Обґрунтовано концепцію інтелектуалізації інформаційного забезпечення управління підприємством на прикладі моделювання інформаційної системи бухгалтерського обліку, засновану на поєднанні та інтеграції комп'ютерних технологій і штучного інтелекту. Запропоновано методи моделювання та визначено архітектоніку моделі бази знань при вирішенні завдання щодо формування облікової політики підприємства

Ключові слова: інформаційне забезпечення управління, облікова політика, інтелектуальна система, бухгалтерська інформація, обліковий процес

Обоснована концепция интеллектуализации информационного обеспечения управления предприятием на примере моделирования информационной системы бухгалтерского учета, которая базируется на интеграции компьютерных технологий и искусственного интеллекта. Предложены методы моделирования и определена архитектоника модели базы знаний при решении задачи формирования учетной политики предприятия

Ключевые слова: информационное обеспечение управления, учетная политика, интеллектуальная система, бухгалтерская информация, учетный процесс

UDC 004.89:65.014.1
DOI: 10.15587/1729-4061.2017.111859

FORMING CONCEPT OF INTELLECTUALIZATION INFORMATION PROVISION OF MANAGING AN ENTERPRISE

A. Grinko
Doctor of Economic Sciences, Professor*
E-mail: grinko.alla@gmail.com
T. Bochulia
Doctor of Economic Sciences, Associate Professor*
E-mail:bochulya@i.ua
P. Hrynko
PhD, Associate Professor**
E-mail: pavelgrinko@gmail.com
I. Yasinetska
Doctor of Economic Sciences,
Associate Professor, Head of Department
Department of geodesy and land management
State Agrarian and Engineering University in Podilya
Shevchenka str., 13, Kamianets-Podilskyi, Ukraine, 32300
E-mail: yia240479@meta.ua
Ia. Levchenko
Mykolas Romeris University
Ateities str., 20, Vilnius, Lithuania, LT-08303
Assistant
Department of Economics and Entrepreneurship
Kharkiv National Automobile and Highway University
Yaroslava Mudroho str., 25, Kharkiv, Ukraine, 61002
E-mail: slavalevcenko1984@gmail.com
*Department of Accounting, Audit and Taxation***
Department of International Economics*
***Kharkiv State University of Food Technology and Trade
Klochkivska str., 333, Kharkiv, Ukraine, 61051

1. Introduction

The new stage in the development of Ukrainian economy is characterized by a combination of changes associated with the communication phenomenon of the world's informational space, generation and dissemination of scientific and intelligent decisions and introduction of new technologies. The sign of the modern globalized world is definition of knowledge and technologies as factors of production which in turn has affected formation of an informational economy characterized by intensity of the processes of informatization and intellectualization.

Information for management has gained a new meaning in the context of managerial influence on decision-making and data interpretation in accordance with the assigned tasks. Accounting and analytical support of management is a source of relevant information characterized by clarity, transparency, reliability, timeliness and accuracy, which is leveled in other systems of informational support of decision-making. Present-day capabilities of information and communication technologies have made it possible to modify operations of processing, transmission and storage of data by means of changing the qualitative parametrization of the informational environment of the enterprise. Today, the complex information system reflecting the processes and phenomena in the enterprise, its state and prospects of development and covers not only the issues of optimization of economic relations but also social and environmental aspects of economic activity is relevant. This became possible due to development of not only technological innovations but also

the intelligent component of informational processes which made it possible to improve efficiency of the technical, methodological, organizational, technological, communication and professional support of the accounting process.

The tendencies of development of modern software systems based on various design principles enable formation of a new concept of intellectualization of the information system for accounting based on integration of computer technologies and artificial intellect. Modeling of information technologies for accounting ensures flexible adaptation to the specifics of accounting activity of various user categories and promotes close integration with other management subsystems. The expert judgement of complexity of the task of forming enterprise accounting policy is expressed by a great number of rules (products). This is an indication that such a task belongs to the systems of high complexity and has a considerable dynamism concerning modification of economic and legal support. Thus, the defined issue requires intensive study for the purpose of searching ways for effective provision of knowledge and the mechanisms of logical derivation.

2. Literature review and problem statement

The intensive development of information technologies is focused at revision of the organizational concept of accounting with consideration of global trends.

The need to preserve competitive advantages and strengthen business positions in the market causes transformation of the information sphere of decision-making with creation of a developed management infrastructure. Such changes orient scientists to improve methodical tools of accounting as a complex category in conditions of expanding functionality of current software products. The interest to software is significant and a sufficient number of studies are dedicated to discussion of corresponding information technologies in economic and computer related publications. However, in many cases, these publications consider either a concrete issue of computerization problematics or abilities of individual solutions.

Summarizing of the present-day theoretical opinions of scientists on application of system studies and managerial innovations to the processes of modeling information technologies for accounting contributes to determining a wide range of scientific problems to be solved. These include:

– lag of theoretical studies in development of the accounting methodology as an informational function of supporting business procedures;

– imperfect organizational mechanism for adaptation of development of accounting programs to conditions of ecological and social instability of the external and internal environment of enterprises;

– absence of a theoretically substantiated methodology for modeling intelligent accounting systems.

At present, a detailed assessment of globalization coefficients [1] and economic independence of countries [2] is proposed in literature which makes it possible to analyze effectiveness of the state policy regarding integration into the global economic community. Scientists have elaborated new methods for obtaining of effective models of enterprise development considering factors of external influence [3]. Practical approaches to improvement of information support of management are offered based on assessment of internal and external economic environment [4]. A positive manifestation of the information support for business was substantiated recognizing analytics as a strategic differentiator for management [5]. A new concept of accounting with qualitatively new parameters has been developed based on formation of informational and analytical support of management [6]. A new place of intellectual capital in the system of management and intensification of enterprise activity has been defined as a decisive factor of production [7]. The new dimension of information resources in business processes and expansion of competence of enterprise activity has been described through formation of accounting and analytical support of decision making [8]. Importance of knowledge economics in the environment of globalization challenges was considered [9]. Accounting engineering was considered [10] for better understanding and rising significance of the issue of formation of accounting policy. Qualitative and quantitative criteria of assessing efficiency of enterprise activity were characterized with elaboration of timely measures for improving the management process [11].

Thus, the relevance of studies aimed at organization of a modified information subsystem of enterprise management through implementation of technologies and approximation of theoretical and methodological foundations of the modern management concepts is growing in the conditions of intelligent re-designing of economic relations.

3. The aim and objectives of the study

The study's aim was to create a theoretical and methodological basis for implementation of new information technologies to improve accounting and analytical support for enterprise management through modeling the knowledge base as an informative basis for decision making in conditions of communication phenomenon.

To achieve the assigned goal, the following tasks were solved:

– implementation of the concept of technological information management in formation and development of accounting and analytical support for enterprise management was substantiated;

– methods for modeling and formalizing the processes of choosing components of the accounting policy for formation of accounting and analytical support for enterprise management were characterized;

– architectonics of the knowledge base construction model for solving the problem of formation of enterprise accounting policy in an intelligent accounting system was defined.

4. Materials and methods of studying accounting modeling in integration with innovative technologies

The methodological basis of the study was the dialectical method which made it possible to study implementation of innovative technologies in the accounting practice with adaptation to the methodological principles of the accounting and analytical process. Theoretical substantiation is based on observations and analytical work in defining tendencies in integration of technological and intelligent decisions in processing, transmission and storage of information.

To construct architectonics of the integrated subsystem for accounting and analytical support of management, the method of the complex-target system approach and logic simulation was used. To optimize the mechanism of processing and formation of information for management in a computerized decision-making system, economic and mathematical methods and packages of present-day applications were used. Study of the technological support for improving accounting and analysis, architectonics of the accounting and analytical process in conjunction with modern software solutions was based on the method of analogy.

5. The results obtained in the study of theoretical and organizational aspects of intellectualization of information support of enterprise management

The national economy is characterized by the prospects of technological development of economic entities. It has a positive impact for integration into the world community of countries with a sustainable development of economic and social systems.

Ukraine's world rating is changing under the influence of external factors and has not yet attained a stable position. In 2015, the country's development rate [1] was:

1) global innovation index: 36.45 points (64th out of 141);

2) global competitiveness index: 4.03 points (79th out of 140);

3) index of economic globalization: 67.52 points (56th out of 207);

4) index of social globalization: 59.95 points (69th out of 207);

5) index of human development: 0.747 points (81st out of 188).

In 2015, index of economic independence of Ukraine was 46.9 points for ten criteria of which high results were obtained in the following spheres [2]:

– trade freedom: 85.8;
– tax freedom: 78.7;
– monetary freedom: 78.6;
– freedom of investment: 15.0 (the lowest points);
– protection of property rights: 20.0;
– freedom from corruption: 25.0;
– state expenditures: 28.0.

According to the global innovation index, Ukraine has shown rating growth occupying the 64th place among 141 countries in 1995. Achievement of this positive result was due to development of institutions, human capital and research and business. Almost unchanged was development of the domestic market, development of knowledge and technology and the results of creative activity. Over the past 4 years, Ukraine's position was stable for the global innovation index and the indices of human capital, researches and development of knowledge and technologies.

Under the influence of technological transformation of economy, requirements to accounting and analytical information is realized in managerial decisions promoting enterprise development is toughening. But its current state is characterized by non-compliance with the requirements of development of economic activity which takes place in conditions of formation of information economy. However, as the research showed, growth of Ukraine's rating in the global innovation index among the world countries is observed (Table 1).

Over the past 4 years, Ukraine's position has been stable by the indices of global innovation, human capital, researches and development of knowledge and technologies.

Improvement of enterprise activities is accompanied by modification of the management concept with organization of information and communication links of various levels as a whole while actualizing the accounting practice in the information efficiency of the accounting information for internal and external users. Scientific literature describes in detail the nature of economic innovations emerged in connection with the processes of uncertainty, i. e. chaos [3].

Table 1

Dynamics of components of the global innovation index of Ukraine

Components of innovation potential	2011		2012		2013		2014		2015	
	point	place	point	place	point	place	point	place	point	place
Global innovation index	35.01	60 of 125	36.1	63 of 141	35.78	71 of 142	36.3	63 of 143	36.45	64 of 141
Innovation incoming sub index	39.59	67	38.0	78	37.91	83	38.2	88	39.06	84
Institutions	51.0	103	40.0	117	51.4	105	52.9	103	52.2	98
Human capital and studies	44.3	40	42.2	48	37.9	44	36.6	45	40.4	36
Infrastructure	21.5	101	27.1	98	26.0	91	27.1	107	26.3	112
Development of domestic market	39.6	64	38.7	68	44.0	82	45.1	90	43.9	89
Development of business	41.5	45	42.3	51	30.2	79	29.1	87	32.4	78
Innovation outcoming sub index	30.42	52	34.2	47	33.65	58	34.4	46	33.85	47
Development of knowledge and technologies	29.9	40	39.2	30	32.0	45	38.2	32	36.4	34
Results of creative activity	31.0	70	29.2	83	35.3	81	30.6	77	31.3	75
Index of innovation efficiency	0.77	40	0.9	14	0.9	31	0.9	14	0.9	15

The work [3] provides practical recommendations for enhancing professional thinking and ensuring integration of sustainable development into the enterprise models thus contributing to the expansion of key competencies. Each company chooses the option of creating, developing and maintaining value which collectively forms an individual structure of the model requiring improvement over time by adapting to the change of the concepts of economic system development. Management decisions, their informational support are connected with architectonics of the external model of the economic environment and situations arising from the decisions result [4].

The basis of development of accounting theory is interaction of various conceptual, managerial and positivist theories that influence integration of the internal processes. Conceptual changes are accompanied by discovery of new research objects which are information, technologies, scientific and intellectual resources that are objectively recognized as good factors of the present-day society development and modernization of economy.

Informatization and intellectualization have an effect on construction of a new socio-economic paradigm characterized by strengthening of interconnections and deepening of interdependencies between economic, social and environmental systems. Technological development of accounting and analytical support for enterprise management takes a key place in the process of coming into being of a modern information approach in development of economic relations.

Competitive advantages obtained by the enterprise possessing an information resource and rationally utilizing it are proved by the growth of other resources, lower risks and economic security.

For the present-day business, informational support is of a prior significance and has a material influence on business activity because analytics is defined as a strategic differentiator for management [5]. Consumers of economic information expect that consideration of support in making advanced decisions at the expense of building and using of an integrated data base will result in new information flows and compensation for absent information resources.

According to the conclusions drawn by specialists, computerization of accounting is realized not entirely (fragmentally) though functional abilities of modern program products ensure a full support for the accounting process. One of the causes of such inconformity is insufficient integration of the procedure and organization of accounting with present-day information and communication solutions. That is why analysis and systematization of the gained practical experience in modeling of accounting in conditions of employment of expert systems is of a scientific and practical interest.

The problem of rational organization of accounting is so many-sided and serious that it attracts a constant attention of theoreticians and experts. Scientists associate rational organization of accounting with proper information support of economic management. It is stressed that "the meaning-bearing objective of accounting consists of designing a system capable to generate information that becomes a strategic resource in the post-industrial society" [6]. Not discarding the idea of maximum information filtering, creation of information policy is realized based on the new technologies able to generate various systems and sources positioning them as information sources. Researchers pay their attention to an interesting fact that every four of five dollars that are spent by Levi Straus for production of a pair of jeans are spent on information but not the materials and that in tote, information expenditures make three fourth of the given cost for any product" [7]. Further formation of a separate data base for management provides for loading of the filtered information obtained from various sources and having an integral adjusted form satisfying demands and convenient for navigation and prompt analysis. There is a well-reasoned idea that "the accounting theory adapting to the requirements of the "new economy" needs rethinking of the notion of information and information resources from the position of semantic and informative aspect" [8]. Considering limitation of the accounting system concerning informational variety, "information and information resources should become an object of scrupulous study in the accounting theory in view of their importance and strategic character, leading role in the current environment of economic management and orientation for a long-run prospect" [8].

In its turn, the system of rational organization of the accounting process at concrete enterprises is detailed and regulated by the accounting policy. A decision on the choice of an accounting policy is made first and foremost proceeding from the analysis of a number of alternative approaches that take into account compromise between demands of profitability, cost-effectiveness, investment attractiveness, acceptability of the risk level, etc. Formation of the enterprise accounting policy (FEAP) becomes a common task for all agents of economic management and can be considered as an object of computerization, that is, the task of formation of the accounting policy is a constituent element of the enterprise accounting policy.

Any task of management includes two subtasks. The first one is identification of the state of the management system and the environment in which this system is functioning.

The task of state estimation belongs to a vast type of classification tasks and consists of attribution of a concrete object W to one of two sets W_1 or W_2 based on observation p of controlled parameters $x_1, x_2,..., x_p$. Standard procedure of classification consists of the following [12]. It is assumed that the vector of observations X has a normal distribution with parameters (m_1, Σ_1) if it belongs to a set W_1 and has a normal distribution with parameters (m_2, Σ_2) if this vector belongs to the set W_2. There vectors m_1 and m_2 assign mathematical expectations of components X at the taken assumptions and matrices Σ_1 and Σ_2 are dispersion matrices when $\Sigma_1=\Sigma_2$. A so-called discriminant function is entered:

$$z = \alpha_1 x_1 + \alpha_2 x_2 + \ldots + \alpha_p x_p. \quad (1)$$

Now, the object W is attributed to W_1 if $z>C$ and to W_2 in other case.

Parameters α_j, j=1, 2,..., p, and C necessary for the task solution are found in the following way [13].

If observation $X \in W_1$, then z belongs to normal distribution $N(\zeta_1, \sigma_z^2)$, but if $X \in W_2$, then z belongs to distribution $N(\zeta_2, \sigma_z^2)$ where

$$\zeta_1 = \sum_{j=1}^{p} \alpha_j m_{1j}, \quad \zeta_2 = \sum_{j=1}^{p} \alpha_j m_{2j}, \quad \sigma_z^2 = \sum_{i=1}^{p} \sum_{j=1}^{p} \alpha_i \alpha_j \sigma_{ij}^2.$$

The set α_j, j=1.2,...,p is chosen so that the Mahalanobis distance [13] between sets W_1 and W_2 that is calculated by formula

$$\Delta^2 = \frac{(\zeta_1 - \zeta_2)^2}{\sigma_z^2},$$

is minimum. The sought set is found by solution of the system of linear equations

$$\alpha_1\sigma_{11} + \alpha_2\sigma_{12} + \ldots + \alpha_p\sigma_{1p} = m_{11} - m_{21},$$
$$\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$
$$\alpha_1\sigma_{p1} + \alpha_2\sigma_{p2} + \ldots + \alpha_p\sigma_{pp} = m_1 p - m_2 p.$$

Now, the constant C is calculated by formula

$$C = \frac{1}{2}(\zeta_1 + \zeta_2).$$

The described procedure ensures minimum value of the total mixing probability.

A substantial drawback of the discriminatory approach lies in the extremely simplified partition of the whole set of observations into two alternative subsets. It is clear that accuracy and informativeness of the result of solution of the state diagnostics problem increases if the factor space is justifiably split not in two but more subspaces. This reasoning leads to the expediency of formulating and solving a problem of clustering the whole set of diagnosed objects. Standard procedures for solving the clustering problem are well known and described [14]. However, better informational capacity is provided by the methods that realize more multifactorial differentiation of possible enterprise statuses. Among these are methods of rank and regression analysis.

Let us introduce $(f_1, f_2, \ldots, f_n)$, a set of controlled parameters, the specific values of which characterize company's financial status. Divide the range of possible values of each parameter into several subranges. Let the range $\left(f_j^{(c)}, f_j^{(d)}\right)$ of possible values of the j-th parameter be broken into m subranges as follows:

$$\left(f_j^{(c)}, f_j^{(d)}\right) = \left[\left(f_j^{(c_1)}, f_j^{(d_1)}\right) \cup \left(f_j^{(c_2)}, f_j^{(d_2)}\right) \cup \ldots \cup \left(f_j^{(c_m)}, f_j^{(d_m)}\right)\right],$$

when

$$f_j^{(c)} = f_j^{(c_1)},\ f_j^{(d)} = f_j^{(d_m)},\ f_j^{(d_k)} = f_j^{(c_{k+1})},\quad k = 1,2,\ldots,m-1.$$

Each resulting subrange is given a class (rank) number that characterizes the financial status of the company. In this case, if the numerical value of the j-th parameter for particular i-th enterprise is f_{ij}, then the corresponding class number k_{ij} is determined from the conditions:

$$k_{ij} = \begin{cases} 1, & \text{if} \quad f_j^{(c_1)} \le f_{ij} < f_j^{(d_1)}, \\ 2, & \text{if} \quad f_j^{(c_2)} \le f_{ij} < f_j^{(d_2)}, \\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\ m, & \text{if} \quad f_j^{(c_m)} \le f_{ij} \le f_j^{(d_m)}. \end{cases}$$

Thus, each indicator receives a class number depending on which subrange it entered. Now, the status of the enterprise can be estimated by the sum of the ranks which correspond to the partial indicators of the financial status. The drawback of this approach is the failure to take into account possible differences in the importance of indicators. A more accurate analysis can be carried out in accordance with the following procedure for determining financial status [15]. A weight $a_j,\ j = 1,2,\ldots,n,$ is assigned to each indicator depending on its significance. Estimate of the i-th object q_{ij} by this indicator is obtained by multiplying the indicator weight by its class, i. e.

$$q_{ij} = k_{ij}a_j,\quad j = 1,2,\ldots,n,\quad \sum_{j=1}^{n} a_j = 1.$$

The total estimation of the financial status is determined by the sum of the indicator estimates

$$K_i = \sum_{j=1}^{n} q_{ij} = \sum_{j=1}^{n} k_{ij}a_j.$$

The class to which the enterprise belongs is determined proceeding from the obtained sum of points depending on the degree of bankruptcy risk: the 1st class is the lowest risk, the 2nd class is the moderate risk, the 3rd class is a high risk, the 4th class is extremely high risk of bankruptcy.

Structural drawbacks of the procedure:

1) there is no justification of the number of subranges to which the range of possible values for each indicator is divided and the boundaries of these subranges;

2) since estimates of the numerical values of indicators are random variables, then the clear boundary between the subranges that arises in such division can result in a situation where companies having similar values of indicators with the same name will be assigned to two different classes.

The natural way to overcome these shortcomings is to construct a multifactor regression equation which binds value of the total estimation of the company's status with numerical values of the set of partial indicators [16].

Let $f_j,\ j = 1,2,\ldots,n$ is a set of indicators (factors) of the company status; $a_j,\ j = 1,2,\ldots,n$ is a set of the weigh coefficients to be determined and take into account the relative importance of the indicators; y is the final estimate of the status.

Then the ratio

$$y = a_0 + a_1 f_1 + a_2 f_2 + \ldots + a_n f_n \qquad (2)$$

is a regression equation that specifies the value y depending on the values of indicators $f_j,\ j = 1,2,\ldots,n.$ To estimate unknown parameters of equation (2), the least squares method can be used in conjunction with the expert evaluation procedure. This creates a matrix of test situations with a totality of sets of numerical factor values in these situations

$$H = \begin{pmatrix} 1 & f_{11} & f_{12} & \ldots & f_{1n} \\ 1 & f_{21} & f_{22} & \ldots & f_{2n} \\ \ldots & \ldots & \ldots & \ldots & \ldots \\ 1 & f_{m1} & f_{m2} & \ldots & f_{mn} \end{pmatrix},\quad i = 1,2,\ldots,m,\quad j = 1,2,\ldots,n,$$

where f_{ij} are numerical values of the j-th factor in the i-th situation.

Besides, the following are formed: the vector of expert estimates of the total indicator corresponding to the selected situations $Y^T = (y_1, y_2, \ldots, y_m)$, as well as the vector A of the unknown parameters $aj,\ j = 0,1,2,\ldots,n,\ A^T = (a_0, a_1, a_2, \ldots, a_n)$.

In this case, the HA vector is a vector of estimates of the resultant indicator y which is provided by the model (2), and the functional

$$J = (HA - Y)^T (HA - Y) \qquad (3)$$

specifies the sum of squares of deviations of the expected estimates from the expert ones.

Minimization (3) by vector A defines the best set of parameters in the view of the least square method (LSM). This vector has the form $\hat{A}=\left(H^TH\right)^{-1}H^TY$. Substituting components of the vector $\hat{A}$ in (2), a possibility of estimation of the status for any set of numerical values of concrete indicators appears. The fundamental disadvantage of the regression approach is the need for a rather representative sample of observations. This circumstance makes attractive application for solving the assigned task of the current information technologies of artificial intelligence, namely, expert systems (ES).

Expert systems are among the number of intelligent computing systems and are designed for modeling or simulating behavior of an experienced expert when solving tasks of a particular issue [17]. Expert systems concentrate practical experience of the most experienced specialists in the chosen specific area. Practical application of such a system enables [18]:

1) use a qualified consultant who quickly and at a high professional level processes all coming information on the object and provides distribution of probabilities of the possible statuses;

2) promptly make decisions on urgent measures in critical situations;

3) reduce the total number of procedures and time of preliminary analysis of the object status;

4) provide teaching and training of personnel to use the procedure of assessing results of the object status analysis and making appropriate decisions.

During construction of the ES, a mechanism of logical derivation (MLD) based on the system of productional rules [17] is conventionally used and a knowledge base is created. This knowledge base consists of rules (called productional rules) of the following form: "IF the controlled parameter A_1 of the object has value a_1, parameter A_2 has the value a_2, ..., parameter A_n has value a_n, THEN the object is in the status H $(a_1, a_2, ..., a_n)$ with a probability P $(a_1, a_2, ..., a_n)$".

Productional rules, on the one hand, are the most natural way for people to represent knowledge and on the other hand, they cannot always be used in the MLD construction. The reason is that for a full description of the entire variety of possible values of parameters and statuses in a form of a system of rules, it is necessary either significantly increase the number of the rules used or resort to their simplification.

Let in the task of choosing a strategic company management a specific subtask is solved for estimation of the company financial status. This estimate is conventionally carried out taking into account values of a selected set of indicators. A possible set of financial indicators is given in [19]:

1. Estimate of the enterprise property status:

x_1: the ratio of residual value of fixed assets (FA) to the balance;

x_2: the ratio of FA depreciation to the book value of the FA.

2. Estimate of liquidity:

x_3: the ratio of amount of cash assets and liquid securities to current liabilities;

x_4: the ratio of cash assets, payments and other assets to current liabilities;

x_5: the ratio of current assets to current liabilities;

x_6: the ratio of stocks to current liabilities;

x_7: the ratio of working capital to the amount of assets.

3. Estimate of financial stability:

x_8: the ratio of equity capital to business assets;

x_9: the ratio of attracted capital to business assets;

x_{10}: the ratio of attracted capital to equity capital.

4. Estimate of profitability:

x_{11}: the ratio of profitability from sales to production costs;

x_{12}: the ratio of balance sheet profit to equity capital;

x_{13}: the ratio of balance sheet profit to attracted capital;

x_{14}: the ratio of equity capital to net profit;

x_{15}: the ratio of retained earnings to the amount of assets;

x_{16}: the ratio of operating profit to the amount of assets.

5. Estimate of business activity:

x_{17}: the ratio of sales proceeds to the average cost of fixed assets;

x_{18}: the ratio of sales proceeds to average receivables;

x_{19}: the ratio of market value of shares to arrears;

x_{20}: the ratio of proceeds to equity capital;

x_{21}: the ratio of proceeds to the sum of assets;

x_{22}: ratio of net profit, dividends paid to shareholders to equity capital.

Many works use some other indicators.

x_{23}: the ratio of borrowed capital to the balance currency;

x_{24}: the ratio of current assets to current liabilities;

x_{25}: the ratio Cash Flow to current (short-term) liabilities;

x_{26}: the ratio of the difference between the expected cash inflows and current liabilities to the expenses of the enterprise (without depreciation);

x_{27}: the ratio of the average balance of payables to the procurement value multiplied by 365;

x_{28}: the ratio of the average balance of inventories to the value of the cost of raw materials multiplied by 365.

If it is necessary to assess the financial state of an object in this case, a production expert system is applied, then the required volume of the knowledge base of ES will be enormous. Indeed, let us divide the range of possible values of each indicator (in the simplest case) into two subranges corresponding to its unsatisfactory and satisfactory values. Then the total number of productional rules taking into account all possible combinations will be $N=2^{28}\approx 2{,}5\cdot 10^8$. It is impossible to implement such a system. An acceptable approach to solving the problem that arises here is decomposition (splitting the original task into subtasks).

Let us divide all innumerability of the controlled parameters into several groups according to their economic content:

– estimation of the enterprise property status;
– estimation of liquidity;
– estimation of financial stability;
– estimation of profitability;
– estimation of business activity;
– estimation of market activity.

Each of the groups includes indicators that determine some specific generalizing characteristic of the object. For example, an estimate of the company's property status characterizes the status of the company's assets and contains data for analysis of the structure of the main production assets; the assessment of liquidity determines ability of the enterprise to repay current liabilities.

Now, for each group, we assign a task of assessment of the corresponding generalizing characteristic using a production expert subsystem that uses the indicators entering this group.

Designate indicators of the financial status as follows. Enter F_{ij}, the value of the i-th indicator in the j-th group $j=1,2,...,m,\ i=1,2,...,n_j$.

Next, form m (by number of groups) of productional expert subsystems using the appropriate sets of indicators. The system of rules for the j-th group of indicators has the form:

"IF" F_{1j} is equal to a_{1j}, F_{2j} is equal to a_{2j}, a_{n_jj} is equal to a_{n_jj}, THEN the j-th generalized characteristic z_j will be equal to F_{1j}.

Let the range of possible values for each indicator be divided into three subranges: "low", "medium", "high". Then the j-th expert subsystem will contain $N_j=3^{n_j}$ productional rules where n_j is the number of controlled indicators in the j-th group. The number of these indicators is small, so formation of such systems is not difficult.

The final stage of the procedure is assessment of the system status as a whole. To do this, use the appropriate generalizing expert system of productional rules:

"IF" H_1 is equal to b_1, H_2 is equal to b_2,..., H_m is equal to b_m, THEN the status of the system is equal to $Z(H_1,H_2,...,H_m)$.

Solution of this subtask forms the information support of the second subtask. In the course of solving the second subtask, comprehension of the problem situation occurs, the purpose of management is determined, the general strategy for solving the problem situation and the optimal management are developed taking into account the possible consequences of the decisions made.

Formation, substantiation, and preparation of the enterprise accounting policy are the tasks of application of methods and means of artificial intellect in accounting systems of which the following can be distinguished:

– roster method or the method of "rough force";

– the method of task description in terms of the approach that uses status space;

– the method of reducing to a subtask.

The accounting policy performs a certain social function by realizing concrete interests of various social groups because the accounting and reporting information formed as a result of realizing the accounting policy reflects interests of certain groups of people. In connection with this, there are subjective and objective factors that influence formalization of the enterprise accounting policy.

Objective factors include a real business situation in economy and the enterprise. Subjective factors are:

– current and long-term objectives of entrepreneurship;

– the degree to which the business situation is learned;

– the depth of understanding of the business situation features;

– the purpose and tasks of management;

– personnel qualification;

– the level of understanding of the management process.

To solve the issue of choosing methods of formalization of the processes of choosing the enterprise accounting policy, correlation of effects of subjective and objective factors is of a high interest. It was established that 90 % of accounting methods have a subjective character and are applied in a result of accumulation of skills and habits by personnel. So, choice of an accounting policy is one of manifestations of free will of the business subjects concerning the ways and methods of accounting. Thus, what is proposed is the model of construction of a knowledge base for solving the task of forming the enterprise accounting policy in the intelligent accounting system (Fig. 1).

Let us consider a formalized description of the task of FEAP formation. In the approach under consideration, it is expedient to use the notion of a rule of transition from one state into another.

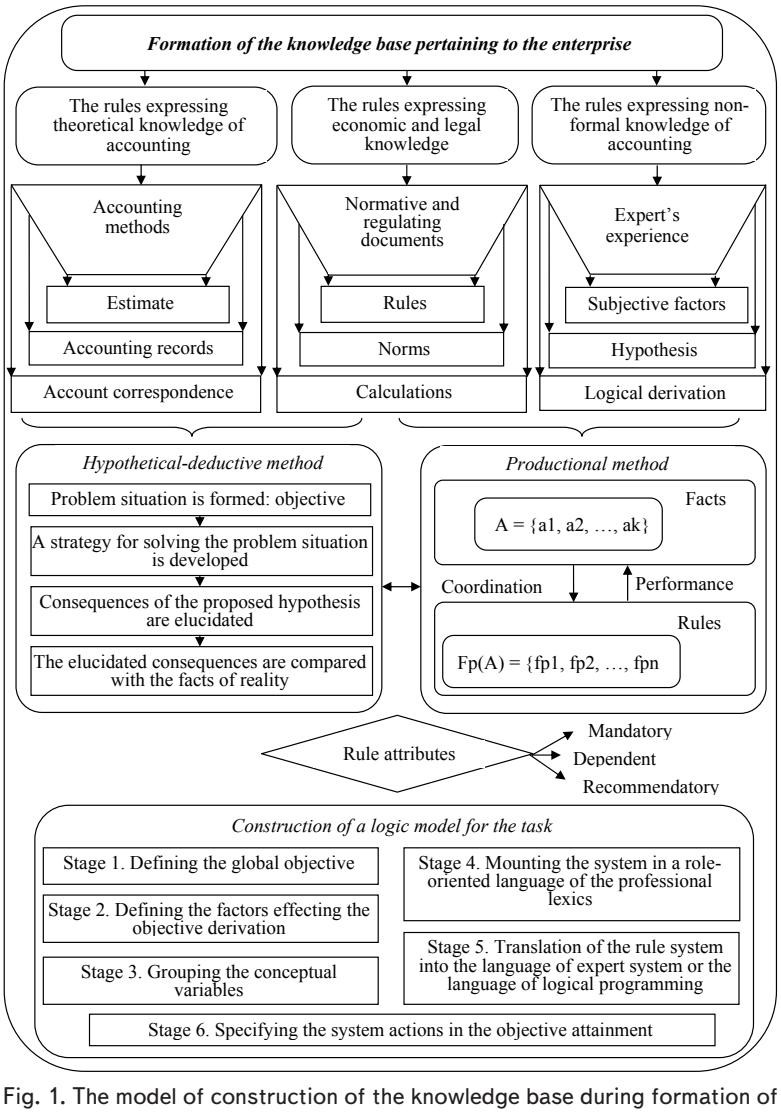

Fig. 1. The model of construction of the knowledge base during formation of the enterprise accounting policy in an intelligent accounting system

Effectiveness of the accounting and analytical support for enterprise management can be calculated as an indicator of completeness of provision of the assigned and solved management tasks with accounting and analytical information:

$$E_{AAP}=I_{AAP}\times\frac{n_D}{n_T}, \quad (4)$$

where E_{AAP} is efficiency of the accounting and analytical support for the enterprise management; I_{AAP} is informative-

ness of the accounting and analytical support for the enterprise management; n_T is the number of assigned tasks; n_D is the number of solved tasks.

Informativeness of the accounting and analytical support of the enterprise management is calculated according to the indicators of content richness, availability and representativeness of information:

$$I_{AAP} = \sqrt[3]{A_{AAI} \times P_{AAI} \times R_{AAI}}, \quad (5)$$

where A_{AAI} is availability of accounting and analytical information; P_{AAI} is the content richness of accounting and analytical information; R_{AAI} is representativeness of accounting and analytical support of the enterprise management;

$$A_{AAI} = \frac{n_Q}{n_A}, \quad (6)$$

where n_Q is the number of answers; n_A is the number of requests for accounting and analytical information;

$$P_{AAI} = \frac{AAI_F}{n_{I_T}}, \quad (7)$$

where AAI_F is actual accounting and analytical information; n_{I_T} is total amount of information;

$$R_{AAI} = \frac{AAI_T}{AAI_F}, \quad (8)$$

where AAI_T is the accounting and analytical information used in execution of the assigned task.

Efficiency evaluation of the accounting and analytical support of the enterprise management in terms of content richness, availability and representativeness of information allows one to monitor as much as possible accurately its status with on-line monitoring of qualitative parameters of accounting and analytical information.

New aspects are added to the existing axiom system that models the process of knowledge acquisition in the knowledge base (KB). Let us consider the axiomatic system of the FEAP task and assess types and characteristics of the rules applied in the task solving process.

Modeling of accounting support of the enterprise management involves comprehensive application of its methods and scientific approaches not only for reflection of economic processes and phenomena (through specifically created symbols, descriptions) but also to stimulate development of accounting [10]. In the case of inclusion of axioms in the KB, a problem arises with determination of detailing level and the rules which are accepted as the postulates requiring no corollaries or proofs. For example, initial axioms of KB can include the principle of dual recording in one case and account correspondence that is acceptable from the point of view of the approved Plan of accounts. Any account correspondence proposed in the content of the new accounting method is checked for consistency with the initial axiomatics. It is clear that the search for solutions in the column of statuses grows in depth in the first case and in width in the second case. Thus, the principles that are put in the basis of provision with knowledge can influence effectiveness of the solution search.

The rules expressing institutional knowledge of the system of normative accounting regulation are formed based on the normative-legal documents. Accountant can use such documents in his practical activities during elaboration of recommendations on formation of the accounting policy which in its turn is transferred to the system of rules expressed as implications.

Productional expert systems (ES) make it possible to accumulate experience of many experts in an unlimited time interval. According to the assessment results, real number of initial formalized rules can be 3 to 5 times more and this figure will grow during system functioning due to the experience accumulation. Productional ESs with such quantity of rules belong to the systems of high complexity. The rules providing non-formal knowledge depend on the expert's experience concerning the outcomes of using one or other accounting method and the expert conclusion on the results. They enable estimation of the facts of economic activities, interpret them and derive on this ground new results that are accepted as facts. With the help of these rules, subjective factors influencing formation of the enterprise accounting policy can be taken into consideration.

Shortage of information leads to unreliability of the development prediction, application of inappropriate planning methods (which logically follow from the first outcome), mistakes in planning which will cost dear for business [11]. Beside the formalized information sources in the form of databases (DB) of various subsystems in the system of enterprise management, the information obtained from experts is of value. People from the enterprise management, account department, workers of economic and legal departments and external economic experts, lawyers, workers of auditing companies and companies producing accounting support software may serve as experts.

The problem of formation of the enterprise auditing policy and the approaches to its solution illustrate availability of application of the hypothetical-deductive method as a circular sequence of the procedures presented in Fig. 2.

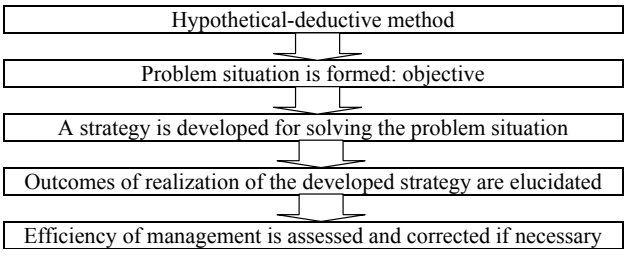

Fig. 2. Sequence of FEAP with the use of the hypothetical-deductive method

A problem situation emerges in a case when important facts are revealed and require substantiation or explanation. In the accounting systems, such important facts that require explanation include compliance of the accounting methods and means with the tasks standing before the subject of economic management.

Hypothesizing for finding out the strategy of a problem situation solution is realized in a way of logical conclusion. The outcomes of hypotheses must be not only explanation of the facts for sake of which hypothesizing was taken but also prediction of new, earlier unknown facts. Thus, each of the hypotheses shall be the tool of both explanation and prediction. Comparison of the results obtained with the hypothesis that was put forward with the facts of reality makes it possible to check the hypothesis, correct or dispose

it and choose more likely one. Consequently, in the course of investigation of the hypothesis, new problems arise. To solve these problems, it is necessary to come back to the problem situation but at a new level of a higher quality.

It is worth to note that the hypothetical-deductive method of formalization is more general in comparison with the axiomatic method because any postulate (axiom) assumed as a basis of the system base can be considered as a hypothesis for solving a problem situation with a possibility equal to one. However, it does not exclude any other principles that may be viewed as hypotheses for solution of the problem situation.

Quite often, a theory is understood as a well checked system of hypotheses. However, we do not see a deep contradiction in this aspect, at least from the point of view of formal logic, since any theory must be ever substantiated by practice no matter how strict and checked it were. The history of science convincingly evidences that emergence of new facts and new points of view on already known facts can result in a revision of any theory basics seemingly steadfast.

The knowledge and skills accumulated in the KB in the process of formation of the enterprises accounting policy enable improvement of theoretical and methodical principles of accounting.

The task of formation of the enterprise accounting policy can be taken to the class of those tasks which are hard to realize by algorithmic methods. The following peculiarities were revealed during description of its statement.

1. The well-structured knowledge which is used in task solution has no a strict algorithm of converting one data into other. Thus, the search for solution is not algorithmized but is informally determined by an expert according to the concrete situation.

2. In most cases, a non-organized or badly organized text or knowledge of a human expert serves as a source of knowledge.

3. The method of providing knowledge influences realization of the solution search process. In this regard, model of knowledge provision already contains the solution elements.

4. It is possible to accumulate successful conclusions and solutions, make them clearer, review when a new knowledge is coming and use as axioms in further search for solutions.

5. Task is being solved based on a lightly formalized knowledge that can be obtained at any approximation to the expert.

6. Discussion of the results obtained in studying the effect of technological solutions on modification of accounting and analysis

Considering the great scope of possible statuses, the approach of reducing the task to a number of subtasks is advisable all the more so the task of choosing the enterprise accounting policy can be represented as a hierarchical structure. At the first level of the subtasks, directions of the enterprise accounting policy are found and the further levels deal with the spheres of registration, means and methods of registration, etc. The method of reducing the task to subtasks has one more advantage: it is not necessary to solve all subtasks by the same means. This method is helpful for imagination of global aspects of the task and when less global tasks are solved, other methods can be used. Thus, what is at issue is a combined provision of knowledge. At definite nodes of the subtask graph, the means of recalculation, status spaces, linguistic methods of chain substitution and common calculation methods can be used.

In this way, it is possible to formulate first two important principles of development of an information system for formation of accounting policy (ISFAP). The first is the principle of reducing to subtasks and the second is the principle of combining the methods.

Since the ICFAP KB was developed on the basis of axioms and rules of logical conclusion, it is advisable to use the productional approach as the basis for the ISFAP construction. This approach realizes the proposed model for task solution. Firstly, this approach is convenient for hierarchical provision of knowledge inclusive the knowledge of task decomposition. Secondly, the systems that realize the productional approach contribute to extending of the possibility of combining variety of knowledge types and the use of external KBs and DBs. Thirdly, the productional systems are realized as separate software systems for personal computers.

In recent scientific literature and periodicals, the productional approach and the productional systems are subject to a severe criticism, so let us concentrate in more detail on more substantiated studies.

First of all, the critics point out complexity of providing the expert knowledge since not all knowledge in the expert's possession can be formulated. Note that the considerable part of knowledge on formation of the enterprise accounting policy is the provisions of normative and legislative acts that regulate accounting. Usually, these provisions order as follows: "If <conditions>, Then <actions>, that is knowledge, from time immemorial, is given as rules but just formulated in a natural language. In this case, there are no problems with translation of the expert's informal knowledge into formalized structure of a productional type since the knowledge is provided namely in this form.

The next object for criticism is unavoidable inconsistency of the expert's knowledge in a shape of a strict system of rules and the great quantity of the latter results in high labor content for their ordering. This drawback becomes an argument in favor of using namely productional approach. Inconsistency and ambiguity of rules exist in the system of normative regulation of accounting. In this case, the systems for ordering rules become a tool of search for such collisions. Thus, ISFAP enable logical check for correctness of the system for normative accounting regulation.

As imperfection of the productional approach, complexity or impossibility of rule formulation by the expert himself is mentioned: an expert in the subject field is not a professional in the field of ES. This problem is especially topical for ISFAP construction which is explained by high dynamism of changes in the accounting regulation system and requires correction of the rules that express economic and legal knowledge. Thus, the system of rules must be ever improved and the user must have money for such improvement.

Realization of the latter requirement becomes possible by the use of the professional language which ensures formulation of necessary requirements for the change of rules in a common form. Thus, it is necessary to implement the principle of openness in the ISFAP regarding correction and ordering of the rule system for users. Presently, the methods of productional type become a convenient means of accumulation, analysis of such experience and improvement of the ISFAP itself through the use of computerization means. The

possible alternative approach to the problem of improvement of technologies for accounting and analysis consists in the use of present-day methods of regressive analysis [20].

7. Conclusions

1. The concept of technological information management was formulated on the basis of theoretical and organizational principles of the business technology and information activity of economic systems was formed. The proposed concept affects expansion of theoretical-organizational and methodological boundaries of organization of accounting and analysis and makes it possible to improve efficiency of formation of accounting and analytical information in accordance with the multi-aspect requests of users.

2. The choice of the methods for modeling and formalizing selection of components of the accounting policy for formation of accounting and analytical support for enterprise management was substantiated. Expediency of construction of the ISFAP implementing modern systems of artificial intellect and productional systems was substantiated. Creation of an effective enterprise accounting policy is one of the tasks of application of the artificial intellect methods and means in accounting systems. Among the methods in a current use, the method of subjectivism, hypothetical-deductive, productional and expert methods were considered. Their features, advantages and disadvantages were elucidated. It was suggested to use methods for formation of accounting and analytical support of management in accordance with the enterprise model formed on the basis of organized processes, decisions, competencies and motivations provided with information. This contributes to getting additional advantages in satisfying information requests of the management process, achieving equilibrium between the state of the information environment and the prospects of its development. It was substantiated that in order to take into account properties and features of the enterprise model, it is expedient to modify the model of accounting and analytical support of management. Such a model should be built with domination of intellectual and technological regulators in setting up techniques and methods for studying activities of the objects of economic management.

3. Architectonics of the model for constructing the knowledge base in solving the task of formation of the enterprise accounting policy based on integration of computer technologies and artificial intellect was defined. It was proposed to form the knowledge base for accounting and analytical support of management based on the management technologizing concept which is the new line of development of the technologies for the accounting policy organization. The proposed concept provides for functional and practical combining of theoretical fundamentals of accounting and economical and legal basis of its regulation, combining of methods of decomposition and grouping conceptual variables. Introduction of such concept enables visualization of the expert-bookkeeper reasoning logic, contribute to upgrading the level of the managerial decision substantiation and stable enterprise development in current conditions of Ukrainian informational community.

References

1. KOF Index of Globalization [Electronic resource]. – Available at: http://globalization.kof.ethz.ch/
2. 2015 Index of Economic Freedom [Electronic resource]. – Available at: http://www.heritage.org/index/explore?view=by-region-country-year
3. Laszlo, C. Embedded Sustainability: The Next Big Competitive Advantage [Text] / C. Laszlo, N. Zhexembayeva. – Stanford Business Books: Stanford, CA, 2011. – 288 p.
4. Virk, R. Zen Entrepreneurship: Walking the Path of the Career Warrior [Text] / R. Virk. – BayView Labs, 2013. – 298 p.
5. Davenport, T. H. Competing on Analytics: The New Science of Winning [Text] / T. H. Davenport, J. G. Harris. – Boston: Harvard Business Review Press, 2007. – 240 p.
6. Pushkar, M. C. Idealna cyctema obliku: kontseptsiya, arkhitektura, informatsiya [Text]: monohrafiya / M. C. Pushkar, M. H. Chumachenko. – Ternopil: Kart-blansh, 2011. – 336 p.
7. Ctyuart, T. Intellektual'nyy kapital. Novyi ictochnik bogatctva organizaciy [Text] / T. Ctyuart. – Moscow: Pokolenie, 2007. – 196 p.
8. Cemaniuk, V. Z. Informatsiyni recurcy: oblikovo-teoretychnyi acpekt [Text] / V. Z. Cemaniuk // Vicnyk Lvivckoi komertsiynoi akademyi. – 2011. – Issue 35. – P. 319–322.
9. Kvasnyi, L. H. Rozvytok ekonomiky znan yak bezperervnyi protses investuvannia u liudskyi kapital [Text] / L. H. Kvasnyi, O. Ya. Shcherban // Visnyk Natsionalnoho universytetu "Lvivska politekhnika". Menedzhment ta pidpryiemnytstvo v Ukraini: etapy stanovlennia i problemy rozvytku. – 2013. – Issue 767. – P. 206–211.
10. Zhuk, V. M. Bukhhalterskyi inzhynirynh [Electronic resource] / V. M. Zhuk // Oblik i finansy APK: bukhhalterskyi portal. – Available at: http://magazine.faaf.org.ua/buhgalterskiy-inzhiniring.html
11. Karminskiy, A. Operativnyy analiz ispolneniya byudzheta s pomoshch'yu kontrollinga [Text] / A. Karminskiy // Menedzhment i menedzher. – 2011. – Issue 6. – P. 15–19.
12. Afifi, A. Statisticheskiy analiz [Text] / A. Afifi, S. Ehyzen. – Moscow: MIR, 1982. – 488 p.
13. Fisher, R. A. The Use of Multiple Measurements in Taxonomic Problems [Text] / R. A. Fisher // Annals of Eugenics. – 1936. – Vol. 7, Issue 2. – P. 179–188. doi: 10.1111/j.1469-1809.1936.tb02137.x
14. Mandel', I. D. Metody klaster analiza [Text] / I. D. Mandel'. – Moscow: Finansy i statistika, 1988. – 176 p.
15. Dil'man, I. Ranzhirovanie ob'ektov [Text] / I. Dil'man. – Moscow: MIR, 1998. – 198 p.
16. Dreyper, N. Prikladnoy regressionnyy analiz. Vol. 1 [Text] / N. Dreyper, G. Smit. – Moscow: Finansy i statistika, 1986. – 365 p.
17. Dzharratano, D. Ehkspertnye sistemy: principy, razrabotka i programmirovanie [Text] / D. Dzharratano, G. Rayli. – Moscow: izd. dom «Vil'yams», 2006. – 1152 p.

18. Rassel, S. Iskusstvennyy intellekt. Sovremennyy podhod [Text] / S. Rassel, P. Norvig. – Moscow: Radio i svyaz', 2006. – 312 p.
19. Martynov, E. E. Sistema pokazateley dlya ocenki finansovogo sostoyaniya firmy [Text] / E. E. Martynov, A. A. Harchenko, I. A. Cherepanova // Ekonomika, upravlenie, pravo. – 2007. – Issue 4. – P. 24–29.
20. Raskin, L. Models and methods of regression analysis under conditions of fuzzy initial data [Text] / L. Raskin, O. Sira, Y. Ivanchykhin // Eastern-European Journal of Enterprise Technologies. – 2017. – Vol. 4, Issue 4 (88). – P. 12–19. doi: 10.15587/1729-4061.2017.107536

Запропоновано комплексну модель управління будівельними проектами, яка в когерентний спосіб сприяє створенню далекоглядної, збалансованої цінності. Ця концепція представлена у вигляді «кристалу» кумулятивного застосування трьох пар методів. Перша синергетична пара – інжиніринг вартості та цифрова модель будівництва. Друга – аналіз «вигоди-витрати» і теорія динаміки цінності проекту. Третя – профілювання контрактних систем і стратегії ціноутворення

Ключові слова: управління проектами, інжиніринг, архітектура, збалансована цінність, синергетичний ефект, прийняття рішень

Предложена комплексная модель управления строительными проектами, которая когерентно способствует созданию дальновидной, сбалансированной ценности. Эта концепция представлена в виде «кристалла» кумулятивного применения трёх пар методов. Первая синергетическая пара – инжиниринг стоимости и цифровая модель строительства. Вторая – анализ «выгоды-затраты» и теория динамики ценности проекта. Третья – профилирование контрактных систем и стратегии ценообразования

Ключевые слова: управление проектами, инжиниринг, архитектура, сбалансированная ценность, синергетический эффект, принятие решений

UDC 330.322:658
DOI: 10.15587/1729-4061.2017.110112

FORMATION OF A CUMULATIVE MODEL FOR MANAGING THE VALUE OF CONSTRUCTION PROJECTS

O. Bugrov
PhD, Associate Professor*
E-mail: bugrov.oleksandr@gmail.com
O. Bugrova
PhD, Associate Professor*
Department of economic theory
National University of Kyiv-Mohyla Academy
Skovorody str., 2, Kyiv, Ukraine, 04070
E-mail: bugrova.olena@gmail.com
*Department of project management
Kyiv National University of
Construction and Architecture
Povitroflotsky ave., 31, Kyiv, Ukraine, 03037

1. Introduction

The mental structure "*Live and let others live*" has been popular for a long time. However, it is acquiring a special sense under current conditions. Over recent time, the theory and practice of project management have been actively improved in line with the modern requirements to the development of socio-economic systems. The most urgent global challenges include such issues as the need for reducing greenhouse gas emissions and increasing power efficiency of meeting social needs. In addition, the task of creation and implementation of forward-looking strategies for achieving optimal value throughout a whole range of consecutive project cycles is becoming increasingly important. This task is closely linked to the development of technologies for innovative solutions to engineering problems.

Thus, today it is more important than ever that projects should comply with the principles of optimal expediency by the vector of sustainable development in harmony with nature. People are responsible for what "living" environment they will leave to their descendants – upcoming generations. At the same time, investment and construction projects in various sectors of socio-economic reality is exactly the area where scientific-practical answers to these challenges can be most thoroughly and reliably worked out.

Formulation of a comprehensive model to solve these tasks in the process of project preparation and implementation is a scientific problem. In this case, it is important that such a model is not complicated and cumbersome, because it would be impractical to use otherwise. In addition, the model should not be amorphous, it must acquire a complete and distinct form.

2. Literature review and problem statement

In accordance with the concept of knowledge economy, development implies active application of creative technologies, which provide breakthroughs in production competitiveness [1]. This statement may be supplemented by the fact that it is related not only to the sphere of industry, but rather to the entire socio-economic system.

Under modern conditions, knowledge is becoming a major factor of competitive advantages. Sustainability of