Functionality	+++	+++	++	++	++	++
Modularity and integration	++	++	++	++	++	++
Prevalence	++	++	++	++	++	++
Tools for creation	–+	–+	++	–+	–+	–+
Duration of development and imple-mentation	–+	–+	–+	–+	–+	–+
Difficulty in settings	–+	–+	++	–+	–+	++

According to the comparative analysis of business process management intelligent systems from table II, it can be concluded that such systems as CLIPS or Mycin have the most functional capabilities. However, they are more complex in development and implementation. The ability to integrate individual modules is inherited in all considered IS. CLIPS and Mycin also have the widest coverage areas. At the same time, based on the completeness of functionality combined with the simplicity of settings and operation, Project Expert can be considered the best one for business processes modelling [6].

According to the comparative analysis of business process management intelligent systems from Table II, it can be concluded that such systems as CLIPS, Mycin have the most functional capabilities. However, they are more complex in development and implementation.

The ability to integrate individual modules is inherited in all considered IS. CLIPS and Mycin also have the widest coverage areas. At the same time, based on the completeness of functionality combined with the simplicity of settings and operation, Project Expert can be considered the best one for business processes modelling.

We illustrate the application of the Project Expert system for forecasting business processes, with the help of an existing enterprise example, which is engaged in the production and selling of bakery products to the population. At the initial stage of simulation in the Project Expert environment, the introduction and adjustment of initial indicators for the financial environment, the list of products and services and the main types of deductions are implemented. Then, the forecasting of investment development is carried out and a calendar plan is established that regulates the implementation of the main stages of the enterprise in the procurement and operation of the equipment, the start of the production process.

The next stage is to create an operational plan that includes the definition of personnel costs and other costs of the enterprise, as well as forecasting and reflecting the sales volumes of the produced products.

After inputting of the initial data and the formation of an investment and operational plan, in the Project Expert system there is a possibility of automated calculation of the indicators of the enterprise during the projection period (Fig. 3).

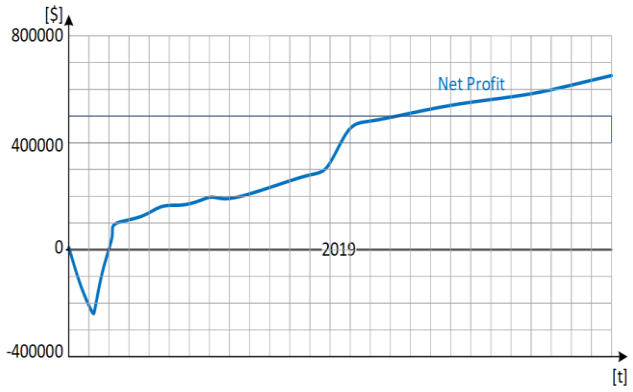

Fig. 3. Category 1 and category 2

The submitted graphic analysis showed that there is a dynamics of net profit growth during the projection period after the return of initial investments in 2018.

Also, with the help of the Project Expert system, it is possible to obtain a calculation of the financial performance of the company throughout the project implementation period [8].

The next stage of an automated calculation is to obtain a break-even point based on the comparison of direct and constant costs. This indicator represents the volume or level of operations when total income is equal to aggregate expenses, that is the point of zero profit or zero loss [9] (Fig. 4).

These reviews have highlighted that the will reach a break-even point with total expenses equal the volume of sales of goods in the amount of 2 411 478.

One of the important tasks of intelligent analysis by means of Project Expert is the definition of the limit values of the deviations of the project parameters from the set values under which the project is considered to be effective. As the indicator, it is usually taken the payback period, and as parameters, there are the ones that have the greatest impact on these indicators [10].

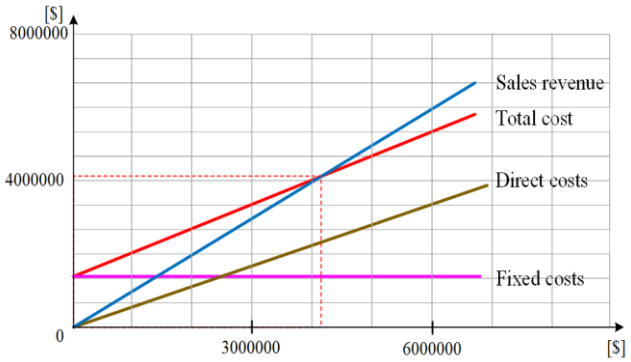

Fig. 4. Category 1 and category 2

The analysis result can be executed graphically. The intersection of the line representing the parameter value with the horizontal axis corresponds to the extreme value of the deviation of the parameter from the current value at which the project is effective (Fig. 5). The graph presented in Figure 5 presents that direct costs have the greatest impact on the efficiency of the enterprise. At the same time, the maximum increase in the direct costs under the condition of the profitability of the project can reach 50%.

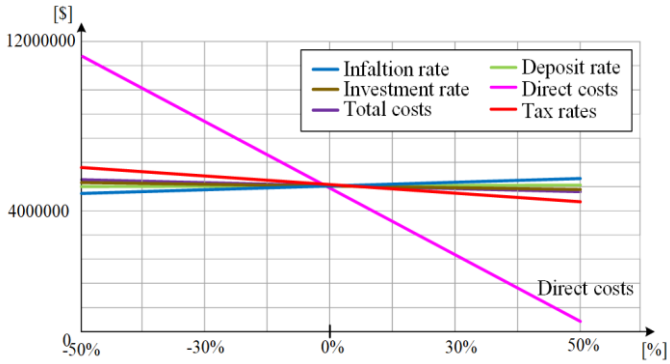

Fig. 5. The sensitivity analysis

The important role among the statistical indicators plays the result of calculating the sustainability of the project. In our case, it is 100%, so it is very likely that the project can be completed. Otherwise, there is the risk of a shortage of funds (Table III).

TABLE III
THE STATISTICAL ANALYSIS OF THE PROJECT

Investment efficiency	The average	Uncertainty
Discount payback period	11	0
Profile Index	7,08	0,02
Net present value	5110652	0,03
Internal rate return	799,09	0,03
Payback period	10	0,06
Average rate of return	439,26	0,02
Modified rate of return	216,86	0,02

In conclusion, on the basis of simulation modelling of the enterprise Project Expert system during the projection period, it is managed to get the resulting operating indicators and financial statements and assess the efficiency of the project. In general, the indicators of profits and losses, liquidity analysis, payback period and the effectiveness of investment over the projection period have proved the efficiency of the operational and financial plan and investment attractiveness of the analyzed enterprise.

CONCLUSION

To summarize, the research on intelligent business process modelling systems allowed identifying their main features and characteristics; to classify them and to develop criteria for comparison. According to the completed comparative analysis, a well-founded choice of system for simulation of business processes of the enterprise and their intelligent analysis was carried out. On the basis of the selected Project Expert system, a simulation of the business activity of a particular company during the projection period was carried out and automated analysis of the resulting modelling indicators was made. Thus, the obtained net profit and current and urgent liquidity indicators during the projection period showed the effectiveness of the developed investment and operating plan. The calculated value of the break-even point has allowed establishing that total costs equal the volume of sales of products in reaching 2 411 478. The payback period of the developed project was 7 months, which confirmed the investment attractiveness of this enterprise. The Project Expert tools have been also used to determine the limit values of the project parameter deviations from the set values under which the project is effective and it is established that the calculated sustainability index suggests that the project can be completed.

So, in general, it may be mentioned that the introduction of intelligent systems for business processes modelling of the enterprise and forecasting its activities for future periods will enable the management of the company to obtain relevant and necessary information for the adoption of effective management decisions and the development of strategic plans.

REFERENCES

[1] B. V. Kuzmenko, and O. A. Chaikovska, "*The systems of artificial intelligence*," Kyiv, Alterpres, 2006.
[2] H. F. Ivanchenko,"The systems of artificial intelligence," Kyiv, KNEU, 2011.
[3] D. F. Liuher, "*The artificial intelligence: strategies and methods of solving difficult issues*," Moscow,Vyliams (in Russian), 2003, pp. 866.
[4] A. A. Emelianov, E. A. Vlasova, and R. V. Duma, "*Simulation modeling of economic systems*," Moscow,Finansyiistatistika(in Russian), 2002.
[5] D. Waterman, "*Guide to expert systems*," Moscow, Myr, 1989.
[6] A. A. Barsehian, M. S. Kupryianov, V. V. Stepanenko, and Y. Y. Kholod, "*Methods and models of data analysis: OLAP and Data Mining*," St-Petersburg, BKhV, 2004.
[7] V. Mashkov and A. Smolarz and V. Lytvynenko, "The problem of system fault-tolerance," *Informatyka Automatyka Pomiary w Gospodarce i Ochronie Środowiska* (IAPGOŚ), 4(4), pp. 41-44, 2014.
[8] Z. Omiotek and W. Wójcik, "The use of Hellwig's method for dimension reduction in feature space of thyroid ultrasound images," *Informatyka, Automatyka, Pomiary W Gospodarce I Ochronie Środowiska*, 4(3), pp. 14-17, 2014.
[9] P. V. Poliakov, and S. A. Korobov, "Software tools for developing business plans: Project Expert system," *Volhohrad*, vol. HU, pp. 48, 2004.
[10] H. S. Prokudin, M. T. Dekhtiaru, "*Simulation modeling in informational systems*," Kyiv:NTU., no. 9, pp. 181–189, 2004.
[11] A. P. Rotshtein, and H. B. Rakytyanska, "Diagnosis problem solving using fuzzy relations," *IEEE Transactions on Fuzzy Systems*, vol. 16, no. 3, pp. 664-675, 2008.
[12] S. I. Vyatkin, A. N. Romanyuk, and Z. Y. Gotra, "Offsetting, relations, and blending with perturbation functions," *Proc. of SPIE 10445*, 2017.
[13] L. I. Timchenko, S. V. Pavlov, N. I. Kokryatskaya, et al. "Bio-inspired approach to multistage image processing,"*Proc. of SPIE 10445*, 2017.
[14] M. F. Kirichenko, Yu. V. Krak, A. A. Polishchuk, "Pseudo inverse and projective matrices in problems of synthesis of functional transformers," Kibernetika i Sistemnyj Analiz, vol. 40, no. 3, pp. 116-129, 2004.
[15] K. G. Selivanova, O. G. Avrunin and S. M. Zlepko, "Quality improvement of diagnosis of the electromyography data based on statistical characteristics of the measured signals,"*Proc. of SPIE 10031*, 2016.