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THE CONCEPT OF INTELLECTUAL CAPITAL DEVELOPMENT IN THE INTENSIFICATION OF INNOVATION AND INVESTMENT TRANSFORMATIONS OF THE ENTERPRISE

Summary

The need to find new methods for managing socio-economic facilities, their innovation and investment activities is becoming urgent under the influence of integration and globalization in the economy, the rapid pace of scientific and technological progress, the development of information systems and computer *technology. Under these conditions, the intellectual capital of the enterprise, the use of which is embodied in the planning and development of intangible assets, investment and innovation processes and the latest management systems becomes crucial. Therefore, the purpose of this study is to develop new approaches to the management of intangible assets based on the use of economic and mathematical methods and models. Based on the results of the study, the authors proposed a scientific and methodical approach to planning the development of intangible assets of the enterprise. The method of assessing the effectiveness of the plan of improvement and development of intangible assets of the enterprise was developed. The approach to the management of innovation and investment processes and the development of information technology in the enterprise is justified. This makes it possible to take into account all the changes occurring in all areas of the enterprise, as well as to determine the development of its information, intellectual, financial and organizational systems, which creates the prerequisites for quality information support for successful activities.*

Introduction

Enterprises today must be able to adapt to global integration processes. Due to the rapid development of market relations, the speed and scale of technological changes, it is impossible to ensure the competitiveness of companies only through the use of material and financial resources, which are becoming generally available to most economic entities. World experience is not determined in favor of one of these assets in relation to the costs of their creation, but in the "intellectual revolution" it tends to significantly exceed the share of intangible assets over tangible assets.

That is why the particular interest among the participants in economic relations is the question of using in-house enterprises factors of a non-material nature. Moreover, the success of management participants is determined by the use of not only the "intangible massif", but also some of its components (intellectual capital, intellectual property, etc.). Objects of intellectual property, as evidenced by world experience, can significantly increase the market value of the company.

The development of information and technology has led to revolutionary changes in all spheres of social life. First of all, it concerns the sphere of finance, credit, currency, trade, the transfer of sources of economic development from traditional production to superfinance, information resources and intellectual property, which leads to a profound deformation of all mechanisms of the market economy, private property and competition.

It is traditionally believed that the economic basis determines the type of society. Using this interrelation, post-industrial society is the last link in the series pre-industrial, industrial and post-industrial, or agrarian, industrial, information society. However, today there is no consensus among scholars as to whether humanity is really moving into a new era of economic life, or whether this is just a new stage in the development of the industrial age. If to analyze the economic development of the world, new technologies and human intelligence have always been the driving force behind the development of society and the economy. Today it is clearly possible to trace changes in the system of human values, in particular, the strengthening of the role of intelligence, the power of knowledge.

At the company level, it is possible to talk about strengthening the role of intellectual capital and innovation in the production process. The peculiarity of the modern economy is that the main factor of production has become information, which, however, cannot be put on a par with land and capital – the most important factors of the pre-industrial and industrial eras. The latter, entering the process of interaction with the subjects of production, do not change their form, remain objective. Information cannot be used in production in its original form, in the process of production it acquires a subjective form, turning into knowledge. Knowledge holders become the main industrial class in the post-industrial economy, a class that does not require the exploitation of other classes, unlike the capitalist system. The success stories of Microsoft, Intel, Google, and others prove that the precondition for a company's financial growth can be not capital, but an idea embodied in production. It has become obvious that success can be achieved without significant material resources, but the availability of intangible resources has become a necessity in today's environment. In addition, with the emergence of more and more high-tech companies, a new problem arose: the mismatch between the market value and the book value of a company's assets. That is, traditional reporting indicators become irrelevant with the growth of intangible assets, the role of which in creating information wealth is particularly high.

Part 1. Intangible assets as the basis for the development of intellectual capital of the enterprise

Exploring the role of intangible assets in the development of post-industrial society and the transition to a new stage of economic development, it is worth paying attention to a certain composition of intangible assets, as well as to some components of intellectual capital. In particular, it is believed that a brand name is part of a company's reputational capital and one of the key success factors. Analyzing today's markets, it is possible to see that consumer preferences often shape the success of companies. However, in the conditions of production transition to qualitatively new brands, the levels are not so important. In other words, the increase in the popularity of the brand leads to a redistribution of consumer preferences and, accordingly, cash flows. On this basis, it is necessary to allocate those components of intellectual capital, that is "intangible", which bring income, but do not affect the production and creation of new technologies.

Extreme attention to creating successful brands and a positive image of the company in the market has led to the fact that at the current stage of economic development the manufacturer spends a lot of money on advertising and promotion in order to stay in the market. Analysing the price of high-tech goods, it can be concluded that the cost of materials is insignificant, because the buyer, when purchasing a computer or a smartphone, is paying for the use of leading technologies that have been applied in the production process. Otherwise, the buyer may not pay for the use of the latest technology, but for a well-known brand name that covers the manufacturer's considerable marketing costs. Of course, information about the popularity of the trademark or brand is important for making management decisions and forming the company's development strategy, but it is important to understand that brand popularity cannot be a component of intellectual capital, because it does not create anything new in quality. That is why the formation of the knowledge economy has become the main priority of economic growth policy, not only for developed countries, but also in general.

The knowledge economy is a historically relative and rather contradictory phenomenon, since it places the innovation process at different levels at the center of the economic system. The innovation process in the economy provides such institutions: the activities of which are aimed at the preparation of human capital and a favorable information environment for innovation activities; which are directly involved in the process of creation, commercialization and use of new knowledge; which are aimed at providing innovation activities with material resources.

The internal innovative nature is explained by the fact that they are a direct product of the human mind, activity, intelligence. In this abstract form, intellectual property as a commodity can be transferred to any number of buyers, that is, intellectual property for sale. The realization of the public product, respectively, can be seen as a consequence of the realization of intellectual property rights. From here it is possible to form features of realization of intellectual property: the product is not alienated by the seller, but only borrowed, used by both the seller and the buyer; the special agreement is the starting point for all future agreements, since their nature requires a clear definition of methods and forms of protection of common interests, insurance of risks, provision of guarantees, distribution of profits; money plays the role of the cumulative price received for the right to use intellectual property.

Consequently, given the significant impact of innovation processes on the development and competitiveness of enterprises, the conceptual model of intangible assets management on the development of modern economy in the country, should be aimed at and built on the following principles of its implementation.

According to the authors, the creation of a conceptual model for the management of intangible assets in Ukrainian enterprises should reveal a number of problematic aspects: definition of the functional and structural representation of the management system of intangible assets in Ukrainian enterprises; disclosure of the organization of the information process of intangible assets management; internal model of representation of intangible assets management in the process of creation (implementation) of an intellectual (innovative) product; definition of the evaluation system of intangible assets at an industrial enterprise; determination of the system for assessing the effectiveness of intangible asset management at an industrial enterprise; identification of the assessment of the commercial potential of intangible assets at various stages of implementation (creation or use). The available practical experience shows that the assessment serves as the basis for developing a system of coordination and regulation of intangible assets management, and, if necessary, to improve the organizational structure of the enterprise. Evaluation allows to make the right choice of economic, administrative methods of management to increase the contribution of a particular link in achieving the goals. Thus, the structure of management accounting in general with respect to intangible assets management at the enterprises of Ukraine should be detailed, taking into account the identified methods in the process of further research that will allow to implement certain directions in the conceptual model of management of building intangible assets.

The role of intangible assets in the formation of the new economic era is decisive, as they reflect the intellectual potential of the organization. The effective use of intangible assets in domestic industrial enterprises will increase its economic profitability and profitability, which will contribute to the implementation of management accounting.

The results of the study of the essence of intangible assets and the economic content of the definition of the concept suggest that as an object of scientific knowledge intangible assets are a complex and multifaceted structural element in the economic theory of today, which, in accordance with the requirements of the development of the modern market economy of the country with an orientation to the global economic space is increasingly identified with the object of intellectual property and the implementation of innovative processes in the course of economic activity of domestic wood industry companies.

Part 2. Economic and mathematical models in the management of intangible assets

The rapid development of scientific and technological progress, increasing level of informatization and intellectualization of production processes, intensification of the use of intangible factors of production and intellectual capital are generally recognized trends in the transition to the post-industrial stage of civilization. Therefore, activities related to the formation and use of intangible assets have a significant impact on the company’s success in the competitive struggle inherent in the market economy. This entails the need for a reasonable approach to the management of processes of formation of intangible assets of the enterprise, as the state of their use, as well as areas of further improvement and development and risks associated with them do not always have quantitative measurements, and require qualitative evaluations with the appropriate use of economic and mathematical methods and models. In this regard, the management system of the company faces the task of a reasonable choice of options for the development of intangible assets (by type), with elements of planning of quantitative and qualitative indicators and integrated solutions to production and economic problems.

The conducted study makes it possible to state an important fact, recorded by scientists, that out of every six dollars of the market value of investments of an enterprise only one is fixed in the balance sheet of companies, and the last five dollars represent intangible assets [1]. The authors of this work agree with the opinion of scientists that information and intellectual capital is the basis of intangible assets that improve the quality of enterprise management and efficiency of its activities [2; 3]. At the same time, the results of many scientific studies show that the competitive and economic advantages that a firm obtains from the use of various types of intangible assets associated with the development of information systems lie in the firm's ability to apply them in management [6; 14]. Consequently, investments in intangible assets provide a qualitatively new level of management activities of the enterprise and increase profitability. However, it should be taken into account that the development of intangible assets requires significant investments and is inherently innovative, so it is important to consider the risks of the management process [4] associated with the formation of intangible assets, as well as the optimization of both operational and strategic planning of development and improvement.

In economic science and practice, there are traditional approaches to the use of optimization methods for modeling many economic processes. V. Andriienko, I. Ivchenko, Z. Sokolovska, A. Yepifanov and many other scientists consider the problems of econometric and mathematical modeling, widely used in the study of complex economic systems and processes related to real (tangible) assets [7; 8]. Research in the field of intangible assets focuses on their evaluation by reporting companies, or in terms of their impact on value capitalization, economic security, etc. It is advisable to expand the scientific and methodological approaches in the construction of a comprehensive approach in solving the problems of planning and development of intangible assets of enterprises, which will make it possible to assess the role of intangible assets in the implementation of strategic objectives of enterprises, and their sustainable economic growth.

Intangible assets are a complex economic category consisting of many economic elements. The absence of the material form of such components (software, databases, intellectual and information components, etc.) explains the situation that such assets are difficult to quantify (only the natural value evaluation of individual components at the date of their acquisition or creation and at the stages of use is possible). Then to manage the formation of intangible assets, their further improvement and rapid development it is necessary to develop new tools for a reasonable choice of individual options, based primarily on both qualitative and quantitative indicators. It is advisable to determine such indicators in the context of the target direction of the enterprise, its organizational and economic changes. For this purpose, it is advisable to conduct expert evaluations using tools of economic and mathematical modeling [1]. The authors of the study share the opinion of Y. Samokhvalov and Y. Naumenko, that the expert method in combination with other economic and mathematical methods can serve as a constructive tool for the study of complex economic systems, which include processes of using intangible assets in enterprises [9]. Experts should be joined by highly qualified specialists from many fields of knowledge and practical experience, capable of giving a qualitative assessment of the actual changes occurring with the use of intangible assets of the enterprise, and determine the available directions of forecasting. This will make it possible to assess the effectiveness of alternative planning options. This will allow to evaluate the effectiveness of alternative planning options, to optimize measures for the formation of intangible assets of enterprises to ensure the effectiveness of their functioning in the long term. When considering the substantiation of processes for the formation of intangible assets and the implementation of related activities, it is advisable to develop a reference plan for assessing the effectiveness (feasibility) of activities.

This sequence involves solving interdependent problems: the development of a mathematical model of the reference plan and the calculation of numerical values of the factor characteristics (variables of this plan); development of a mathematical model of the effectiveness of the plan and methods for assessing the effectiveness of alternative plans in comparison with the reference plan. Thus, the calculation of the reference plan for the development of intangible assets is an important part of the strategic planning of the development of enterprises, and the mathematical interpretation of planning the development of intangible assets is carried out in the following sequence.

Modeling of planning processes for the development and improvement of intangible assets

Consider the $m \times n$-sized matrix of the action plan obtained from the questionnaire data of the experts, where m – is the number of experts (the number of the matrix rows), and *n* is the number of factor characteristics (number of columns), $m \geq n$; x_{ij} i is the matrix element in absolute units (the real value of the J factor, estimated by the i-th expert)., $i = 1,2,\dots,m$; $j = 1,2,\dots,n$. It is necessary to find the next linear function of the plan that will most closely match the original expert estimates:

$$Z = a_1 x_1 + a_2 x_2 + a_3 x_3 + \dots + a_n x_n = \sum_{j=1}^{n} a_j x_j \ , \qquad (1)$$

As it is known, equation 1 also determines some hyperplane in space R^n. If the numerical values of the factor scores of the expert assessments were perfectly matched, the reference plan would be represented on the plane (1) by a single point with hyperplanation:

$$Z = k\left(x_1^*, x_2^*, x_3^*, \dots, x_n^*\right) \tag{2}$$

However, the experts' opinions do not coincide, and so each row of the matrix on the plane (1) will correspond to some point with an applicator,

$$Z_i = a_1 x_{i1} + a_2 x_{i2} + a_3 x_{i3} + \dots + a_n x_{in}, \tag{3}$$

that is, a set of points that do not coincide with the reference plan point i, randomly scattered near it. Assume that the obligatory condition of equivalence of expressed evaluations for the expert survey is satisfied. Then it can be assumed that all the points z_i belong to one hyperplane of the desired reference plan, and the deviations k -Z_i are random. To calculate the coefficients a_j of the linear model (1) apply the method of least squares, which minimizes the sum of squares of deviations of points Z_i deviations from the point k. As a criterion of agreement of the required function (1) consider such set $\{a_1, a_2, a_3, \dots, a_n\}$, coefficients, which satisfies the method of least squares

$$S = \frac{1}{m} \cdot \sum_{i=1}^{m} (k - z_i)^2 = \frac{1}{m} \sum_{i=1}^{m} \left(k - \sum_{j=1}^{n} a_j x_{ij} \right)^2 \longrightarrow \min, \tag{4}$$

where k – is the plan function value at the optimum point $(x_1^*, x_2^*, x_3^* \dots, x_n^*)$, x_j^* – reference values of the factors X_j, Z_i – is the system function value at the point $\left(x_{i1}, x_{i2}, x_{i3} \dots, x_{in}\right)$.

Taking into account condition (4) to calculate the coefficients of the plan-linear model leads to a system of so-called *m* conditional equations with *n* unknowns, which is then converted into a system of n normal equations with unknowns a_j. The constructed system will have the following form:

$$\begin{cases} a_1 \sum x_{i1}^2 + a_2 \sum x_{i1} x_{i2} + a_3 \sum x_{i1} x_{i3} \dots + a_n \sum x_{i1} x_{in} = k \sum x_{i1} \\ a_1 \sum x_{i1} x_{i2} + a_2 \sum x_{i2}^2 + a_3 \sum x_{i2} x_{i3} \dots + a_n \sum x_{i2} x_{in} = k \sum x_{i2} \\ a_1 \sum x_{i1} x_{i3} + a_2 \sum x_{i2} x_{i3} + a_3 \sum x_{i3}^2 \dots + a_n \sum x_{i3} x_{in} = k \sum x_{i3} \\ \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \\ a_1 \sum x_{i1} x_{in} + a_2 \sum x_{i2} x_{in} + a_3 \sum x_{i3} x_{in} \dots + a_n \sum x_{in}^2 = k \sum x_{in} \end{cases} \tag{5}$$

where the summation is performed on *i* from 1 to *m*. According to Cramer's rule, find its solution with an arbitrary multiplier k ≠ 0. The solution of system (5) is expressed by the equations:

$$a_1 = \frac{k\,\Delta_1}{\Delta},\ a_2 = \frac{k\,\Delta_2}{\Delta},\ a_3 = \frac{k\,\Delta_3}{\Delta},\ \dots, a_n = \frac{k\,\Delta_n}{\Delta}, \tag{6}$$

where Δ – is the main determinant of the system (5);

$$\Delta=\begin{cases}\sum x_{i1}^2 & \sum x_{i1}x_{i2} & \sum x_{i1}x_{i3} & \dots & \sum x_{i1}x_{in} \\ \sum x_{i1}x_{i2} & \sum x_{i2}^2 & \sum x_{i2}x_{i3} & \dots & \sum x_{i2}x_{in} \\ \sum x_{i1}x_{i3} & \sum x_{i2}x_{i3} & \sum x_{i3}^2 & \dots & \sum x_{i3}x_{in} \\ \dots\dots\dots & \dots\dots\dots & \dots\dots\dots & \dots & \dots\dots\dots \\ \sum x_{i1}x_{in} & \sum x_{i2}x_{in} & \sum x_{i3}x_{in} & \dots & \sum x_{in}^2\end{cases}, \tag{7}$$

$k\Delta_j$ – determinants that are formed by Δ replacing the j-th column by the column of intercept terms (5). Given (6), the output function of the plan looks as follows:

$$Z = k\left(\frac{\Delta_1}{\Delta}x_1+\frac{\Delta_2}{\Delta}x_2+\frac{\Delta_3}{\Delta}x_3+\dots+\frac{\Delta_n}{\Delta}x_n\right), \tag{8}$$

where k≠0 – is an arbitrary set parameter.

Function (8) defines a one-parameter family of hyperplanes formed to the accuracy of the "parallel" transfer k≠0 along the Oz coordinate of n-dimensional space. By fixing k, it is possible to get one of them. Note that the arbitrary choice of k, although it changes the coefficients (6) of the linear model (8), but these coefficients for each k satisfy condition (4), since in the case of parallel transfer the deviations of the hyperplanes $k\text{-}Z_i$ remain unchanged.

In other words, for any k the coefficients (6) will perfectly correspond to expert estimates. If add equality (2) to equation (8), the following will be obtained:

$$\begin{cases} Z = k\left(\frac{\Delta_1}{\Delta}x_1+\frac{\Delta_2}{\Delta}x_2+\frac{\Delta_3}{\Delta}x_3+\dots+\frac{\Delta_n}{\Delta}x_n\right), \\ Z = k \end{cases} \tag{9}$$

The hyperline of operational plans is defined by these equations in R^n space. It follows from (9) that each plan the variables of which satisfy the identical equation:

$$1 = k\left(\frac{\Delta_1}{\Delta}x_1+\frac{\Delta_2}{\Delta}x_2+\frac{\Delta_3}{\Delta}x_3+\dots+\frac{\Delta_n}{\Delta}x_n\right) \tag{10}$$

It is considered operational. Condition (10) is a prerequisite for the proposed plan to be operational. For all further cases assume k = 1, and the plan function (hyperline of operational plans) will be determined by the system of equations:

$$\begin{cases} Z = k\left(\frac{\Delta_1}{\Delta}x_1+\frac{\Delta_2}{\Delta}x_2+\frac{\Delta_3}{\Delta}x_3+\dots+\frac{\Delta_n}{\Delta}x_n\right) \\ Z = 1 \end{cases} \tag{11}$$

Assessment of the adequacy of the mathematical model of the plan according to the data obtained

Perform an assessment of the adequacy of the mathematical model to the data obtained. The planning function should be tested for adequacy to the original data by Fisher's criterion based on the following inequality:

$$F < F_T\left(\alpha, k_1, k_2\right), \tag{12}$$

Where F is the calculated value of the criterion; F_T theoretical value of the criterion; α is a five-percent significance level; $k_1 = m - n$, $k_2 = m - 1$ is the number of degrees of freedom. The calculated value of F is determined by the formulas:

$$\begin{cases} F = \dfrac{D_A}{D_B} \\ D_A = \dfrac{1}{m-n}\sum_{i=1}^{m}\left(Z_i - k\right)^2 \\ D_B = \dfrac{1}{m-n}\sum_{i=1}^{m}\left(Z_i - \overline{Z}\right)^2 \end{cases} \tag{13}$$

where D_A is the variance of adequacy, D_B is the variance of reproduction. Accepting that $k = 1$; estimated value of the plan function in line i according to expert estimates x_{ij}; $\overline{Z}$ – is average with Z_i. If inequality (12) is not satisfied, then instead of the linear model (1) it is necessary to select an algebraic function of higher order. Note that the construction of a nonlinear algebraic function of the plan is a time-consuming task, so it is advisable to use software to solve it.

A method for determining operational plans and a multi-criteria optimal (reference) plan

An acceptable plan for the development and improvement of intangible assets will be any plan that corresponds to a given value of the factor characteristics, obtained with the help of expert evaluations. According to this definition, a necessary and sufficient condition for the admissibility of the proposed plan $\{x_1, x_2, x_3, ..., x_n\}$ on the accepted set of factor characteristics is the fulfillment of inequalities:

$$\begin{cases} \min\{x_{i1}\} \le x_1 \le \max\{x_{i1}\} \\ \min\{x_{i2}\} \le x_2 \le \max\{x_{i2}\} \\ \min\{x_{i3}\} \le x_3 \le \max\{x_{i3}\} \\ \dots\dots\dots\dots\dots\dots\dots\dots \\ \min\{x_{in}\} \le x_n \le \max\{x_{in}\} \end{cases} \tag{*}$$

There exists an infinite set of plans satisfying the inequalities (*). In this set, plans are operational if their variables identically satisfy the hyperline equation (11) such that:

$$\frac{\Delta_1}{\Delta}x_1 + \frac{\Delta_2}{\Delta}x_2 + \frac{\Delta_3}{\Delta}x_3 + ... + \frac{\Delta_n}{\Delta}x_n \equiv 1 \tag{14}$$

To determine operational plans, the following must be done. Now denote any points of Z_r, Z_s xpert evaluations through E_r, E_s on the hyperplane planes on either side of the hyperline (11), so that:

$$\begin{cases} 1 - Z_r > 0 \\ 1 - Z_s < 0, \quad r, s \in i \end{cases} \tag{15}$$

Figure 1 shows two sets of such points for Euclidean space R^3. Then it is obvious that the operational plans will be represented by a countable set of points $A(x_1, x_2, x_3, ..., x_n)_A$, $B(x_1, x_2, x_3, ..., x_n)_B$, $G(x_1, x_2, x_3, ..., x_n)_G$ and intersections of hyperlines with hyperlines of LM plans. There are six such points in Figure 1. To find the coordinates of points A,B,..., G, i.e., the set of operational plans $(x_1, x_2, x_3, ..., x_n)_A$, $(x_1, x_2, x_3, ..., x_n)_B$, $(x_1, x_2, x_3, ..., x_n)_G$, the following operations must be performed:

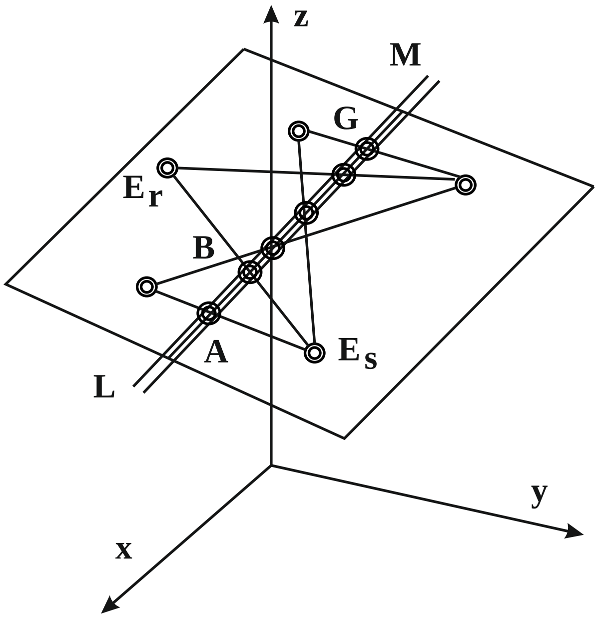


Figure 1. Supporting points of the plan

It is assumed that the resulting linear model of the plan function (11) is the matrix of the plan $m * n$ in the coded values of x_{ij}, $i = 1,2,3,...,m$ is the number of experts, $j = 1,2,3,...,n$ is the number of factors (Table 1).

Table 1

Matrix of the action plan

i/j	x_1	x_2	$\dots$	x_n
1	x_{11}	x_{12}	$\dots$	x_{1n}
2	x_{21}	x_{22}	$\dots$	x_{2n}
...	$\dots$	$\dots$	$\dots$	$\dots$
m	x_{m1}	x_{m2}	$\dots$	x_{mn}

It is necessary for the *i*-th line of Table 1 ($i = 1,2,3,..., m$) to find the sequence $\{z_i\}$ of plan 11 values at the points of expert estimates, the difference of $1-z_i$ and the difference of $|1-z_i|$ module and also fill in Table 2.

Table 2

Plan matrix in coded values

i	$1-z_i$	$\lvert 1-z_i \rvert$
1	$1-z_1$	$\lvert 1-z_1 \rvert$
...	...	...
m	$1-z_m$	$\lvert 1-z_m \rvert$

The obtained differences $1-z_i$ have various signs and correspond to the points of (11) the plan on different sides of admissible (or operational) plans hyperline (Figure 1), with segments E_r, E_s, connecting points of expert estimates, for which $1-z_r > 0$, and $1-z_s < 0$, define the operational plans. The number of operational plans is equal to the product of the number of rows in Table 2, where $1-z_i > 0$, and the number of rows, where $1-z_i < 0$. This value is the number of admissible pairs, by which the points below are found by successive approximations:

$$A(x_1, x_2, x_3,..., x_n)_A,\ B(x_1, x_2, x_3,..., x_n)_B, \dots, G(x_1, x_2, x_3,..., x_n)_G.$$

According to Tables 2 and 3 form all possible pairs r,s, where $1-z_r > 0$, $1-z_s < 0$. For each such pair fill in Table 3.

Table 3

The value of the plan function at the points of expert evaluations

I	x_1	$\dots$	x_n	$1-z_i$	$\lvert 1-z_i \rvert$
r	x_{r1}	$\dots$	x_{rm}	$1-z_r$	$\lvert 1-z_r \rvert$
s	x_{s1}	$\dots$	x_{sn}	$1-z_s$	$\lvert 1-z_s \rvert$

The exact operating plan provided by the expert pair (r,s,), is found by the known formulas for dividing a segment in a given ratio λ :

$$\begin{cases} x_1 = \dfrac{x_{s1} + \lambda_{rs} x_{r1}}{1 + \lambda_{rs}} \\ x_2 = \dfrac{x_{s2} + \lambda_{rs} x_{r2}}{1 + \lambda_{rs}} \\ x_3 = \dfrac{x_{s3} + \lambda_{rs} x_{r3}}{1 + \lambda_{rs}} \\ \dots\dots\dots\dots\dots\dots\dots\dots \\ x_n = \dfrac{x_{sn} + \lambda_{rs} x_{rn}}{1 + \lambda_{rs}} \end{cases} \tag{16}$$

In formulas (16) the number λ_{rs} is the ratio of the modulus of the differences $|1 - z_s|$, $|1 - z_r|$, as such

$$\lambda_{rs} = \frac{|1 - z_s|}{|1 - z_r|}, \tag{17}$$

at the same time the number in the numerator of fraction 17 must be the smaller of the compared ones. In addition, the elements of the row of table 4 are multiplied by λ_{rs} , for which

$$|1 - z_r| > |1 - z_s|. \tag{18}$$

The formulated rules (17), (18) follow from the geometrical content of the segment division in a given relation. If the calculations of the operational plan are correct, then the coordinates (16) satisfy the identical equation (14) with an error ε not exceeding the miscalculation.

On the set of obtained operational plans according to the chosen optimization criterion we determine the reference (optimal) plan, which corresponds to the initial expert estimates. If two or more criteria are chosen, the optimal plan multicriteria model is obtained. The problem of unambiguous selection of a multi-criteria model does not always have a solution, especially when the number of factor characteristics of the plan is large (variables x_{ij}).

As an optimization criterion is taken the sum of coordinates (16) of the operational plan, equally satisfying equation (11), that is

$$K_i = \sum_{i=1}^{n} x_i = x_1 + x_2 + x_3 + \ldots + x_{n(A \neq B \neq \ldots \neq G)}, \tag{19}$$

where x_i is the coded value, and the reference (optimal) plan is the one of the operational plans that satisfies the following condition:

$$\min\left(\sum_A, \sum_B, ..., \sum_G\right). \tag{20}$$

The number K_i is called the multidimensional optimality criterion. Note, that the number of operational plans, and therefore the number of sums, $\sum_1$, is equal to the product of the number of expert points located on both sides of the hyperline. Thus, if 4 expert points satisfy one of the inequalities of 15, and 3 expert points satisfy the other (for m = 7), there will be 12 operational plans. As a rule, only one of them is optimal according to criterion (20). If it turns out that two or more plans meet the optimality condition, then an additional condition should be set for the plans equivalent to the optimality condition. This will make it possible to make an unambiguous choice.

The reference plan is intended to serve as a generally accepted norm, or standard, which regulates and optimizes the development and improvement of the intangible assets of an enterprise. The reference plan is developed for a specific category of enterprises at a certain level of the hierarchy.

The reference plan recommended for a number of objective reasons, for example, in conditions of underfunding, can not always be implemented in full. Certain deviations from the reference plan, respectively, raise the problem of comparing the practically implemented plan with its theoretical standard. The task of comparing objects (in this case, the reference and operational plans) is usually solved on the basis of the concept of efficiency of these objects.

The method for assessing the effectiveness of alternative plans

The next stage of the study proposes a method for evaluating the effectiveness of alternative plans. The implementation of some proposed plan for the development and improvement of intangible assets of the enterprise on the set of $\{x_1, x_2, x_3, ..., x_n\}$ random numerical values of factor characteristics $\{X_1, X_2, X_3, ..., X_n\}$ is an event that provides with a certain probability the degree of such development and improvement, which is sufficient to successfully solve the problems.

The a priori probability of the level of improvement and development of intangible assets provided by the developed plan is called the effectiveness of the plan. The stochastic function expressing this probability is called the efficiency function of the plan. The optimality criterion of the plan will be considered as an argument of the efficiency function.

For analytical construction of the efficiency function, the results of calculations of operational plans are used. It is assumed that the effectiveness of the reference plan has a maximum value and is equal to 1 (according to the definition of probability). The number *i*, which is the criterion of optimality of the reference plan (K_e), is taken as the criterion of optimality of the operational plan (K_i). The difference

$$\Delta K = K_i - K_e \tag{21}$$

is an increase in the optimality criterion of plan i. In this case, the value

$$\Delta p = \frac{K_i - K_e}{K_e} \tag{22}$$

the change in efficiency when using a particular variant of the operational plan instead of the reference. Consequently, for the effectiveness of the operational plan the following formula is obtained:

$$P_i = 1 - \frac{\Delta K}{K_e}. \tag{23}$$

The efficiency function (23) takes the form:

$$P = 1 - \frac{K - K_e}{K_e}, \tag{24}$$

and can be used to evaluate the effectiveness of any alternative plan, not necessarily an operational one. In this case, the above condition of acceptability must be replaced by a more rigid one:

$$K_e \leq K \leq 2K_e, \tag{25}$$

where K – is a criterion of the alternative plan optimality, K_e – is the reference plan optimality criterion. An index K is calculated in coded coordinates, based on the values of the variables x_i, embedded in the alternative plan.

Next, it is necessary to find out the geometrical meaning of the plan efficiency function, (Figure 2), conditioned by expression (24), noting that with monotonous growth K within the limits of (25) the ratio $(K - K_e)/K_e$ monotonically increases from 0 to 1.

Set the current value of *x* of random size *X* for the current value of random size *K*.

$$X = \frac{K - K_e}{K_e}. \tag{26}$$

Then the distribution function of this random variable will be written as follows:

$$F(x) = \begin{cases} x,\ if\ \ 0 \leq x < 1,\ K_e \leq K < 2K_e \\ 1,\ if\ \ x \geq 1,\ K \geq 2K_e \end{cases} \tag{27}$$

In this case, the efficiency function (24) is nothing more than the addition of the distribution function $F(x)$ to 1. Figure 2 shows graphs of both functions.

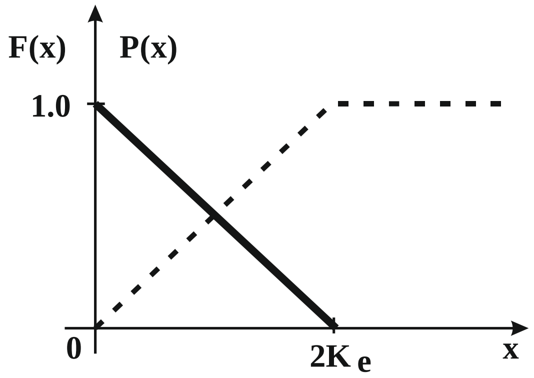


Figure 2. Graphs of efficiency and distribution functions

The proposed methods make it possible to develop a system of measures capable of ensuring the economic growth of the enterprise in the long term on the basis of the development of intangible assets of the enterprise in such areas: development of computer systems and technologies; intellectualization of labor; expansion of the network of economic interactions in the context of interaction with market mechanisms; formation of innovations and innovative ideas to improve product quality and its competitiveness in the market. The solution to this problem is due to the fact that intangible assets at the present stage of scientific and technological development are becoming dominant over tangible assets to ensure the success of enterprises. The lack of material form, the close connection with investment processes, the various results of the impact on the company’s activities (ensuring an increase in profits, the growth of market value, the creation of an information environment, the improvement of socio-economic standards, etc.) give preference to assessing their availability, improvement and development by qualitative indicators, which are not reflected in financial statements.

The results allow us to formulate a comprehensive approach to planning the development of intangible assets of the enterprise, based on modern scientific and mathematical methods and conclusions of scientists and specialists, allowing the use of both quantitative and qualitative indicators.

Part 3. Key aspects of the governance system in modern management

Orientation to the needs of consumers, conducting a flexible scientific, technical and production policy, striving for innovation are determined by new ideas of modern management philosophy. Adaptation to dynamic market changes and selection of optimal development strategy are the central problems of domestic enterprises today. In this regard, the problem of finding effective management tools and methods to implement the results of scientific and technological progress in all areas of the enterprise, which will reduce its costs and increase profitability, as well as improve social standards.

Therefore, the organization of the enterprise requires the introduction of innovative business processes and building an effective management system to reduce the inherent innovation and investment risks. It is the management of innovative business processes of the enterprise using information technology in the context of the innovation strategy will help the company to enter foreign markets on a partnership basis and ensure effective profitability.

Dynamic changes in technology, increased competition, competition for consumers and product quality encourage companies to actively seek new approaches in building an enterprise management system. In this situation, modern methods of information processing and formation of information support play a key role in increasing the efficiency of enterprise production and economic activity management.

The science and practice of management uses a number of approaches and methods, which at the stage of development of the information society acquire the characteristic features of information as a set of distinctive properties.

The authors consider that the approach in the coverage of these theoretical aspects should be understood as a theoretical direction (position) of the management process, which includes the presence of a set of purposeful in content principles and methods of management. Therefore, an urgent problem of modern management science is the need to create and develop a theoretical concept that would combine the achievements and integrate "classical" approaches to form a universal model of management, capable of reflecting current trends in the development of society and business.

The modern science of management is characterized by a large number of consensus groups, directions, concepts, approaches, trends, which can be systematized by dividing into two main groups: approaches of individual consensus groups of management and modern integrated approaches. Consensus groups of traditional management, in contrast to modern, tried to identify their own unique way to improve management, perceived the management process as individual influential actions to regulate the activities of the enterprise and did not consider the enterprise as a complex economic system and the relationship between its elements, the external environment.

In modern theories of management approaches to the organization of management try to take into account the features of the functioning of socio-economic objects as complex economic systems, their elements and trends in the environment in which they function.

Thus, the orientation on the needs of the consumer, flexible scientific, technological and production policy, the desire for innovation determine the new ideas of modern management, the philosophy of which over a long period of development substantiates two basic approaches to business management (functional and process). Their combination and practical application form comprehensive approaches, the choice of which allows to implement the optimal version of the management system, taking into account the complexity of production and economic objects. The essence of functional management is to ensure the performance of functions of the production and economic system with a focus on certain end goals. An alternative to the functional approach is the process approach. The essence of process management is to allocate business processes as a sequence of actions aimed at achieving a final, measurable and concrete result.

According to the authors, the application of the process approach and the construction of a set of business processes is necessary when using modern information management technologies and the latest, innovative approaches in all areas of social and production systems. The application of situational, functional, complex and other integrated approaches specified by the authors in Table 1 will allow to optimize the current management decisions within the industrial enterprise and to form a unified information space of its activity.

Thus, the innovative difference between the practical implementation of the process approach and the functional approach is that the main focus of management is not on individual functions performed by various departments and officials, but on cross-functional processes that integrate individual functions into common flows and ensure the achievement of company goals [1; 7; 9; 11; 12]. Such features of the process approach can generate innovative ideas and create a wide field for their implementation.

Thus, the modern concept of process management involves the transformation of an organization’s business in order to more closely coordinate the activities of its functional parts, increase their flexibility and synergy, providing a successful environment for solving production problems and various types of innovation.

There is no unambiguous approach to defining the concept of "business process" in modern scientific thought. Some scientists define a business process as a set of different activities, within which the "input" uses the planned types and amounts of resources, and as a result of this activity the "output" creates a product of value to consumers [15, p. 11]. According to some scientists, a business process is a set of logically interdependent actions performed to achieve a certain result of entrepreneurial activity [16, p. 5].

According to the authors, from the perspective of the modern market, all processes that are performed to obtain the end results of economic activities of the enterprise, and ensure its profit, are business processes. After all, if a process is understood as any activity involving a particular set of functions that uses resources at the beginning of the process and is transformed into a final product before its completion [16, p. 94], then business processes should be understood as a consistent systematization of a set of activities that create value for the industrial enterprise and its target audience and provide profit.

Accordingly, under the process management system of industrial and economic objects we understand a set of socio-economic and technical functions and tools for their implementation, implementing management processes within the existing business processes to achieve their goals.

Thus, the process model of the enterprise consists of a well-defined set of business processes, which involve responsible executors, providing business process management, as well as employees of structural units, performing production tasks in accordance with the functional purpose of the business process. Therefore, an industrial enterprise can be viewed as a business system in which all business processes are aimed at implementing a strategy for the development and implementation of innovation, in order to ensure its long-term competitiveness, profitability and ability to integrate into global economic processes.

Such a business system must be consistent with the innovative business model that the company will choose for all of its activities to ensure their competitiveness and profitability through innovation, highlighting the constituent stages of value creation for each product and the aggregate business.

The innovative model of enterprise organization is a fundamental condition for its functioning, since innovations are initiated by the development of scientific and technological progress and are one of the means of adapting enterprises to changing conditions of the external environment. In this context, it should be noted that today, in order to increase the profitability of their business, in addition to investing large financial resources in research and development, it is also advisable to ensure their effective use in accordance with the most successful innovation strategy. This strategy will substantiate the main directions, level and types of innovations in accordance with the potential of the enterprise and its main business processes. They, according to the criteria of their effectiveness and further development, should be determined by the level of growth of production, profit, market share and so on.

Innovative business processes have a significant impact on the determining conditions of the enterprise, causing dynamic changes in its internal and external environment. In the internal environment of the enterprise the following prerequisites are created for application: modern tools for planning of income and expenses of the enterprise, methods of control procedures; modern methods of information support of activities; software and hardware of information security systems of innovative business processes; modernization of equipment and implementation of new technologies, etc.

The interaction of the enterprise with the external environment creates the prerequisites for long-term cooperation with suppliers and buyers, the company's entry into foreign markets, attracting foreign investment, promoting innovative development.

Thus, taking into account the features of the essence and prerequisites of the innovative model of business organization will allow to form an effective management system of innovative business processes, which will ensure the interconnection of all elements of the innovation process, its progressive development from the initial stage. There is continuous interaction with all kinds of business processes of the enterprise.

Accordingly, the innovative business process is defined as the latest system of consistent, purposeful and regulated activities that operate in conjunction with all business processes of the enterprise, in which under the influence of management processes and resources inputs become outputs – the results of the process, which can provide innovation and profit, progressive development of the enterprise and its ability to adapt to changing changes in the external environment with a high level of competitiveness.

Determining the main stages of the management decision-making process is the most important in the study of management. Most authors suggest the same sequence of the process of preparation and making decisions.

Thus, M.P. Voynarenko cites the following stages of rational problem solving: problem diagnosis, formulation of constraints and decision criteria, identification of alternatives, evaluation of alternatives, choice of alternatives, implementation (implementation), performance monitoring, feedback [10]. Generalization of information allowed to identify the main stages of making management decisions. In particular, the first stage is the collection, processing and storage of information. This information is classified, systematized and, if necessary, transferred to the next stages for decision-making.

The second stage identifies the current situation with the previously necessary use of previously tested experience in solving management problems. It reveals the signs of a fundamentally new situation that requires the development of new approaches to solving the problem. The main tasks of this block are solved by the special analytical services of the enterprise. They diagnose the problem, identifying its characteristics and causes, as well as highlighting relevant information (relevant to the particular problem), and, accordingly, provide the next, third stage.

The third stage is the development of projects (alternatives) to solve problems based on constraints and criteria. The complexity of the problem determines the necessary means to solve it.

The fourth stage evaluates alternative solutions to the problem, using the standards (criteria) of decision-making, which are formed in the information block, allocated by the management of the enterprise, taking into account the limitations of capabilities and methods of assessment of management and management personnel.

At the fifth stage a decision is made. It is worth noting the following feature of this sequence of decision-making, if the problem has been correctly identified, and alternative solutions are objectively evaluated, it is easy to make a decision. Otherwise, it is advisable to proceed to the third stage. This is difficult to do in conditions of uncertainty and risk.

The evaluation of alternatives varies according to the degree of certainty associated with possible future conditions. There are usually three options: confidence, risk, and uncertainty.

In making decisions, managers must anticipate their possible outcomes under different circumstances or environmental conditions. In essence, decision making occurs in a variety of circumstances due to risk.

When it is known which decision is being made, the alternative that has the greatest effect under the given conditions is chosen. In this case, the decision-maker knows exactly the outcome of each choice.

The complete opposite is uncertainty because there is no information about the probability of various conditions. This often occurs when environmental factors are unknown or complex, and it is impossible to obtain relevant information. Risk is a state between two polar cases, certainty and uncertainty. Risk is a situation that allows to predict not only the possible consequences of each decision option, but also the probability of their occurrence.

Uncertainty and risk situations should not be confused, because they are fundamentally different in terms of the criteria used to select the optimal decision. In a risk situation, the probability of the consequences of a decision is often expressed through mathematical expectations, while in an uncertainty situation, there is no probability of the consequences of a decision. In many cases, in a situation of uncertainty, it is advisable to change the strategy of behavior in accordance with the selected criteria.

Thus, in a general interpretation, the problem of decision-making is characterized by a set of elements: the necessary information; the rules for choosing a decision; alternative solutions; the features of decision-making; criteria and rules formulated on the basis of information about the situation; the availability of time.

Based on the seriousness of the problem, the order of its solution can be presented in the form of a model consisting of structural and process components that detail the above steps.

The results of decision-making affect both the managers responsible for the decisions and the external environment. For example, environmental disasters occur in the environment and are the responsibility of business managers who do not take appropriate action.

Thus, a person’s perceptions and attitudes are individual and sometimes opposite in the same life situation. Each person can react differently to the same situation and make subjective decisions, sometimes unrealistic ones.

The role of managerial decisions as the basis of management is that they determine the sequence of actions to achieve the main goal. Management decision is considered as a result of management, which is realized in the process of purposeful activity and is expressed through its final results. Implementation of management decisions is conditioned by interrelated functions. Consistent implementation of such functions forms the process of development and implementation of solutions. It is characterized by a universal set of procedures linked by a sequence of stages. Procedures, performed by the management and staff of the management apparatus, provide the relationship between the object and the subject of management through the implementation of management decisions. Characteristic properties of this process are continuity, discreteness, alternativeness, social significance, efficiency, productivity.

Naturally, depending on the sphere of decision-making, as well as on the situations and problems that arise, the set of functions and blocks with operations and procedures may be different. It reflects only the essential side of the technological process of management and the place of decision-making technologies in it.

Each function, depending on the level of management (highest, middle, lowest) is given the amount of authority necessary and sufficient for managers to perform specific operations and procedures for this function, as well as the adoption and implementation of decisions.

The scope of authority of each function determines the quantitative and qualitative characteristics of the information necessary to complete it. The set of functions provides their filling at the levels of management. The relationship between management functions and operations is determined by the fact that the former reflect the types of managerial work (answering the question of what to do), and the latter reflect the management cycle (answering the question of how to make sure that the sequence of managerial actions is observed).

The relationship between the functions determines their content, as well as the characteristics of the necessary information, authority and responsibility of the manager at a particular stage of the decision-making process. The use of such a scheme makes it possible to determine quite objectively and the number of management personnel involved in decision-making, and the content and sequence of their actions, and the indicators of information circulating in the control channels, and certain means of automation.

Specific implementation of management functions and decision-making units depend on the organizational and functional structure of the organization, the activities of management personnel, the system of internal and external relations.

Management decision in the organization has a hierarchical structure, which has three levels of management: strategic, which makes strategic decisions that determine the life of the organization for many years to come; functional (operational), which develop strategies for development, marketing, etc., combined with the management strategy of the organization. At this level, decisions are made that correspond to the basics, the ideology of the strategic organizational decision; tactical, in which decisions made at the strategic level are implemented on a day-to-day basis. Decisions that are directly related to management are made at this level.

Decisions made at all levels are related to the organization’s mission, primary purpose and strategy. These concepts are at the core of strategic decision making. Defining the mission, goals, and developing an action strategy to ensure that the organization achieves its mission and goals are the most important tasks of senior management, which form the basis of strategic management.

Mission is understood as a statement of philosophy and purpose, the content of the organization (broad meaning), as well as a statement that reveals the content of the organization, which shows the difference between this organization and similar ones. A mission is a specific end state or desired outcome that the organization seeks to achieve.

To achieve a goal, certain tasks (a job, a series of jobs, or a part of a job that must be done in a certain time) must be accomplished. Tasks are formed in the decision-making system according to the management plan. The goal answers the question of what result is to be achieved, the tasks that need to be solved to achieve the goal.

To give purposefulness to the management of the organization and its orientation to specific results for each goal (including management decisions), limitations are defined – criteria for selecting an alternative solution. In this case, the management decision must be consistent with the management mechanism by hierarchical levels, available or allocated forces and means.

Thus, practical experience shows that managerial decisions can be developed on the initiative of managers at both the strategic and tactical levels. There are no fundamental differences in the relationship of managerial decisions at the levels of the hierarchy in this case, but there are peculiarities of the organization of the process of development, adoption and implementation of decisions.

Part 3. Knowledge of performers in innovation management models

The rapid pace of scientific and technological development, the speed and scale of technological change, the complex conditions of growing competition, increasing globalization and integration processes determine the need for constant adaptation of the enterprise to the external environment, ensuring a high degree of its dynamism, adaptability and flexibility to achieve effective functioning. No less important are the issues of ensuring innovative development, which is recognized as the basis of functioning [14; 27]. It is believed that without dealing with issues of innovative development, an enterprise cannot function successfully [13; 28]. The results of studies also show that the effectiveness of innovative activity of the enterprise depends primarily on the quality of information produced by its information system, as well as the knowledge and ability to use it by specialists who provide strategic management of the enterprise by making sound management decisions [6; 27; 8].

The conditions for sustainable development of innovative economy, as well as the current state of innovative development of enterprises require a comprehensive approach to the study of external and internal factors. Scientifically substantiated methods of building a management system and options to optimize management decisions relating to the further innovative development of enterprises and the introduction of technologies that ensure their effective operation, stable income and active market positions are needed. The scientific works substantiated the fundamental provisions that form the basis for the study of innovation processes in relation to the development of enterprise management system on the basis of the use of economic and mathematical methods and models [4; 5; 11; 7]. However, improving the quality of information support requires the search for innovative approaches to the implementation of information systems in management, such as digitalization, as well as appropriate training of specialists to enhance their knowledge and the formation of tools for their effective implementation, which together will ensure informed decisions on innovation management [18; 29].

However, in order to choose the optimal management decision within a given time frame (management cycles), it is necessary to take into account the technical, economic and financial capabilities of the enterprise and a number of other factors. This can be done only on the basis of modeling of economic processes. In a broad sense, modeling is the substitution of a real object by a nominal one in order to obtain information about the original object. It means carrying out such researches of the object-model, which cannot be carried out with the original object [20; 26]. Thus, a model should be understood as an object that reproduces the original object and is a means of representing, explaining and predicting its behavior. Models can be of different types: real, abstract, mathematical, computer, cognitive, pragmatic, static, dynamic, etc. The main properties of models are their finiteness, approximation, completeness, adequacy and truthfulness [7; 24].

The use of different types of models to choose the option of decision-making in the implementation of management functions of innovation processes, in our view, will determine the best alternative, taking into account existing constraints, risks and the level of human capital development in the enterprise. This will also make the decision-making process operative and dynamic, will ensure the consideration of algorithmically given conditions.

Any modern industrial enterprise is a complex dynamic system. Its multidimensionality is due to the complex material and informational processes taking place within it. A certain set of these processes forms the basis of the production activity of the enterprise, the innovative orientation of which depends on the chosen development strategy, as well as the organizational and economic features of the innovation management system.

The implementation of the tasks of the innovation management system, aimed at achieving the goals, is a process of transforming information into sound administrative and managerial actions. The latter transform the original managed system into a certain or optimal state at a qualitatively new level. The main stages of the innovation management system include [17; 18]: determining the goals of the system; obtaining information about the state of the system; processing and analysis of information; making a management decision; informing executives about the decision; implementation of the management decision and achievement of innovative goals.

Thus, the adoption of an innovative management decision in this study should be understood as the choice of one or more options for innovative development based on certain criteria. The system responds to these options transition to a qualitatively new level [10; 12]. The system's response to an innovative management decision is new information (feedback), which is re-processed and analyzed. It becomes the basis for making a new decision or adjusting the previous one.

The result of implementing innovative solutions becomes largely dependent on the knowledge base and intellectual skills of specialists at different levels of the management hierarchy, from the lower to the upper level of the enterprise management system. It is obvious that the successful functioning of the entire innovation system of the enterprise depends on the professionalism and experience of individual specialists. That is why a specific managerial decision is focused on the direct executor. Accordingly, in the case of ineffective execution of management decisions by a performer of a certain level, it is advisable to take risks when making management decisions on the functioning of innovative processes.

The choice of risk components in the study is due to rapid scientific and technological progress, the informatization of the economic environment, the digitization of economic processes and the need for continuous training of employees. Among them are: education (K_o); professional development (K_c); creativity ($K_к$). Adequate response of innovative processes to management decisions depends on certain components of the executor. It is logical to conclude that management should focus on the professionalism of executors, assigning them certain functions in the process of implementing innovative solutions. The risk in the achievement of innovative goals of the entire socio-economic system increases without taking into account the educational and professional abilities of the executors.

Obviously, with this approach, the level of risk can be quantified by assessing the performer's abilities as a system of his knowledge and its practical implementation [19; 25; 30]. Accordingly, it is reasonable to calculate the knowledge system of the performer as the sum of estimates of individual attributes (according to the method of expert evaluations), characterizing the level of education (K_o), professional development (K_c), and creativity ($K_к$):

$$K = \prod_{i=1}^{n} K_i \,, \tag{28}$$

where K_i is an executor's individual feature assessments, n is the number of features (here n = 3). It is logical to conclude that the conditional intensity of the appearance of risk factors is the inverse of the estimation of the system of knowledge of the executor in a fairly short period of time, i.e.,

$$\lambda_1(\Delta t) = \frac{1}{K\Delta t} \,, \tag{29}$$

where λ_1 is the conditional intensity of the risk factors appearance, *1/h*; *K* is the performer's knowledge system estimation; Δt is time interval, *h*.

Thus, the higher the estimate of the system of knowledge of the executor, the lower the intensity of the manifestation of risk factors. This fully corresponds to the main provisions of making innovative management decisions at the enterprise, as shown in the subgraph (Figure 3).

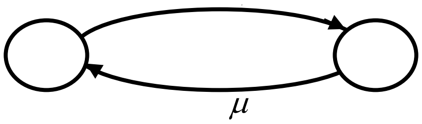


Figure 3. A subgraph of the executor's knowledge system that evaluates states in the internal information environment

Accordingly, the system of Kolmogorov equations for the subgraph (Figure 3) will display the relationship of different probabilities at different points in time and will have the following form:

$$\begin{cases} \dfrac{dp_0(t)}{dt} = -\lambda_2 p_0(t) + \mu_1 p_1(t) \\ \dfrac{dp_1(t)}{dt} = \lambda_1 p_0(t) - \mu_1 p_1(t) \end{cases}. \tag{30}$$

The solution of system (30) under the condition *p0 (0) = 1, p1 (0) = 0* will have the following form:

$$\begin{cases} p_0(t) = \dfrac{\mu_1}{\mu_1 + \lambda_1}\left[1 + \dfrac{\lambda_1}{\mu_1} e^{-(\lambda_1 + \mu_1)t}\right] \\ p_1(t) = \dfrac{\lambda_1}{\mu_1 + \lambda_1}\left[1 - e^{-(\lambda_1 + \mu_1)t}\right] \end{cases}. \tag{31}$$

In this case, the risk function will be calculated in the following sequence:

$$U_p(t) = \frac{\lambda_1}{\mu_1 + \lambda_1}\left[1 - e^{-(\lambda_1 + \mu_1)t}\right]. \tag{32}$$

The next step is to determine the risk factor:

$$U_p = \frac{\lambda_1}{\mu_1 + \lambda_1}. \tag{33}$$

Thus, all functions of management of innovation processes have two characteristics in common: they all require decision-making, and their implementation requires highly skilled professionals and innovative communications. Obviously, decision-making in the management of innovation processes is a series of correct decisions that the manager chooses among several alternatives at a certain time and place. The decision-making function is the main part of the manager's activity at a certain level of the management system.

However, making sound, correct innovative decisions for the manager is a necessary key condition for the successful implementation of innovative processes of the enterprise. Manager of any level makes decisions in the process of forming the goals of innovation processes, as well as in the process of achieving them [8].

Since the functions of management of the implementation of innovative processes depend on the level of the management system, there are differences in the nature of innovative decisions that are taken at different levels. The above conclusion and analysis of the obtained models allowed the authors to form a number of proposals to reduce the level of risk in decision-making on the management of innovation processes, namely:

– assessment of the knowledge system and the choice of executors to implement an innovative management decision;

– determination of the duration of the innovation management decision-making cycle;

– choosing the optimal duration of the cycle "innovation – information – solutions – implementation – information".

Individual qualities of performers can be attributed to risk factors. At a certain level of risk, according to the developed models, it is possible to calculate the requirements for the individual qualities of the performer.

Thus, if formula (29) is substituted into formula (33) and providing $\Delta t = t$, then formula (33) will look as follows:

$$U_p = 1 - e^{-\prod_{I=1}^{n} K_I^{-1}}, \tag{34}$$

where K_i is an executor's individual feature assessments.

Using algebraic transformations, formula (29) takes the following form:

$$\prod_{i=1}^{n} K_i(U_p) = -\left[\ln(1-U_p)\right]^{-1}, \tag{35}$$

where U_p is the risk level.

Figure 4 shows the dependence of the level of risk on the individual qualities of the performer on the basis of the results obtained.

As can be seen, with the increase of a certain level of individual qualities of the executor in the implementation of innovative solutions, the level of risk *(Up)* decreases. Then the individual qualities of the executor are calculated by the formula:

$$\prod_{i=z}^{n} K_i = K_o \times K_c \times K_\kappa, \tag{36}$$

where K_o is an individual education assessment; K_c is an individual professional development assessment; K_κ is an individual creativity assessment.

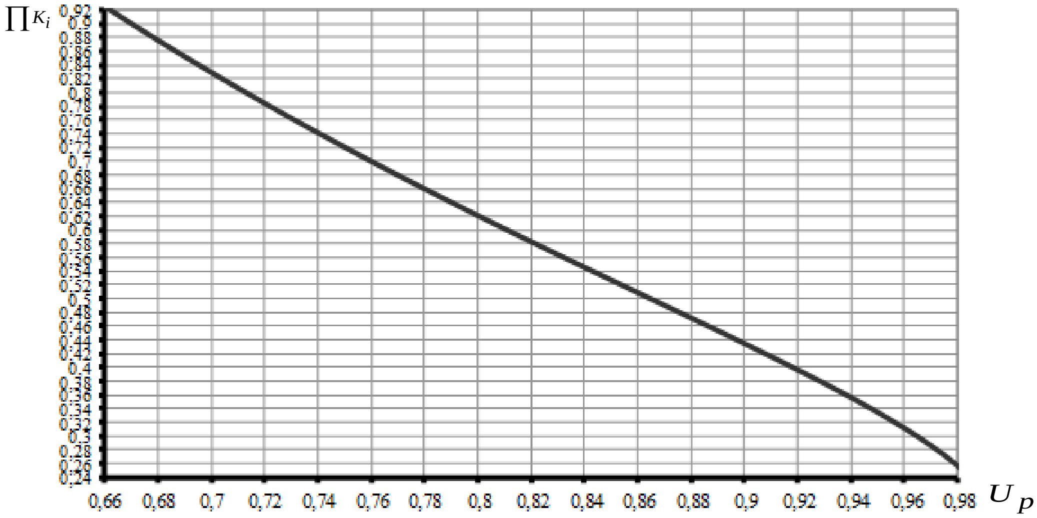


Figure 4. Dependence of the risk level on the executor's individual qualities in innovative solutions implementation

Given formula (36), formula (35) will look as follows:

$$K_o \times K_c \times K_\kappa = -\left[\ln(1-U_p)\right]^{-1}, \tag{37}$$

where K_o is an individual education assessment; K_c is an individual professional development assessment; K_κ is an individual creativity assessment; U_p is the risk level. Using the formula (37), at a certain level of risk it is possible to choose the executor, the level of individual qualities of which will correspond to the conditions of implementation of an innovative management decision. Also, using the formula (37), it is possible to select performers according to individual estimates among the employees of the company with similar levels of certain characteristics. With this approach to the choice of performers it is possible to regulate the level of risk in the implementation of innovation process management of industrial enterprises.

The effectiveness of innovative management decisions depending on the choice of the executor is calculated by the formula:

$$w_B = -\frac{K_B}{\ln(1-U_p)}, \tag{38}$$

where w_B is the effectiveness of innovative managerial decisions; K_B is the level of individual qualities of the selected performer; U_p is a certain level of risk.

This approach to determining the effectiveness of innovative management decisions allows to choose the "ideal" performer according to its individual qualities under the following condition:

$$opt\left\{\begin{matrix} w_B \to 1 \\ if \quad K_B \to \left[-\ln(1-U_p)\right] \end{matrix}\right\}, \tag{39}$$

where w_B is the effectiveness of innovative managerial decisions; K_B is the level of individual qualities of the selected performer; U_p is a certain level of risk.

Thus, it is advisable to take into account the individual qualities of the performer when selecting him or her. This allows the most effective use of the knowledge system of managers at different levels of the hierarchy and ensures the implementation of clearly formulated innovative solutions. In the case of an underestimation of the performer's capabilities, his/her efficiency will be low, because the task before him/her is set below his/her capabilities. Conversely, overestimating the capabilities of the executor will lead to the failure of innovative management decisions, as well as to a decrease in the effectiveness of the control function of the innovative processes of the enterprise.

It should be noted that the cycle of making an innovative management decision is a certain amount of time from the emergence of the situation to the implementation of the management decision. That is, the cycle is the sum of the intensity of making innovative managerial decisions and the intensity of implementation of this decision by executors. The cycle of making innovative managerial decisions is calculated by the formula:

$$\bar{t}_ц = \lambda + \mu, \tag{40}$$

where $\bar{t}_ц$ the average duration of the innovation management decision-making cycle, h; λ intensity of implementation of management decisions by executives, 1/h; μ intensity of management decision making, 1/h.

If to assume that the intensity of making innovative decisions depends on the individual qualities of the top management of the enterprise, and the intensity of implementing managerial decisions depends on the individual qualities of executors (lower management), then, using formula (29), the equation is obtained:

$$\mu = \frac{\prod_{i=1}^{n} K_i^{VL}}{\Delta t}, \tag{41}$$

$$\lambda = \frac{1}{\Delta t \cdot \prod_{i=1}^{n} K_i^{VK}}, \tag{42}$$

where K_i^{VL} is an assessment of the individual qualities of the top management of the enterprise on the i-th basis; K_i^{VK} is the executor's individual qualities assessment on the i-th basis; *Δ t* is the determinable optimal time interval, *h*.

Substituting formulas (41) and (42) into formula (40), the following is true:

$$\bar{t}_{ц} = \frac{1+\prod_{i=1}^{n} K_i^{VL} \cdot \prod_{i=1}^{n} K_i^{VK}}{\prod_{i=1}^{n} K_i^{VK}}. \qquad (43)$$

Figure 5 shows the change in cycle time depending on the assessment of the individual qualities of the executor.

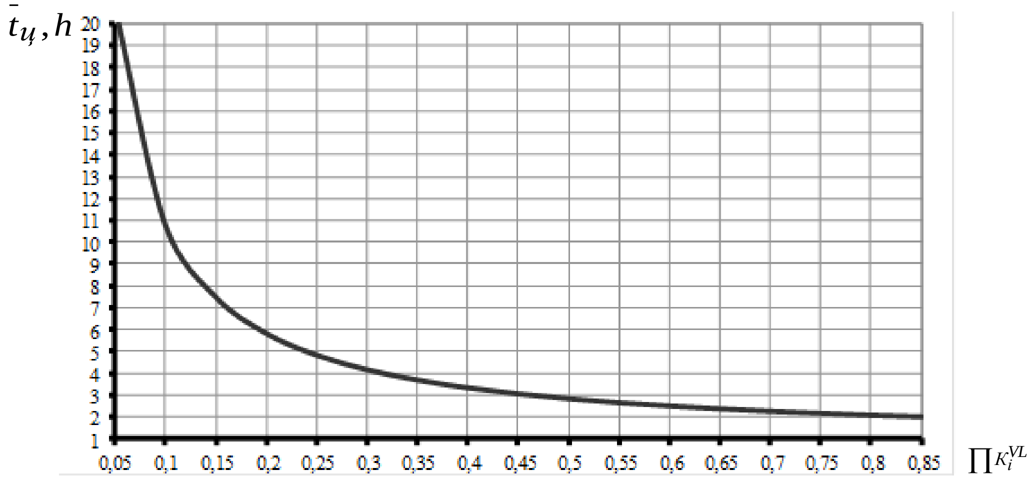


Figure 5. Dependence of the duration of the cycle of making an innovative managerial decision on the individual qualities of the executor

As can be seen from Fig. 3, the duration of the cycle decreases as the individual qualities of the performer increase. According to the formula (42), it is possible to calculate the average duration of making an innovative decision at the level of top management of the enterprise, taking into account the individual qualities of executors:

$$\bar{t}_{ВЛ} = \frac{\bar{t}_{ц} \cdot \prod_{i=1}^{n} K_i^{VK} - 1}{\prod_{i=1}^{n} K_i^{VL}}. \qquad (44)$$

As can be seen from Figure 4, the higher the level of individual qualities of performers, the more time the upper level of the enterprise management system can spend on making innovative management decisions. It is connected with consideration of various variants, influencing factors and substantiation of correct decisions.

The results of practical testing of the models on small innovation-oriented enterprises of different industries in Khmelnytskyi region and their graphic representation (Figure 4 – Figure 6) showed that the obtained models (36) and (44) prove the need for purposeful choice of executors of innovative management decisions. This significantly reduces the level of risk when making

and implementing these decisions, increases the effectiveness of the implementation of innovative processes in various areas of the enterprise.

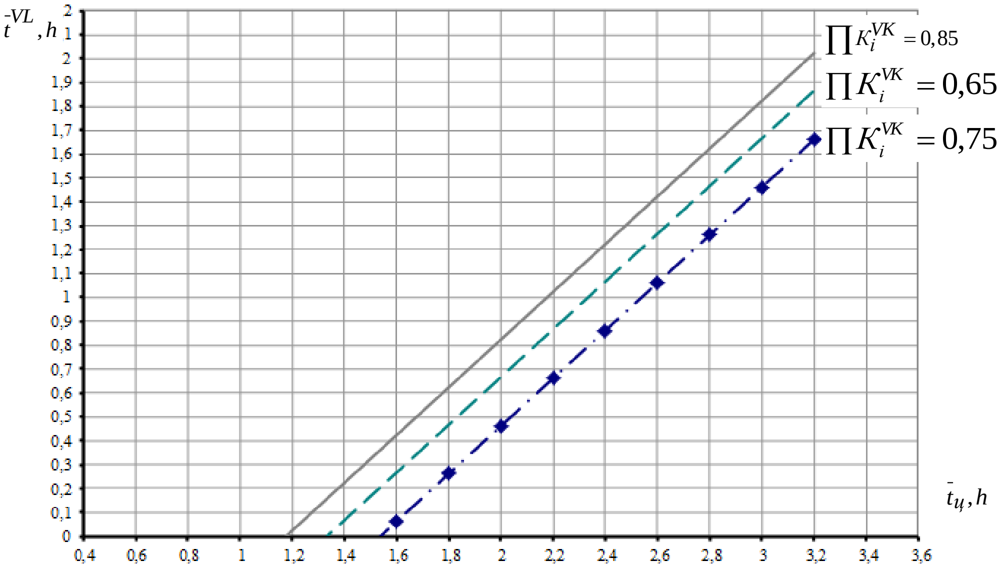


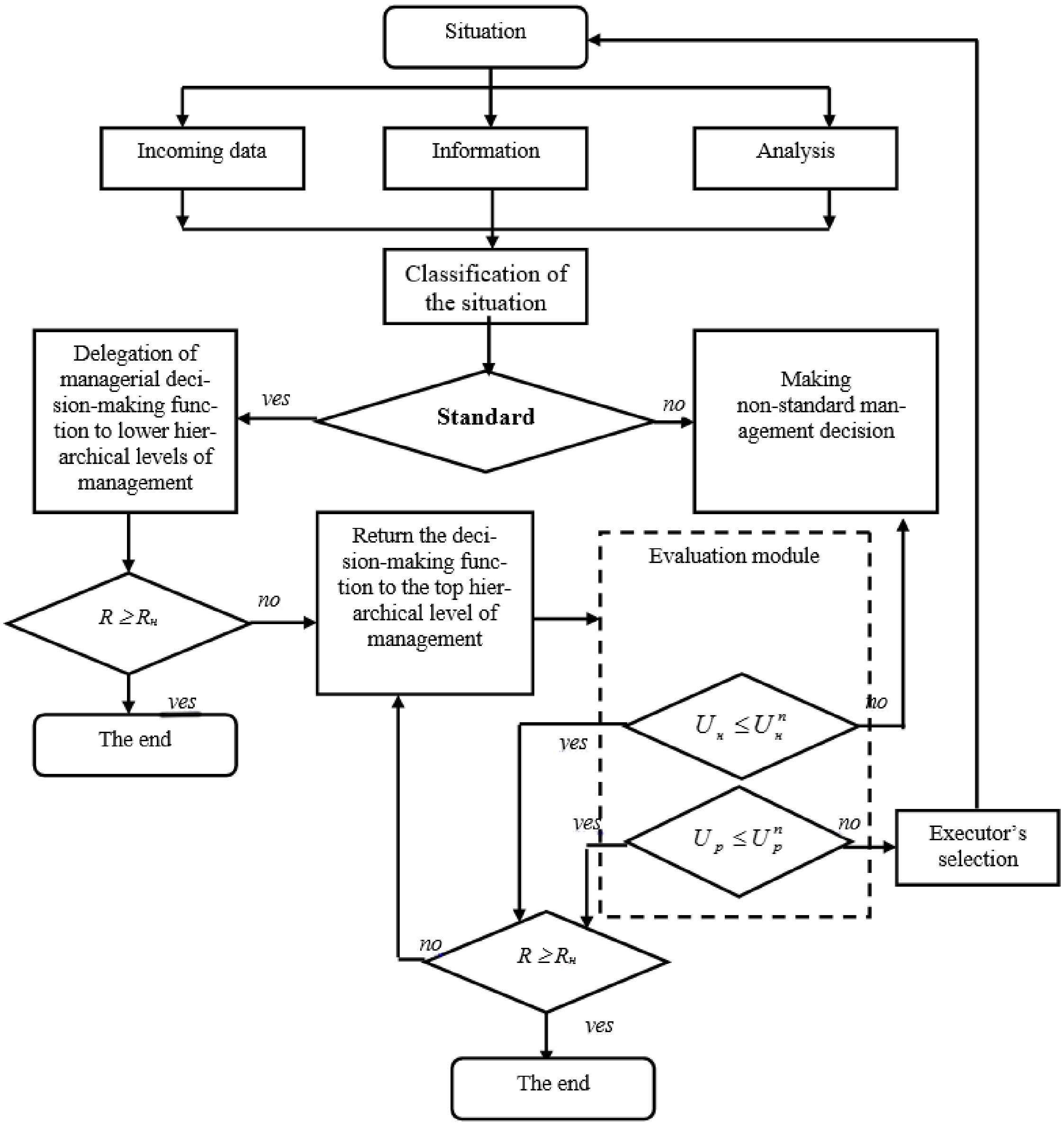
Figure 6. Possible duration of an innovative management decision by the top management, depending on the individual qualities of the executors

Decision-making should begin with the collection and synthesis of information, analysis of the situation and assessment of problems.

In the case of a standard situation, the control system of the innovation process makes decisions and transmits information through communication via a feedback mechanism. The lower level of the management system informs the top management, and, according to the algorithm (Figure 7), the lower management independently solves the tasks.

As evidenced by practical experience, in a standard situation, as a rule, the intervention of management structures in the work of the object is inappropriate. But at the same time, the top-level manager must anticipate (even in a standard situation) the complexity of the system and have sufficient information.

By delegating the decision-making function to the lower level of management, the manager runs the risk of an unexpected result of the system. In this regard, the manager must have the necessary knowledge and complete information before making management decisions, even in a standard situation, because this situation can transform into a non-standard one. When a standard decision is made, after the processes of collection, synthesis and analysis, the situation is identified and compared with the standards. If the results obtained do not satisfy the innovation process management system, then the process of replacing executors takes place.



R, R_n is the result of the system response (n is predicted); $U_н$, $U_н^n$ is the level of uncertainty (n is predicted); U_p, U_p^n is the risk level (n is predicted).

Figure 7. Decision-making model in the innovation process management system for standard and non-standard situations

The resulting model shows that when a standard decision is made, the functions of making innovative management decisions are delegated to lower levels of management. Therefore, the sustainable functioning of the management system of the innovation process largely depends on the organization of management and the model of management decision-making.

Part 5. Information and intelligence mechanisms in management

Nowadays, human capital and information resources are becoming the main factors in the development of modern society and the world economy as a whole. Information resources and knowledge are part of human capital and the basis for sound management decisions. Therefore, an important factor in achieving the strategic goals of the company is its ability to use the latest information and communication technologies in decision support systems to improve their feasibility and reduce risks. This requires each business entity (from both large companies and small businesses) to quickly adapt to the external environment and restructure its own business management system.

Justification of ways to optimize management decisions requires appropriate research, the use of practical experience in combination with scientific methods and economic and mathematical models to reduce risks when introducing new technologies, as well as for the successful implementation of sustainable development strategies.

To manage an industrial enterprise, given the level of development of information systems and computer technology, it is necessary to focus primarily on the systematic approach, which allows you to form a comprehensive aspect of the study of the effectiveness of the enterprise. Systemic approach is a higher level of research methodology, which requires the highest possible consideration of all components of the problem in their relationship, with the allocation of the main and essential, determining the nature of the relationship between aspects, properties and characteristics.

Management is carried out by directing managerial influence in the form of generating tasks for each structural unit, taking into account the feedback about the state of the managed system and the external environment. The purpose of the management system is to form such impacts on the managed system, which would induce the latter to adopt the state conditioned by the purpose of management. It is believed that, with regard to an industrial enterprise, it can be argued that the purpose of management (at the operational level) is the implementation of the production program within the technical and economic constraints; control actions are the work plans of departments; feedback – data on the progress of production (production and product movement, equipment status, stocks, etc.). It is clear that the plans and content of the feedback are nothing but information. Therefore, the processes of formation of control actions are the processes of transformation of managerial information. The implementation of these processes constitutes the main content of the activity of management services, including economic ones.

Scientists have substantiated the fundamental principles underlying the study of management decision-making, correlated with the development of the management system of the company and using for this economic and mathematical methods and models. However, the growing demands on the quality of information support of management systems require the search for new tools to expand the knowledge of specialists and the formation of effective methods for their implementation, which will ensure sound management decisions within the management system of the company.

The systematic approach includes the following aspects: elemental aspect (identification of the elements of the system, its power, determining the level of generalization of the system); structural aspect (the establishment of the structural characteristics of the system – the type of structure that determines the relationship, quantitative and qualitative interdependencies); functional aspect (identification of the functions of the system as a whole and its components (subsystems)); integrative aspect (clarification of the purpose of the system, the contradictions in its functioning, ways and means of resolving contradictions); communicative aspect (the determination of the place of existence of the system, the nature of subordination and coordination with other systems); historical aspect (the study of the history of the system, the stages of its development, the degree achieved, and, on this basis, predicting the prospects).

Building models of choice of standard or non-standard decision-making, according to the authors, will allow the company to implement the best option, taking into account the existing risks and the level of human capital development. It will also make the decision-making process operative and dynamic, will provide consideration of algorithmic conditions.

The value of knowledge and information in the enterprise management system

Any type of management activity involves managing people grouped into sections, departments, and services. The paper considers that in practical terms it is the management of social groups of people, and, therefore, management should be seen as a socially managed system – an integrity consisting of interdependent parts, each of which contributes to the characteristics of the whole.

Therefore, it should be concluded that the enterprise management system is a set of all subsystems (elements, processes, technologies, information resources), the relationship between them, providing a given functioning of the enterprise and its further development.

There is a close relationship between the management system, its subsystems, elements and the external environment. This relationship is accompanied by the movement of information in the form of information flows, which can lead both to the development of enterprise management system and to its degradation (if the quality of information is insufficient). Enterprise management system operates on the basis of information about the state of the object, input (material, labor, financial resources) and output data (finished products, financial results) in accordance with the goal (to ensure the production of proper quality).

Thus, the industrial enterprise is a self-developing system, the main feature of which is the independent elaboration of the goal of its development and criteria for its achievement, changing its structure and functions of the elements (subsystems) depending on the degree of achievement of the planned directions of development. Self-development, in contrast to self-organization, is initiated by the system itself, based on reliable predictions of changes in the environment and its own characteristics. However, at all stages of the enterprise, there is a need for management as a set of processes that support the enterprise as a holistic system in a given state and transfer it to a qualitatively new planned position through the organization and implementation of purposeful influences. After achieving the planned objectives, management provides support for the system in the former state and transfer it to a qualitatively new state in the case of the formation of new goals and objectives.

Thus, the management of the enterprise occurs continuously, on the basis of information flows, which provide the relationship between the elements of its management system. The circulation and use of information involves the implementation of managerial impacts, which are based on the adoption of appropriate management decisions. Therefore, the authors agree with the opinion of scientists that management can be represented as a process of development, adoption and implementation of management decisions aimed at achieving the goals of the enterprise.

In this study, the authors support the position of M.P. Voynarenko, that the process of making a management decision is a set of sequential actions of the subject of management, which begins with the emergence of a problem situation and ends with the implementation of certain measures to address this situation [6]. The effectiveness of management decisions depends on the orderly interconnection of elements and subsystems of the management system, as well as on the correct organization of information flows. The attention of management is focused on the goals of the whole system, and the properties of the elements and subsystems that function and develop within the system are subordinate to its properties as a whole.

Organizational and practical activities of both the management personnel of the enterprise, and the management process itself is also informational in nature, because it involves obtaining information for decision-making and transfer of information about the decisions taken. At each stage of forming a business decision, new information may be required that was not formed in the previous stages, and therefore must be obtained quickly to make a decision. However, the authors believe that for different stages or stages of managerial decision-making information takes on different significance.

In the first stages of formation of management decisions the amount of information, its types, opportunities for obtaining new, additional information are important, in the second – its flow, in the third – the possibilities of its processing. Thus, the amount of information, its novelty, value, sufficiency, and so forth are important in determining the purpose of management. The more information about current scientific research is used in developing a management strategy, the more objectively the goal is formulated, hence the more relevant it is to the management process.

When analyzing the state and dynamics of factors of the economic environment, types of information are the most important, as they determine the possibility of a comprehensive and systematic approach to the assessment of the situation, and subsequently to the development of management decisions. At the stage of formation of managerial decisions and analytical activity an important role is played by the ability to process information (selected for the obtained decision), which depends on the form of its presentation. However, the main condition for the validity of managerial decisions is the value of information, to determine which different methods and approaches are used.

With the use of computers, it is possible to store large amounts of information on machine carriers, but even under such conditions (for its effective use) it is necessary to determine such structures for organizing information, where there is the possibility of rapid search, selection, recording, modification of the information base.

In difficult economic conditions, in which domestic enterprises are for a long period of time, the issues of reducing operating costs, economical use of the resource base are relevant. Therefore, for the management technology of the production enterprise the task of optimization of the management process becomes constant and involves the exclusion of such activities and operations that reduce the efficiency of the enterprise. On the basis of analytical materials it can be concluded that the revival of industrial enterprises after the global economic crisis today is largely due to anthropocentric consciousness of society, the development of intellectual activity, increasing technological level of production and the spread of modern information and telecommunication technologies.

In connection with the above facts, which have an external impact on the improvement of management technologies, it is important to form a new type of managers' thinking, focused on progressive analytical and innovative activities. Development of management technology in a particular enterprise involves determining the number, sequence and nature of operations that make up the management process, development and selection for each operation of appropriate methods, techniques and technical means, identifying the optimal conditions for managerial decisions. The clear functioning of the management system of a production enterprise requires the division of the management process into separate sequential operations, and the effective organization of the management process requires the correct combination of operations, taking into account the responsibilities and capabilities of performers. Each individual operation must be related to the previous and subsequent operations of a given control process cycle.

Logically, the management process presented in the work allows to conclude that the management technology is directly related to the process of algorithmization of operations within certain functions of the management system as a whole at the enterprise, regardless of the level of management. Fulfillment of this condition confirms that almost all parts of the management process can be formalized, so a special place in management technology today is occupied by its technical side. Management technology usually includes a set of material resources (office equipment, means of communication, computers, etc.), which reduce the complexity of managerial labor, time and improve the quality of decisions. Human mental abilities have certain tasks, features, reserves and their limitations, and the use of operational and long-term memory of modern computer technology allows to expand the intellectual capacity of specialists to solve management problems and justified choice of optimal management decisions.

Thus, modern management technologies can be implemented only on the basis of modern information technology. Automation of the management process, available software that is constantly updated, global information networks radically change all components of industrial and economic activity of the enterprise from production to consumption. Currently, new information technologies and complex systems, which help to accurately and quickly solve problems from preparation of production to sales, ensure the integration of management functions, are becoming increasingly important for domestic enterprises.

Thus, the following information characteristics inherent in the enterprise management system were identified: the information essence of the enterprise objectives, processes of their implementation, its successful functioning and development; the development of methods of formation and use of information resources at a particular enterprise; information interaction between elements of the management system and information exchange between the enterprise management system and the external environment; systematization of information flows and information resources within the system, accumulation of knowledge; intensive exchange of information causes the mutual spread of ideas, concepts and management methods, increasing the potential for enterprise development; intellectualization of the work of management personnel; development of each enterprise's own approaches to the evaluation of information and information system of the enterprise, development of an information system of a flexible (mobile) nature.

Thus, the theoretical study of the main categories revealing the features of enterprise management and defining its conceptual apparatus allowed to note new directions of information nature of modern development of the theory and practice of management, as well as to establish their impact on management processes, which, in turn, requires new ways and methods of their study and practical implementation.

The development of information and communication technologies contributes to the deepening of the information nature of management work, and an integral part of management technologies today are computer system technologies, the implementation of which is integrative in nature and provides integrated information and analytical systems. For qualified creation and use of an information system, it is necessary to clearly understand its purpose and functions. Enterprises are increasingly using modern information systems to evaluate and regulate external and internal information flows, which makes it possible to use them for analysis, forecasting and management decision-making.

Managers responsible for making decisions in industrial enterprises are essentially information processors, and an industrial enterprise in the abstract sense can be viewed as an organization that acts as an information processing system. From this it can be concluded that an organized integrated system of collection, processing, distribution, accumulation, systematization, storage and use of information in a regulated time and in the right form is called an information management system.

Each management system of the economic object is integrated with the economic information system, which should be understood as a set of internal and external flows of direct and reverse information of the economic object, methods, equipment, professionals involved in processing information and making management decisions. Thus, the information system is a system of information support to employees of management services and performs the technological functions of processing, accumulation, storage and transmission of information to both internal and external users. The modern level of informatization of society and the formation of a knowledge economy determine the use of the latest technical, technological and software tools in various information systems of economic objects. Therefore, there is a need to define the automated information system as a set of information resources, economic and mathematical methods and models, technical, software, technological tools and specialists, designed to process information and making management decisions to achieve the goal.

Creation of automated information systems contributes to the efficiency of production at the enterprise and ensures the quality of management. To date, the experience of creating automated information systems, the introduction of optimization methods, formalization of production and business situations, equipping state and commercial structures with modern computer technology radically changed the technology of information processes in management. Domestic enterprises, despite the negative consequences of the crisis, are also trying to organize management activities using automated information systems.

The main component of an automated information system is information technology. Automated information technology is a systematically organized set of methods and means of operations for collecting, recording, transmitting, accumulating, searching, processing and protecting information through the use of effective software, computer equipment and communications, as well as ways of providing information to consumers.

The growing demand for information technology and services in recent years has led to the fact that modern information processing technologies are focused on the use of the widest range of works, and above all computer technology and communications. On their basis, automated systems and networks of different configurations are created not only for the accumulation, storage, processing of information, but also for the maximum approximation of the components of automated information systems to the workplace of the head and managers of the headquarters.

Today there is a tendency to combine different types of information technology into a single integrated complex. Thanks to modern means of communication, which provide not only extremely wide technological possibilities of automation of management, but also are the basis for the creation of a variety of network variants of automated information technologies: local, multi-level, distributed, global computer networks, e-mail, digital integrated service networks.

All of them are focused on the technological interaction of the set of objects created by devices to transmit, process, accumulate, store, protect information, and allows the creation of integrated computer data processing systems of great complexity, virtually unlimited operational opportunities for management processes. Such systems can be called management information systems. They are developed as a set of information technologies and software. It supports a unified way of presenting data, provides information and computing needs of professionals. Of particular importance in such systems is the protection of information during transmission and processing.

The functions of the management information system determine its structure, which includes the following procedures: collection and registration of data; preparation of information arrays; processing, accumulation and storage of data; formation of result information; transfer of data from sources to the place of processing, and results to consumers of information to make management decisions. Different business entities collect and register information in different ways.

This procedure is most difficult in automated management processes of industrial enterprises, firms, where the collection and registration of primary information reflecting the production and economic and other activities of the object. Particular importance is given to the reliability, completeness, and timeliness of the primary information. Collection of information, as a rule, is accompanied by its fixation on a tangible medium (document, machine carrier), implementation in software and technical complexes. Accounting in primary documents is mostly done manually, so the procedures of collection and registration are still the most time-consuming, and the process of document automation is still relevant.

Therefore, in an automated control system, special attention should be paid to the use of technical means of information collection and registration, combining operations of measurement, registration, accumulation and transmission of information through communication channels, input directly into the information system to form documents or data.

Modern industrial enterprises must realize the importance of effective management of all activities. And for this, first of all, it is necessary to have a full range of production, financial and marketing information available promptly. As a result, the demand for integrated management systems has continued to grow recently. The system, designed primarily to manage and plan the production process, includes the following core modules: production management; project management; accounting; material flow management; marketing; equipment maintenance and repair; quality management; information flow management; industry solutions. The accounting functions, although deeply developed, play an auxiliary role, and it is not always possible to separate the accounting module, as the information in accounting comes automatically from other modules. Based on the study of the essence of enterprise management, information characteristics of the management process, automated information systems, information technology, the authors propose to define an integrated enterprise management information system as a system of integration of information resources, knowledge, processes and employees to gather, process and use information of automated management information systems to make informed management decisions.

Thus, the information system can be conventionally perceived as a special mechanism of quality control, which encourages learning from personal experience and the use of knowledge to improve skills and performance. Automated information technology involves the formation of a set of specific technical means that implement the information process, and systems to ensure management of this set of technical means.

The vast majority of technical means to implement information technology is computer technology, so new information technology should be understood as computer information technology, although "information technology" involves the transformation of information, including on paper.

Many companies have created control information systems that provide feedback between certain management plans and actual company performance. Businesses with up-to-date and accurate control systems have a better chance of success. Enterprise management is characterized by a large number of not only different types of plans, but also types of control, the quality of which is ensured through the use of modern information systems. The expected results of building an enterprise management system in terms of integration of modern automated information systems are: the effectiveness of the enterprise management process based on automated information systems; rational choice of management functions and ensuring their interaction; the organization of the elements of management system and ensuring its continuous development based on automated information systems; achievement of objectives of current management and strategic development of the enterprise; ability to flexibly solve various problems of enterprise management; improvement of quality of management decisions by means of coordinated work of all subsystems.

Therefore, the management function when using information systems should be understood as a product of division and specialization of managerial labor, a separate area of management, which allows to carry out the managerial impact, taking into account the means and capabilities of modern software and information systems. A clear definition of automation of functions is provided by corporate information systems, which are now implemented in all large enterprises. To improve the efficiency of implementation of the management system in the full integration of modern automated information systems in the practical activities of enterprises, it is possible to recommend the development of a universal system that will be applicable to different types of enterprises, but for each enterprise should assess the feasibility of modeling and implementation.

Thus, the dominant management practice has changed in recent decades. The emphasis of management has shifted from achieving the economic efficiency of the enterprise to ensuring quality, flexibility, sound decision making, and the creation of organizational knowledge. Management trends determine the direction of the company's research and development behavior in order to build sufficient capacity to accommodate changes in the external environment and achieve long-term goals, as well as the effective implementation of competitive strategy. At the same time, the trend of the management system should not only correspond to the development strategy of the enterprise, but also in certain periods (for example, in periods of depression and crisis) to be its primary basis.

Thus, the authors believe that the value of information is directly related in each case to a specific user, to a specific goal that he/she wants to achieve, and to specific opportunities to achieve the goal. Existing opportunities are evaluated in terms of optimization or reduction of costs of the enterprise due to the results of management decisions.

The main function of performers of all categories, especially managerial ones, is to make decisions to improve or refine this or that area of activity. Depending on the tools for providing and forming solutions, they are divided into standard and non-standard. Situations that arise in the course of the work of the enterprise encourage the manager to implement a set of measures that require the adoption of sound decisions. As a rule, the manager resorts to making a standard decision. Standard solutions save time, clearly predict the end result, and extend the time, if necessary, to make a non-standard decision.

Standard solutions have a clearly predictable end result. A standard decision saves time for reflection and justification of measures. This increases the time for practical implementation of the decisions made. Knowledge and use of standard rules indicates not a lack of creativity and initiative, but a high qualification of managers and management personnel. First, it reduces the time for decision-making, development and implementation of appropriate measures; second, it reduces the likelihood of incorrect decisions; third, it frees up time for decision-making in non-standard, new or complex situations that require the collection of information, its analysis, the use of mathematical and economic-mathematical methods, which are combined the concept of operations research.

If an unforeseen situation arises, the manager must respond appropriately. Hence, the manager resorts to making a non-standard decision. The personal qualities of the manager have a significant impact on making a non-standard decision. When making a non-standard decision, if the situation is appropriate, the scheme of work of the contractor changes.

The main factors that determine the characteristics of management decisions in the use of information systems

A set of measures and methods is used to make a non-standard decision, depending entirely on the performer, his/her experience, competence, individual qualities, etc. When making a non-standard decision, the personality of the manager as a specialist of a certain level is comprehensively covered. The block diagram of making a non-standard decision is presented in Figure 8.

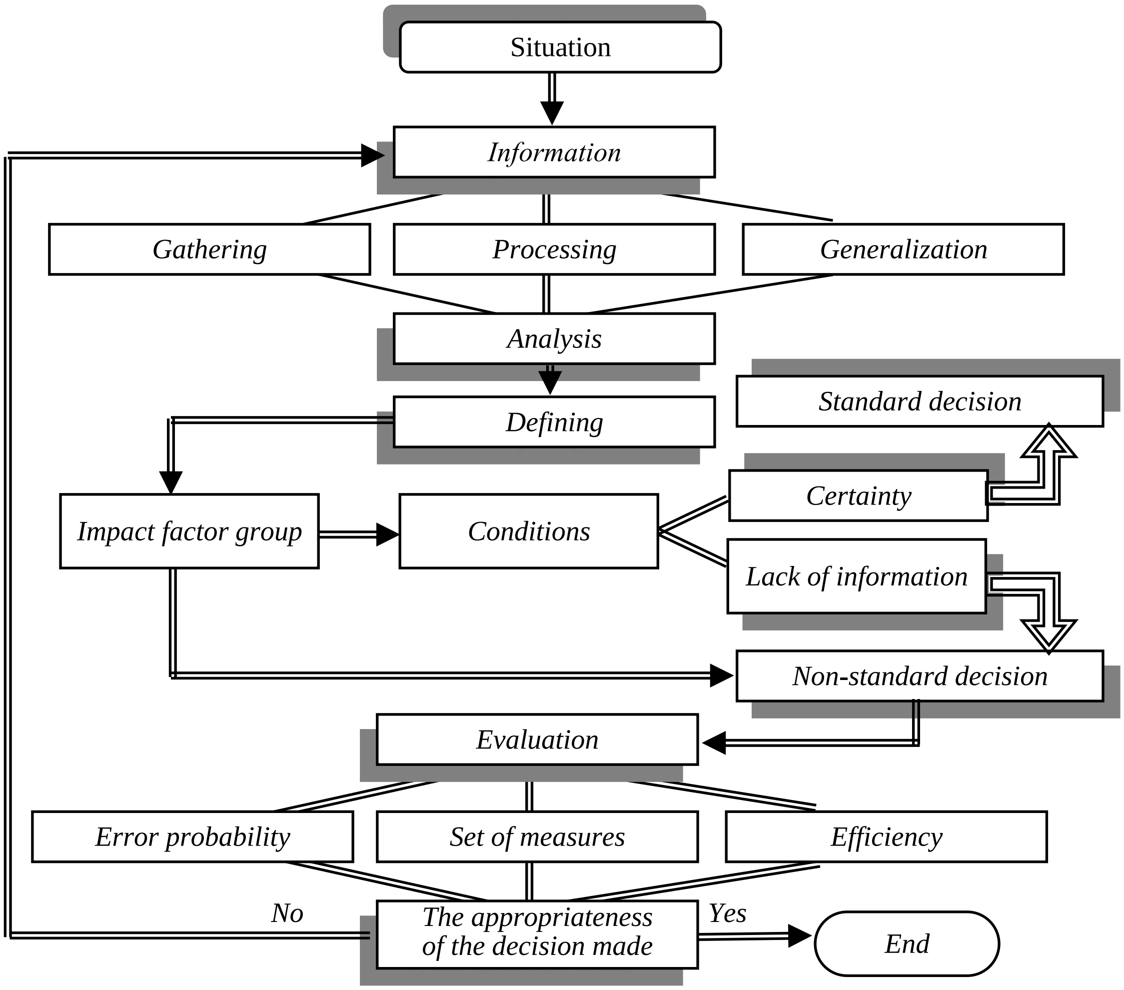


Figure 8. Block diagram of making non-standard decisions

Non-standard decision-making occurs under conditions of uncertainty. Here, statistical and probabilistic methods are widely used to determine the final result. Among them are the following: operations research, queuing theory, probability theory, logic, etc.

The decision-making process is the selection of a decision from several possible options. It consists of successive actions, including both individual measures to improve the effectiveness of the system and comprehensive programs concerning the goal of the system as a whole. Each operation (measure, program) is evaluated by its effectiveness, i.e., by the contribution that its implementation makes. In general, the efficiency indicator can depend on three groups of factors. The first group characterizes the predictable conditions of the business operation, which cannot be changed during its implementation. The second group is sometimes called decision elements, and it can change during the management process, affecting the target function. The third group is the previously known conditions that affect efficiency, but the results of this influence require further study.

Thus, rational control improves the value of the objective function, and optimal control achieves the best result (minimum or maximum). The first and third groups of factors are sometimes grouped under the general concept of "nature," which describes the external conditions of the system that affect the outcome of an operation, event, or program. Depending on the amount and nature of available information, decisions are divided into those made under conditions of certainty, in the presence of risk, and in conditions of uncertainty.

In conditions of certainty, the state of "nature" is known, i.e., the third group of factors is absent or can be assumed to be constant, becoming the first group of factors. For standard situations it means that the target function in each case is not constructed (it is considered that it was constructed in the process of development of corresponding norms and rules). Thus, the decision, as already mentioned, is made by rules according to the scheme: identification of the situation with one of the standard conditions – the choice of standard conditions corresponding to the situation – decision-making on the basis of standard rules.

When all three groups of factors are present, the decision-making problem is formulated as follows: it is necessary to find the elements of the solution, providing the extreme value of the objective function under given conditions, taking into account the influence of unknown factors. In case the probability of occurrence of certain states of "nature" (the third group of factors) can be determined or estimated, then the decision is made in the presence of risk. If the probability of occurrence of a state of "nature" is unknown, then the problem is solved under uncertainty.

Depending on the selected tools and taking into account the potential of modern information systems, the following methods and approaches are used in decision-making. Among them are the following: algorithmic approach (laws, rules, regulations); collective opinion of specialists (expertise); computational and analytical methods for processes that are described analytically (study of functions for minimum and maximum, programming, queue theory, etc.); process modeling; field experiment or observation. Thus, a management decision can be made under conditions of certainty or uncertainty. In any case, the decision is made with some probable risk of achieving the final goal of the management process, despite the increased reliability of calculations carried out with the use of modern software and hardware complexes.

Calculation of the intensity of uncertainty factors appearance

Just as it is calculated for risk factors, it is assumed that the conditional intensity of uncertainty factors is the inverse of the sum of the weighting coefficients. But the higher the value of the weighting factor, the lower the intensity of its manifestation. This contradicts the physics of the process. Therefore, the conditional intensity of the manifestation of uncertainty factors is calculated by the formula:

$$\lambda_2 = \frac{0{,}0417}{1-\sum_{i=1}^{6} k_i}, \qquad \text{with} \sum_{i=1}^{6} k_i \neq 1, \tag{45}$$

where λ_2 is the conditional intensity of uncertainty factors manifestation, 1/h.; k_i is the value of the weighting factor of the i-th factor; $i = \overline{1,6}$.

The subgraph (Figure 9) corresponds to the state of management when making decisions in the external environment.

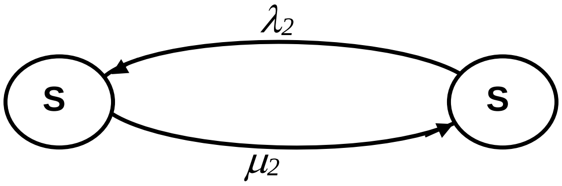


Figure 9. Management state subgraph for decision making in the external environment

For the subgraph (Figure 9) the system of Kolmogorov equations will have the following form:

$$\begin{cases} \dfrac{dp_0(t)}{dt} = -\lambda_2 p_0(t) + \mu_2 p_2(t) \\ \dfrac{dp_2(t)}{dt} = \lambda_2 p_0(t) - \mu_2 p_2(t) \end{cases}. \tag{46}$$

The characteristic equation of the system (46) will be as follows:

$$\begin{vmatrix} -\lambda_2 - k & \mu_2 \\ \lambda_2 & -\mu_2 - k \end{vmatrix} = 0. \tag{47}$$

Opening the determinant (47), the following is obtained:

$$k^2 + \lambda_2 k + \mu_2 k = 0. \tag{48}$$

The radicals of the quadratic equation (48) will be as follows:

$$k_1 = 0; k_2 = -\left(\lambda_2 + \mu_2\right). \tag{49}$$

Then the general solution of the system (45) will have the expression:

$$\begin{cases} p_0\left(t\right) = c_1 + c_2 e^{-(\lambda_2+\mu_2)t} \\ p_2\left(t\right) = \dfrac{\lambda_2}{\mu_2} c_1 - c_2 e^{-(\lambda_2+\mu_2)t} \end{cases}. \tag{50}$$

The partial solution under the condition $p_0(0) = 1$, $p_2(0) = 0$ will have the following form:

$$\begin{cases} p_0\left(t\right) = \dfrac{1}{\lambda_2 + \mu_2}\left[\mu_2 + \lambda_2 e^{-(\lambda_2+\mu_2)t}\right] \\ p_2\left(t\right) = \dfrac{\lambda_2}{\lambda_2 + \mu_2}\left[1 - e^{-(\lambda_2+\mu_2)t}\right] \end{cases}. \tag{51}$$

Then the uncertainty function when considering decision-making operations, taking into account the impact of the external environment, making management decisions will be as follows:

$$U_н\left(t\right) = \frac{\lambda_2}{\lambda_2 + \mu_2}\left[1 - e^{-(\lambda_2+\mu_2)t}\right]. \tag{52}$$

Then the uncertainty factor would be:

$$U_н = \frac{\lambda_2}{\lambda_2 + \mu_2}. \tag{53}$$

The uncertainty function in the absence of managerial response to the manifestation of uncertainty factors, i.e., $\mu_2 = 0$ will have the following form:

$$U_н\left(t\right) = 1 - e^{-\lambda_2 t}. \tag{54}$$

Figure 10. shows the uncertainty functions by α_1, α_2, α_3 factor groups.

As can be seen, the greater the value of the weighting factor, the steeper the line of the uncertainty function. Thus, the obtained model of uncertainty functions allows taking into account the maximum number of random events. The obtained mathematical models provide modeling of the process of making managerial decisions with determining the probable final result.

Possible ways to improve the modeling of management decision-making

Analysis of the sequence and existing methods of modeling management decision-making using the latest computer technology is a set of stages of solving similar problems. At all stages there is a collection, synthesis and analysis of information. In most cases, this collection is proposed to be carried out empirically without sufficient justification.

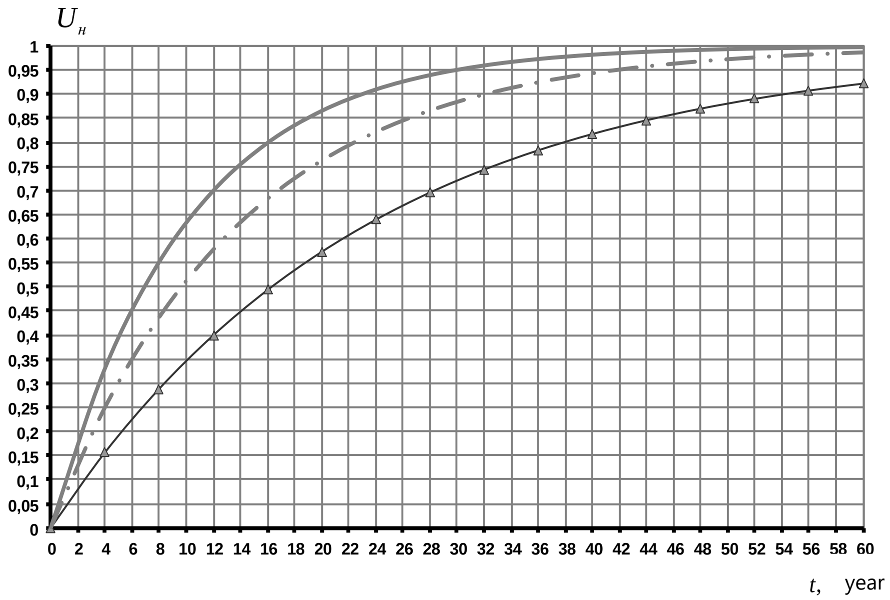


Figure 10. Comparative uncertainty functions for groups of factors

Features of management functioning are determined by the type of tasks to be solved (standard, well-defined, poorly defined and uncertain). The type of tasks determines the specificity of conditions for making management decisions (conditions of certainty, uncertainty and risk), as well as methods of making decisions. Decision-making conditions affect the specifics of making these decisions. If managers have enough information to make a decision, they know the end result and its dependence on certain options. If managers do not have enough information, then management decisions are made under conditions of uncertainty and risk.

But in modeling the process of making management decisions, it is possible, from the author's point of view, to accept the probable conditions of the level of uncertainty. Analysis of modern management shows that in making decisions the official is focused on the executor. Therefore, the level of professionalism, work experience and individual qualities of subordinates are all components of a certain risk in making and implementing management decisions. If to consider managers and executives as a system of binary relations, then managerial decisions are the impact on the object of management, and the implementation of the decision is the reaction of the object to these decisions. Given that the executor has fully understood the management decisions and is experienced enough, he/she will independently implement the decision without additional or clarifying decisions. That is, the object of management will show him/her only after the implementation of the management decision or when another situation arises.

Thus, the level of individual qualities is one of the risk factors. Taking this factor into account allows to manage the degree (level) of risk. That is, under such an interpretation, there can be a correlated (functional) dependence of the decision-making process and the level of uncertainty. The Pareto estimation method states that 20% of all possible factors give up to 80% of the influence on the functioning of systems. Therefore, it is possible to determine a list of possible uncontrollable factors that have a significant impact on management decisions. From this list, the factors to be used as a correction factor and so on can be quantified. Thus, the definition of the list of objective and subjective factors, as well as their conditional quantitative assessment provides a real opportunity to take into account the likely conditions of risk and uncertainty at the stage of management decisions.

Conclusions

Enterprises today should be able to adapt to global integration processes. Due to the rapid development of market relations, the speed and scale of technological changes, it is impossible to ensure the competitiveness of companies only through the use of material and financial resources, which are becoming generally available to most economic entities. World experience is not determined in favor of one of these assets in relation to the costs of their creation, but in the "intellectual revolution" it tends to significantly exceed the share of intangible assets over tangible assets. The study proposes a scientific and methodological approach to a comprehensive understanding of the formation of intellectual capital enterprise as one of the main priorities of its innovation development in difficult economic conditions, as well as related problems of innovative approaches in the management of innovation and investment processes. The study is devoted to the development of scientific and methodological support for the management of innovation processes based on the use of economic and mathematical modeling. The solution to these problems is related to the fact that the rapid development of external and internal environment creates the need for managers to obtain relevant information and make informed management decisions. This requires appropriate qualification of specialists, assessment of their knowledge and potential risks, prompt decision-making, determination of management cycles and delegation of authority.

This study is devoted to the development of scientific and methodological support for management decisions based on the use of economic and mathematical models. The solution of these problems is related to the fact that the rapid development of science and technology creates certain prerequisites for managers to obtain relevant information and make informed management decisions in terms of informatization of economic processes. This requires appropriate knowledge, as well as the ability of managers to standardize situations in order to improve the efficiency of the management system and the speed of decision-making, as well as to reduce management risks.

For this purpose there were offered economic-mathematical models, allowing to make the mathematical description of process of acceptance of the administrative decisions and to reveal the most influential factors. These models also allowed to identify the potential risks in making this kind of decisions, to determine the intensity of uncertainty and to develop a model of management decision-making.

The implementation of the proposals presented in this work will reduce the risk of management decisions with subsequent evaluation of their effectiveness, to identify the key characteristics of the value of information and build a scheme of management decisions, which in general will improve the quality of information support for the implementation of the management function of the development of the company.

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