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COMPLEX METHOD OF THE KNOWLEDGE MANAGEMENT EFFICIENCY EVALUATION IN THE PROJECT ENVIRONMENT

Abstract. There are a large number of modern approaches to the development and implementation of organizational knowledge management systems, methodologies and models of knowledge management. Each of them has its own peculiarities, advantages, and disadvantages, aimed at supporting the knowledge saving process. At the same time, the question of the knowledge system effectiveness remains unclear, what complicates the decision-making process. The article analyzes modern approaches to assessing the effectiveness of the knowledge management system and the feasibility of its implementation in the project environment. The approaches analyzed, such as Kaplan-Norton's Balanced Scorecard (Kaplan-Norton), Non-material Asset Monitor (K.Sweeb), Skandia Navigator (Edvinsson), etc., can be used as macro indicators to determine the benefits of Knowledge Management System, but these indicators cannot reflect actual benefits gained solely by this system in relation to business processes and organizational project objectives. Thus, the **actual scientific task** is not only to develop a specific method of quantifying the benefits that the Knowledge Management System provides, but also to create indicators for project implementation evaluation through Knowledge Management System efficiency. **The paper objective** is to develop a comprehensive method for evaluation of the effectiveness of the Knowledge Management System, taking into account the specifics of project management. The proposed model is a multi-stage process, which allows increasing the reliability of the final decisions on knowledge management in the project and evaluating the profitability of the system. In addition, the model allows reducing the cost of the project, by simulating the influence of the system elements on project parameters. The proposed model is aimed at optimization (the choice of the best algorithm from several), identification (the definition of a system with the most relevant qualifications to the real object in the given conditions) or decision-making on Knowledge Management System in a project environment. **Further research** will be aimed at the development of automated tools for implementing the model, which will optimize the use of the model in project-oriented organizations.

Keywords: knowledge management; model; efficiency; intellectual capital.

Introduction

Problem statement. During the last decade, scientists are paying a lot of attention to knowledge management (KM). At the same time, approaches to assessing the effectiveness of implementing KM instruments are not sufficiently investigated. In other words, organizations spend a significant amount of resources on the creation and improvement of knowledge infrastructure (both management tools and software), but at the same time, insufficient attention is devoted to the development and use of tools that measure the results and effectiveness of investments in KM.

Analysis of recent research and publications. An analysis of recent research has shown that there is a small number of studies in which authors propose methods for assessing the effectiveness of KM, but they do not take into account the specifics of KM in the project environment. Due to a number of features inherent in the design environment, the process of evaluating the effectiveness of using KM is considerably complicated. First, the specificity of project management lies in the uniqueness of the results, so most of the knowledge gained in previous projects cannot be used directly, but need adaptation, that is, the knowledge user will spend some time adapting knowledge. Secondly, in the process of project implementation there is a change in the composition of teams, which leads to the need to involve experts from other projects and units in solving a particular problem, so estimating the time spent solving a problem within a single project adds the time spent by the employee in implementing another project. In the process of modeling the quantitative assessment of the benefits of implementing KM tools, there are three types of key benefits for project management:

1) saving time during problem-solving - reducing the time for the tasks of the project;

2) saving labor costs - saving man-hours of the project in problem-solving;

3) profitability - saving costs during problem-solving.

To date, the paper [1] is among the most mentioned studies to assess the effectiveness of KM. The authors proposed eight steps to create performance indicators for KM that are structurally divided into three stages: 1) strategic level - the development of activities that assess the goals of the organization; 2) Indicators containing an intermediate level linking process performance indicators at the operational level with business performance indicators at the strategic level; 3) indicators containing an operational level that reflect the measured performance of the KM process. But the proposed method is not adapted for its use in the project environment, which complicates the estimation of duration and cost of project tasks.

Thus, the lack of methods for quantifying the benefits gained by the organization from the introduction of KM in the project environment complicates the decision-making process regarding investment volumes and their subsequent use during project implementation.

The paper objective is to develop a comprehensive method for assessing the effectiveness of the KM system that takes into account the specifics of project management and allows us to develop a system of indicators for decision-making based on its profitability.

Quantitative assessment of intellectual assets

Since the value created with the use of KM is an intellectual object, the methods of measuring intellectual resources can also be taken to assess the value of KM. There are different modern approaches for evaluation of the results of KM implementation. Today there are dozens of the most widespread approaches to the assessment of intellectual capital, which can be divided into two groups [2]: qualitative and quantitative. In such a structure, qualitative methods (for example, the Kaplan-Norton Balanced Scorecard, the Non-material Assets Monitor K. Svyeb, the Navigator Skandia L. Edvinson, etc.) are aimed at analyzing the elements and structure of the intellectual capital of the organization, and quantitative methods carry out a monetary assessment intellectual property. In turn, there is also a group of "others" that combines indicators reflecting fluctuations in the price of intellectual property.

Let's consider some models in details. For example, Kaplan-Norton's Balanced Scorecard [3] aims at creating a link between the organization's strategy and operational activities, based on analysis of relationships with clients, financial indicators, business processes, growth rates, etc.

Using the Intangible Assets Monitor [4], developed by K. Swibe, the organization creates an interconnection between the elements of intellectual capital (the external and internal structure is presented as organizational capital, and qualification - as an individual) with four characteristics of the enterprise (growth rate, innovation efficiency, risk).

The analysis of qualitative models showed that their specificity does not correspond to the initial task, that is, the description of intellectual capital, which has market potential, cannot fully solve the problem of assessing the effectiveness of KM in the project environment. Authors of works [5, 6] divided the set of quantitative models into expendable, profitable and market models. Cost methods equate the actual costs incurred by the organization in creating an intellectual asset to its carrying amount. This is not a fair approach because of the constant change of asset value. In turn, profitable methods are based on the fact that the value of intellectual capital is created by its ability to generate more profit. The market subgroup relies on the increase of intellectual capital in comparison with competitors, that is, it uses the market value of the intellectual property.

All above-mentioned methods evaluate intellectual resources in terms of organizational (or *corporate*) level. They can be used as macro indicators to determine the benefits of KM, but such indicators can not reflect the actual benefits gained solely by the KM system in relation to business processes and project objectives of the organization. Thus, the actual research objective is not only the development of a specific method for quantifying the benefits that KM provides for the implementation of projects, but also the creation of indicators, through which it is possible to assess the effectiveness of the project management KM system.

Taking into account the above-mentioned aspects, the assessment of the system's efficiency must be expressed through the performance of the managed system and its own characteristics.

Model of estimation of KM efficiency

Thus, in order to solve the problems presented above, a complex model for assessing the effectiveness of project KM is proposed. The structural scheme of the model is presented in Fig. 1.
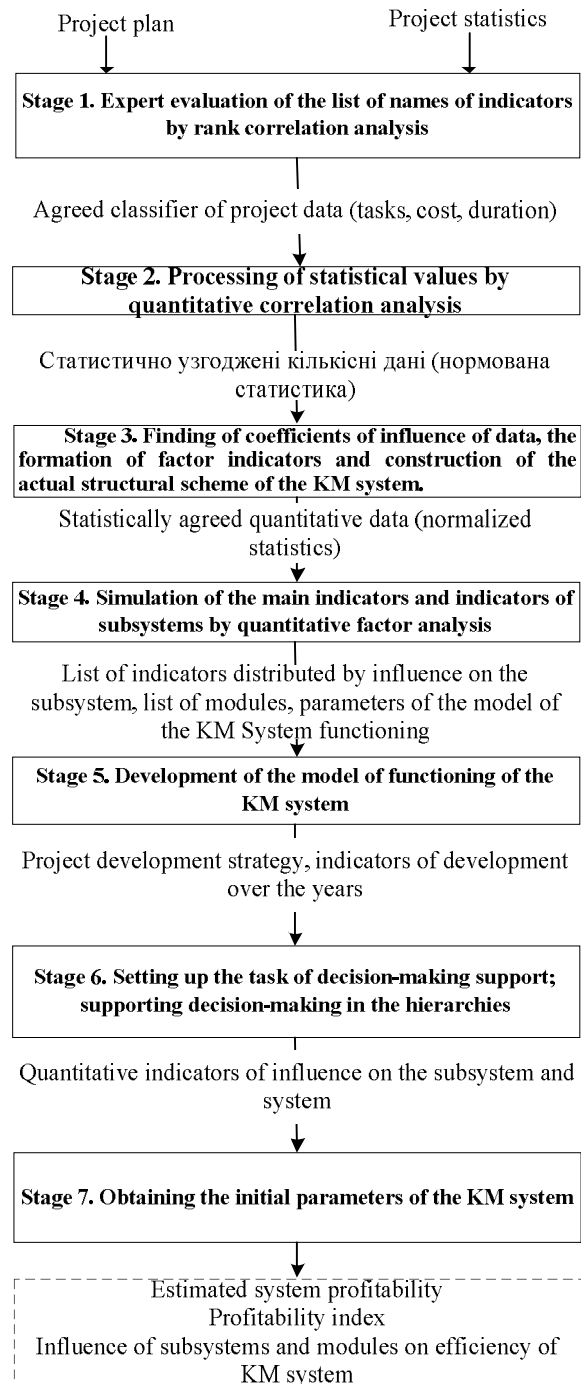
Fig. 1. Structural scheme of elements of the estimating the KM method efficiency in the project environment

The proposed model is aimed at optimization (choice of the best algorithm among several ones which implements one law of the functioning of the system),

identification (the definition of a system whose quality most closely matches the real object in the given conditions) or decision-making with the management of the system ultrasound. During the implementation of the model, the project statistics (data on the duration and cost of work) and information from the project implementation plan, as a result of processing in 7 stages, turns into a quantitative assessment of the performance of the system of ultrasound and its individual elements. The process is carried out with the involvement of experts from different departments involved in the project implementation process. Let's consider all the steps in detail.

The presented structural scheme reflects the sequence of stages, their inputs, and outputs, as a result of the implementation of the listed stages. Based on the information obtained through the implementation of the model, the project manager and management of the organization can make informed decisions about the development KM system and the work of this system in the process of project implementation.

Stage 1. Expert evaluation of the list of names of indicators by rank correlation analysis.

The input data for the KM performance model is the project's statistics on the duration and cost of the tasks. Such data should be processed using the expert judgment method to eliminate statistical links. The stage is performed in the following steps:

1) development of a generalized assessment of project indicators based on individual expert assessments;

2) development of a generalized assessment based on a paired comparison of objects by each expert;

3) determining the relative weights of objects;

4) determination of consensus of expert opinions;

5) determination of dependencies between rankings;

6) assessment of the reliability of the results of processing.

Stage 2. Processing of statistical values by quantitative correlation analysis.

As a result of this phase, the agreed classification of the names of the project data is converted into normalized statistics, divided into groups of works of the project. Correlation analysis is carried out within each group of works identified by the project manager and confirmed by experts in the previous step regarding the cost and duration of tasks in this group $(x_i; y_i)$.

Next, the indicators of variables, data indicators and the impact of these indicators on the groups of works are determined, for which it is expedient to use factor analysis and the method of the main components, are determined. In addition, at this stage, using the KM structural scheme, the project manager defines the structure of the whole system by selecting the appropriate subsystems and modules from the proposed classifier, which will be subject to further analysis.

Stage 3. Finding of coefficients of influence of data, the formation of factor indicators and construction of the actual structural scheme of the KM system.

On the basis of the data obtained in the previous stage, it is necessary to find an influence on the system, using a set of indicators (formal factors of influence), which are formed as follows. First, the convolution

result of the system is set. This is the system index or the integral index of the system. Such indicators and indices are determined by the matrices of data, which are prepared using correlation analysis.

For example, let the group $WP_1(x_1; y_1)$, where x_1 is the cost of a group of works, y_1 is the duration of a group of works, includes the tasks with the following indicators: $(z_1; u_1)$, $(z_2; u_2)$, $(z_3; u_3)$, $(z_4; u_4)$ cost and duration of works, respectively, which are part of the group, for which we have statistics for 5 years. Then the data of the WP_1 project group can be represented as a matrix:

$$X_1 = \begin{pmatrix} 1 & 1 & 1 & 1 & 1 \\ z_{1_1} & z_{1_2} & z_{1_3} & z_{1_4} & kz_1 \cdot z_{1_5} \\ z_{2_1} & z_{2_2} & z_{2_3} & z_{2_4} & kz_2 \cdot z_{2_5} \\ z_{3_1} & z_{3_2} & z_{3_3} & z_{3_4} & kz_3 \cdot z_{3_5} \\ z_{4_1} & z_{4_2} & z_{4_3} & z_{4_4} & kz_4 \cdot z_{4_5} \end{pmatrix}; \quad (1)$$

$$Y_1 = \begin{pmatrix} 1 & 1 & 1 & 1 & 1 \\ u_{1_1} & u_{1_2} & u_{1_3} & u_{1_4} & ku_1 \cdot u_{1_5} \\ u_{2_1} & u_{2_2} & u_{2_3} & u_{2_4} & ku_2 \cdot u_{2_5} \\ u_{3_1} & u_{3_2} & u_{3_3} & u_{3_4} & ku_3 \cdot u_{3_5} \\ u_{4_1} & u_{4_2} & u_{4_3} & u_{4_4} & ku_4 \cdot u_{4_5} \end{pmatrix}. \quad (2)$$

The next step, in order to determine how the performance of a group of works WP_i affects the performance indicators of this group, the group performs a list of actions:

1) construct data matrices (1), (2);

2) run convolution matrices;

3) calculate the formal profitability index I_{rs}, which, before the start of the simulation, is established as $I_{rs} = 1/i$, where i is the number of workgroup projects, which corresponds to the assumption that each group of indicators affects the factor variable equivalently;

4) simulate the actual index I_{rs} without using the KM system. The graph, shown in Fig. 2 shows the result of simulation of the actual index of the KM system, described in [7].
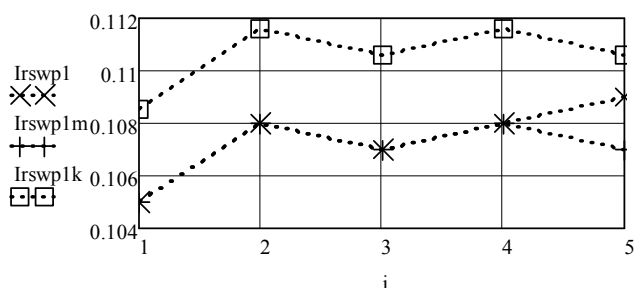
Fig. 2. Example of simulation of the value of the index of profitability of the KM system

Stage 4. Simulation of the main indicators and indicators of subsystems by quantitative factor analysis. Using factor analysis tools, modeling of subsystem

indicators and actual system performance without the influence of ultrasound instruments is performed.

Stage 5. Development of the model of functioning of the KM system by the method of nonlinear dynamics and obtaining solutions of the system of equations.

The next stage is aimed at analyzing the system using nonlinear dynamics methods. For this purpose, the Bulirsch-Stoer Method [8] is used to obtain data on the stages of the project implementation, and to distribute data by stages.

Let's consider the approaches to implementation of the proposed methods. Let us give a simple differential equation that binds an independent variable x, to an unknown function $y(x)$ of this independent variable and its derivatives:

$$y'(x), y''(x), ..., y^{(n)}(x); \qquad (3)$$

$$F(x, y(x), y'(x), ..., y^{(n)}(x)) = 0, \qquad (4)$$

де $F(x, ..., y^{(n)})$ - a function of the specified arguments.

Let's execute the extrapolation value $\widehat{y}_{i+1}$, where $\widehat{y}$ is the approximate value, according to the known previous value. The procedure for finding the next calculated point $(x_{i+1}, \widehat{y}_{i+1})$ consists of two steps:

1. Getting the sequence of decisions at the point $x = x_{i+1}$ using the strategy of reducing the step.

2. Refine the numerical solution on the basis of procedures of polynomial or rational extrapolation.

Stage 6. Setting up the task of decision-making support; supporting decision-making in the hierarchies by T. Saati [9]; modeling the matching parameters in the KM system.

Simulation modeling of the KM system is performed using the hierarchy analysis method, which is to decompose the problem into more simple parts and gradually establish the priorities of the evaluated components using the paired comparison method. This method is based on the evaluation of each alternative and its importance for solving higher-level tasks. The decision-making process includes the following steps:

1) identification of the problem;

2) the decomposition of the problem into the hierarchy of tasks;

3) selection of criteria for evaluating problem-solving;

4) development of matrices of pair comparisons of module criteria;

5) calculation of priorities;

6) synthesis of priorities;

7) verification of consistency.

Stage 7. Obtaining the initial parameters of the KM system. Decision making on the effectiveness of the ultrasound system.

The realization of these stages in the hierarchy analysis method allows us to obtain objective quantitative estimates of the importance of all elements in the structure of the hierarchy associated with the problem stated.

After modeling and verifying the results, an assessment of the efficiency and profitability of the ultrasound system and the formation of a "decision tree", which for the KM system, described in [7], has the following conclusions:

1. The project with the cost of 420090 UAH, the total duration of work 3864 days and human resources 38-49 developers in the application of the KM system profitable at R = 37.6%

2. Due to the application of the KM system, the budget of the project is saved in the amount of 131851 UAH. (31.4%), reduction of the duration of the project in the amount of 1555 days (40.2%), under the conditions of the team of the project to 49 developers of the given qualification.

3. The actual index of system profitability is 0.93. In this case, the formation of a steady phase of the project takes place for 47 days, the ongoing development of the project takes 482 days.

4. The priorities for using the elements of the KM system are as follows:

Economic Knowledge Management Subsystem,

Knowledge Management Infrastructure Subsystem,

Knowledge Risk Factors Subsystem,

Knowledge Management Subsystem,

Subsystem knowledge management.

Conclusion

A large number of modern approaches on development and implementation of organizational knowledge management systems, methodologies and models of knowledge management aimed at ensuring the process of knowledge saving.

At the same time, the question of the effectiveness of using such approaches remains unclear, which complicates the decision-making process regarding their use in the project environment.

The developed model for assessing the effectiveness of knowledge management processes can not only increase the reliability of final decisions on the KM but also reduce the cost of the project, by simulating the influence of the elements of the system on its indicators. The proposed method allows to save up to 31.4% of the project budget and 40.2% of the duration of the project.

Further research will be aimed at the development of automated tools for implementing the model, which will optimize the use of the model in project-oriented organizations.

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Комплексний метод оцінки ефективності системи управління знаннями в проектному середовищі

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Анотація. Відсутність методів кількісної оцінки переваг, отриманих організацією від впровадження управління знаннями (УЗ) в проектному середовищі ускладнює процес прийняття рішень щодо об'ємів інвестування та їх подальшого використання підчас реалізації проектів, тому актуальною науковою задачею є розробка методів та індикаторів, які дозволяють підвищити вимірюваність переваг УЗ. Мета статті полягає в розробці комплексного методу оцінки ефективності системи УЗ, який враховує специфіку проектного менеджменту і дозволяє розробити систему індикаторів для прийняття рішень щодо її рентабельності. В статті проведено аналіз сучасних підходів до оцінки ефективності системи управління знаннями, таких як метод збалансованих показників Каплана-Нортона, Монітор нематеріальних активів К. Свейбі, Навігатор «Skandia» Л. Едвінссона та ін. Визначено недоліки їх використання для аналізу системи УЗ в проектному середовищі. Розглянуто ключові етапи побудови методу оцінки ефективності системи управління знаннями в проектному середовищі. Запропонований багатоетапний процес дозволяє не тільки підвищити достовірність остаточних рішень щодо управління знаннями в проекті та оцінити рентабельність системи, але й знизити витрати проекту за рахунок моделювання впливу елементів системи на його показники. Використання запропонованого методу дозволяє отримати економію до 31.4% бюджету проекту та 40.2% тривалості проекту. Запропонований метод може використовуватись для підтримки прийняття рішень щодо ефективності системи УЗ високотехнологічних проектів.

Ключові слова: управління знаннями; модель; ефективність; інтелектуальний капітал.

Комплексный метод оценки эффективности системы управления знаниями в проектной среде

В. М. Вартанян, Д. А. Штейнбрехер

Аннотация. Отсутствие методов количественной оценки преимуществ, полученных организацией от внедрения инструментов управления знаниями (УЗ) в проектной среде, усложняет процесс принятия решений относительно объемов инвестирования и их дальнейшего использования во время реализации проектов, поэтому актуальной научной задачей является разработка методов и индикаторов, которые позволяют повысить измеримость преимуществ УЗ. Цель статьи заключается в разработке комплексного метода оценки эффективности системы УЗ, который учитывает специфику проектного менеджмента и позволяет разработать систему индикаторов для принятия решений относительно ее рентабельности. В статье проведен анализ современных подходов к оценке эффективности системы управления знаниями, таких как метод сбалансированных показателей Каплана-Нортона, Монитор нематериальных активов К. Свейби, Навигатор «Skandia» Л. Эдвинссона и др. Определены недостатки их использования для анализа системы УЗ в проектной среде. Рассмотрены ключевые этапы разработки метода оценки эффективности системы управления знаниями в проектной среде. Предложенный многоэтапный процесс позволяет не только повысить достоверность окончательных решений по управлению знаниями в проекте и оценить рентабельность системы, но и снизить затраты проекта за счет моделирования влияния элементов системы на его показатели. Использование предложенного метода позволяет получить экономию бюджета проекта до 31.4 и 40.2% продолжительности проекта. Предложенный метод может использоваться для поддержки принятия решений относительно эффективности системы УЗ высокотехнологичных проектов.

Ключевые слова: управление знаниями; модель; эффективность; интеллектуальный капитал.