Seredynska I. The use of key performance indicators in strategic management of an enterprise / Iryna Seredynska, Vira Seredynska, Roman Fedorovych // Галицький економічний вісник — Тернопіль : ТНТУ, 2014. — Том 47. — № 4. — С. 103-116. — (Загальні проблеми економіки та суб'єктів господарювання).

УДК 330.13:658.15

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THE USE OF KEY PERFORMANCE INDICATORS IN STRATEGIC MANAGEMENT OF AN ENTERPRISE

Summary. *The mechanism of the implementation of strategic objectives as well as monitoring and control based on «dashboards» for achievement of strategic goals was discussed. The evaluation of the integral index, calculated by the methods of score evaluations and fuzzy logic using software system mathematical calculations MATLAB was covered. The methods of control to simplify their implementation into existing automation system of economic activity were formalized.*

Key words: *key performance indicators, fuzzy logic, fuzzy sets, score evaluations, linguistic variables, membership functions, utility functions, strategic planning, strategic goals, integral index, level of strategic goal achievement.*

Ірина СЕРЕДИНСЬКА, Віра СЕРЕДИНСЬКА, Роман ФЕДОРОВИЧ

ВИКОРИСТАННЯ КЛЮЧОВИХ ПОКАЗНИКІВ ЕФЕКТИВНОСТІ У СТРАТЕГІЧНОМУ УПРАВЛІННІ

Резюме. *Запропоновано механізм використання ключових показників ефективності на основі побудови «інформаційних панелей» для контролю за виконанням стратегічних завдань і досягненням стратегічних цілей підприємства за різними аспектами його діяльності на основі оцінювання рівня інтегральних показників, розрахованих за допомогою методів бальних оцінок та нечіткої (розмитої) логіки, що ґрунтуються на теорії лінгвістичних змінних та розмитих множин. Запропоновані методи розрахунку інтегральних показників формалізовано, що дозволить спростити їх упровадження в існуючі системи автоматизації економічної діяльності підприємств. За допомогою програмної системи математичних обчислень MATLAB встановлено параметри функцій належності, визначено функції корисності, які описують рівень досягнення ключовими показниками ефективності своїх цільових значень, розраховано інтегральні показники, які описують рівень досягнення підприємством стратегічних цілей за різними аспектам діяльності. Обґрунтовано простоту адаптації обчислювальних засобів програмної системи математичних обчислень MATLAB до можливих змін кількості ключових показників ефективності, з'ясовано, що зміна структури «інформаційної панелі» не вимагає модифікації розробленого програмного забезпечення.*

Ключові слова: *ключові показники ефективності, нечітка логіка, нечіткі множини, бальні оцінки, лінгвістичні змінні, функції приналежності, функції корисності, стратегічне планування, стратегічні цілі, інтегральний показник, рівень досягнення стратегічної цілі.*

Formulation of the problem. Nowadays, most western companies commonly use Key Performance Indicators for effective decision-making process.

Any enterprise regardless its size needs a new set of innovative tools for efficient decision-making. Sets of management tools of strategic planning and control effective a decade ago have lost their relevance. Speedy and continuous dynamic development of the economy and changing conditions in the business environment makes us look for new ways of obtaining and processing information, organization and quality control. Currently, the best solution is to use western experience repeatedly proven in practical business environment, more precisely – a system of key performance indicators, also known as KPI.

Information obtained in the practical application of KPI, acts as a basis for management decisions aimed at achieving long-term goals of the company and increase business efficiency.

It is known even the detailed financial performance is not always enough to obtain a complete picture of the situation in the company, while the assessment of effectiveness makes

it possible to determine whether the management system is well-organized to achieve set number of goals defined by a company – improving profitability, increasing brand and enterprise business value.

Calculations of KPI intended only to provide a basis for making management decisions and identify those problems that are in the way of effective performance of the company [11].

Key Performance Indicators pursuing important purpose. They allow determining the main stream of the company development. Understanding not vague prospective and uncertain goals, but effective and clear decisions top management will be able to organize the business in the most successful way.

Analysis of recent research and publications. The founder of the concept of «management by objectives or KPI» is believed to be P. Drucker. Other researchers who devoted their works to this issue were R. Kaplan and D. Norton, D. McGregor and others [3].

Despite the importance of the results, given the complexity of these problems, they continue to be the subject to scientific debate. Under these conditions, it is necessary to develop a mechanism that would allow focusing on the main points and principles of strategic management, get complete, visual picture of strategic planning process, providing the top management with a tool of proper assessment of the shortcomings and the ways of effective development [4].

Aim of the article. The aim of this article is to develop a mechanism for evaluating the dynamics of strategic business development and control over the implementation of its strategic objectives and the achievement of strategic objectives through KPIs using score evaluations and fuzzy logic in order to increase the accuracy of results and defining on this basis possible ways to improve decision making process and strategic planning.

Research outcome. An important element of strategic planning is to develop a mechanism of effective gathering of the necessary information. In this regard, it is important to correctly select a right set of KPIs, frequency of its measurement and control; processing and coordination of the evaluation process; the sources, methods of data collection and processing; form of representation, transfer, interpretation of data and its storage [1].

KPIs are the part of information systems of all hierarchical levels of enterprise and are used as a tool for planning, management, monitoring and analysis.

Comparison of actual values with target makes it possible to estimate the size of deviations from the desired level and to develop a set of measures aimed at minimizing them. In case of negative dynamics a responsible person must identify the causes and develop measures to remedy the situation [9].

The analysis and systematization of approaches to the definition of KPI and the use of heuristic methods research as «brainstorming», «pros and cons» of enterprises personnel would allow developing a set number of desired KPIs to perform the calculation and offer scale of assessment.

Comparing results of the actual values with target KPIs for the reporting period or/and a number of periods and detection of deviations can be illustrated by means of the so-called «dashboard» as well as the calculation of integrated KPI.

It is built as a table, in which strategic objectives are filled in as well as corresponding list of key performance indicators and their actual and target values.

We suggest calculating the integral indicators using methods of score evaluations and fuzzy (fuzzy) logic theory of linguistic variables and fuzzy sets [5; 6].

To simplify the implementation of KPIs into an existing automatic system of economic activity at the enterprise we propose to introduce the following notations:

$$x_{ij}(i=1,...,n; j=1,...,m_i); y_{ij}(i=1,...,n; j=1,...,m_i) \quad (1)$$

where x_{ij} – the actual value of the KPI; y_{ij} – the target value of the KPI; m_i – the number of KPIs; n – number of objectives.

It is well known that often KPIs have different focus, meaning their increase can be considered as a positive as well as a negative trend. The desired direction of the change in KPI can be described by factors of «orientation»:

$$q_{ij} = \pm 1 (i=1,...,n; j=1,...,m_i) \quad (2)$$

where q_{ij} –factor of «orientation» that can be +1 or –1.

Based on the comparison of actual and target KPIs $[\![(x)]\!]_{ij}, (y_{ij} - i = 1,\dots,n; j = 1,\dots,m_i)$, we can create three scoring levels that describe the level of targets performance achievement («not achieved», «partially achieved», «achieved»).

We will identify them as $z_{ij}^{k}(i=1,...,n; j,...,m_i; k=1,2,3)$, where the symbol "$k$" will mark zone of KPIs estimation.

If the target value is reached (this corresponds to the condition $\left(x_{ij}/y_{ij}\right)^{q_{ij}} < 0,5$, then $z_{ij}^{1} = 0,1; z_{ij}^{2} = 0; z_{ij}^{3} = 0$ If the target values are partly achieved $(0,5 \le [\![(x_1ij/y_1ij)]\!]^{\uparrow}(q_1ij) < 1)$ then $z_{ij}^{1} = 0; z_{ij}^{2} = 0,2; z_{ij}^{3} = 0$. If the target values are achieved (this corresponds to the condition then $z_{ij}^{1} = 0; z_{ij}^{2} = 0; z_{ij}^{3} = 0,3$.

These values of score evaluations in vector-matrix form describe the following equation:

$$\left[z_{ij}^{1}; z_{ij}^{2}; z_{ij}^{3}\right] = \begin{cases} [0,1\ \ 0\ \ 0], & if\ \left(x_{ij}/y_{ij}\right)^{q_{ij}} \le 0,5 \\ [0\ \ 0,2\ \ 0], & if\ 0,5 \le \left(x_{ij}/y_{ij}\right)^{q_{ij}} < 1 \\ [0\ \ 0\ \ 0,3], & if\ \left(x_{ij}/y_{ij}\right)^{q_{ij}} \ge 1 \end{cases} \quad (3)$$

After determining the score evaluations $z_{ij}^{1}; z_{ij}^{2}; z_{ij}^{3}(i=1,...,n; j=1,m_i)$ all KPIs that describe the level of achievement of their target values determine their total value:

$$\varsigma_i^k \sum_{j=1}^{m_i} z_{ij}^k (i = 1,...,n) \tag{4}$$

where ς_i^k – total value of k score of i – objective $\left(i = 1,...n\right)$

The known total value score evaluations for each of the objective we can calculate the integral index, which describes the level of strategic objectives achievement.

$$K_i = \left(\varsigma_i^1 + \varsigma_i^2 + \varsigma_i^3\right) \Big/ \left(m_i\right) \times 0,3^{(i=1,...,n)} \tag{5}$$

where $K_i (i = 1,...,n)$ – integral index.

In the denominator of the formula (6) the maximum possible value of the score evaluations sum is given:

$$\sum_{i=1}^{m_i} \varsigma_i^3 = m_i \times 0,3 \tag{6}$$

To summarize the level of strategic goals in general for all objectives can be based on the following formula:

$$K = \frac{1}{n} \sum_{i=1}^{n} K_i (i = 1,...,n) \tag{7}$$

where K – a combined integral index, which reflects the average level of strategic goals in general; n – number of strategic goals.

Briefly the following algorithm can describe the method of score evaluations for the control over the implementation of strategic objectives and the achievement of strategic goals for the company:

1. Within the allocated objectives to establish actual and target values KPIs (1) and factors of «orientation» (2), which describe the direction of their desired changes for the company as a whole, for individual business processes, individual plans of employees.

2. According to the formula (3) to determine the scoring for failure to achieve, partially achieve or full achievement of their KPI target values within each of the objective of the whole enterprise, in specific business processes, individual plans of employees.

3. According to the formula (4) to determine the total value of score evaluations for failure to achieve, partial achievement or full achievement of their KPI target values for each of the objective for the company as a whole, for individual business processes, individual plans of employees.

4. According to the formula (5) to calculate the integrated parameters that describe the level of achievement of the strategic goals of each of the objectives for the company as a whole, for individual business processes, individual plans of employees.

5. According to the formula (6) to find a combined integral index, which reflects the average level of strategic goals for the company as a whole, for individual business processes, individual plans of employees.

6. To perform qualitative analysis of strategic goals for certain KPI to assess achievement of strategic objectives and on this basis to develop recommendations to improve strategic planning, monitoring and control.

The process of monitoring and evaluation of strategic objectives using score evaluation is simple and straightforward, although is associated with certain disadvantages.

If the actual value of KPI is close to edges of evaluation described in (3), then the score, which reflects if KPI reached its target value, strongly depends on small changes of the index.

As a result, there are typical errors that lead to downfall in accuracy of the gathered information about KPIs achievements of their strategic objectives, which undermines the effectiveness of the practical application of the developed method of control [8, 11].

These disadvantages can be eliminated by fuzzy logic based on the theory of linguistic variables and fuzzy sets, the study of which has recently been given more attention [6; 5].

A great contribution to the development of fuzzy logic and fuzzy sets theory have such researchers as F. Martin McNeill, Ellen Thro, Lotfi Zadeh, Daniel Schwartz, Ebrahim Mamdani and others [2]. One of Zadeh's core points was that classic mathematics could be used to create a link between language structure such as words and expressions with human intelligence. He proved that a vast majority of concepts are better expressed by words than by mathematics [2]. Therefore, fuzzy logic provides a concept that can build better models of reality.

Moreover, the current business environment in Ukraine can be characterized by conditions of uncertainty and instability. To conduct successful performance managers should take chaotic solutions that require an appropriate level of experience, skills and intuition. Particularly turbulent and changing market makes strategic decisions even harder.

Algorithmic modeling and strategic decisions based on a clear logic and the usual classical models of strategic management lose its effectiveness, which in many cases leads to catastrophic consequences resulting in negative economic, technical and social disasters.

As it was noted above, the formula (3) describes the quantitative level of achievement of KPIs their target values. The first score z_{ij}^1 describes the failure to achieve goals; the second one z_{ij}^2, shows that KPI's have partially achieved assigned goals, while the third score z_{ij}^3 illustrates full achievement of goals. This method of quantitative evaluation of KPIs can be equally described using the followings terms: «target is achieved», «target partially achieved», «target achieved».

This analogy between quantitative and qualitative assessment indicates it is appropriate to use the methods of the theory of fuzzy sets [6] and linguistic variables for monitoring KPIs [2]. The rate of KPIs can be described by three possible meanings that are expressed verbally. At its core, the so-called «linguistic variable», and its «sets» (possible meanings) are above-mentioned three levels of KPI achievement («not achieved», «partially achieved», «achieved»).

Thus, each level of KPIs describes a relevant linguistic variable that has the following meanings:

$$s_{\downarrow}ij(x_{\downarrow}ij, y_{\downarrow}ij, q_{\downarrow}ij) = \{@("\backslash"\text{not achieved}\backslash""(if\,(x_{\downarrow}ij / y_{\downarrow}ij)^{\uparrow}(q_{\downarrow}ij) < 0,5)@"\backslash"\text{partially achieved}\backslash"$$
$$(\text{if } 0,5 \le (x_{\downarrow}ij / y_{\downarrow}ij)^{\uparrow}(q_{\downarrow}ij) < 1)@"\backslash"\text{achieved}\backslash"(if\,(x_{\downarrow}ij / y_{\downarrow}ij)^{\uparrow}(q_{\downarrow}ij) \ge 1)) \quad (8)$$

where s_{ij} – the linguistic variable describing KPI achievement it's the target value.

The formula (8) reflects not only the terms of the linguistic variable, but also the order in which the values of the linguistic variable according to the actual and target values of KPIs. Scoring evaluation (3) can be replaced by verbal linguistic variable (8). Each of the term of the linguistic variable can be put into line with membership functions that refer the actual values of KPIs to such three fuzzy sets «target not achieved», «target partially achieved », «target achieved».

Firstly, we will discuss the first membership function that corresponds with the term «achieved». According to the proposed method of controlling, terms «achieved» linguistic variable $s_{ij}(i=1,...,n; j,...,m_i)$ reflects the membership function $\varphi_3(x_{ij}, y_{ij}, q_{ij})$, which describes «the set of integers greater than 1». This follows from the fact that the criterion for achieving KPI target value is condition – $\left(x_{ij} / y_{ij}\right)^{q_{ij}} \geq 1$.

Before moving forward discussing the membership functions further, we would like to make the following remark. Function $\varphi_3(x_{ij}, y_{ij}, q_{ij})$ depends on three arguments (x_{ij}, y_{ij}, q_{ij}) .However, the calculations of the values of the formula (9) must be found by dividing arguments x_{ij} / y_{ij} and bring it to a degree q_{ij}.

$$\varphi_3(x_{ij}, y_{ij}, q_{ij}) = \varphi_3\left(\left(x_{ij} / y_{ij}\right)^{q_{ij}}\right)(i=1,...,n; j=1,...,m_i) \quad (9)$$

Thus, arguments (x_{ij}, y_{ij}, q_{ij}) related to each other as elements of product, so actually the function $\varphi_3(x_{ij}, y_{ij}, q_{ij})$ depends on one argument that is equal to $u_{ij} = \left(x_{ij} / y_{ij}\right)^{q_{ij}}$.

Due to this characteristic the membership function with regards to the term «achieved» can be expressed by $\varphi_3(\mathrm{u})$ depending on one argument u which describes the so-called «set of numbers larger than 1».

In the theory of fuzzy sets membership functions that relate to the set of «numbers larger than a certain constant», are described using the following expressions:

$$\varphi(u) = a\left(\frac{1}{1+exp(c(u-d)^2)} + b\right) \quad (10)$$

where $\varphi(u)$ – the membership function; u its argument belongs to the fuzzy set; c,d,b – parameters of the function.

Function parameters c,d,b are real numbers, which should be selected in a way to reflect the desired set. Their values are established experimentally (by using a selection of samples) or from solving the corresponding identification tasks [7].

Membership function that describes the set of numbers «larger (equal) per than 1» is shown below:

$$\varphi_{\downarrow}3(u) = \left\{(2\left[1/(1+\exp(-\left[15(u-0,85)\right]^{\uparrow}2)-0,5\right]@0; if\ u \leq 0,85-|; if\ u > 0,85 \quad (11)\right.$$

The parameters for this function are determined experimentally (by selection). We would like to stress that the set of numbers greater than one, can be described by other membership functions.

Similarly term «partly achieved» corresponds to the membership function, which describes the set of numbers larger (equal) 0.5. This set describes this function:

$$\varphi_{\downarrow} 2(u) = \left\{(2\left[1/(1+\exp(-\left[15(u-0,35)\right]^{\uparrow} 2)-0,5\right]@0; if\ u \le 0,35-|; if\ u > 0,35 \right. \qquad (12)$$

The parameters for this function are chosen experimentally (by selection).

Lastly, the membership function that describes the term «not achieved» will be discussed below. According to formula (3) this term corresponds to the values of the argument, which lie in the range.

However, we have already used the membership function $\varphi_2(u)$ to describe the set of integers greater than 0,5 ($u \ge 0,5$). It is enough to consider only the left side of the interval $0 < u < 0,5$, to be precise the condition to describe the term «not achieved».

We can conclude based on the above that term «not achieved» corresponds to the function that describes the set of integers greater than zero (when argument is always positive).

However, if the term «not achieved» is described by the membership function of the set of numbers «greater than zero», then this function in $u_0 = 0$ will have a gap (figure 1). This contradicts the continuity requirements, which are applied to the membership functions [7; 10]. Therefore, the term «not achieved» must describe a function that is close to zero in the point $u_0 : \varphi_1(u_0) \approx 0$, and has a value close to 1 in the point $u_c : \varphi_1(u_c) \approx 1$ where the coordinate u_c belongs to the segment and is close to the point $u = 0$.

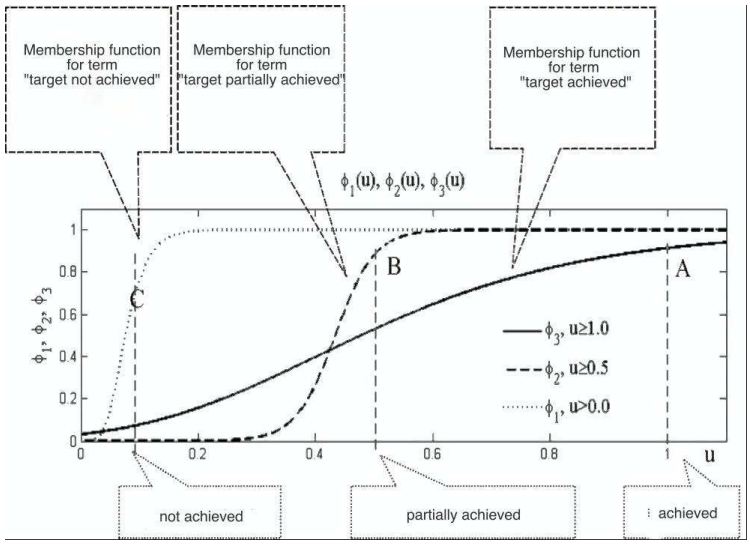

Figure 1. Membership function $\varphi_1, \varphi_2, \varphi_3$ *

Рисунок 1. Графіки функцій приналежності $\varphi_1, \varphi_2, \varphi_3$ *

*Source: Developed by the author's

*Джерело: розроблено авторами

Based on the practice of designing membership functions [7;10;12] a value $u_c = 0,1$ was selected experimentally. This value meets the requirements that are applied to the function $\varphi_1(u)$ and does not contradict the statement $(\varphi_1(u_0) \approx 0; \varphi_1(u_c) \approx 1; \varphi_1(u) \approx 1, if\ u \geq u_c$ (as well as serves the requirements for continuity of membership functions. On this basis, the term «not achieved» describes the membership function that displays a set of numbers larger (equal) than 0,1:

$$\varphi_{\downarrow}1(u) = \left\{(2\left[1/(1+\exp(-\left[15(u-0)\right]^{\uparrow} 2) - 0,5\right]@0; if\ u \leq 0) - |; u > 0 \right. \quad (13)$$

Parameters of this function also found experimentally.

Parameters of the function $\varphi_3(u)$, which describe the set of «numbers larger (equal) 1» are selected in the way so that at the point $u = 1$ (condition «target achieved») function had a value close to 1: $\varphi_3(1) \approx 1$.

Similar functions φ_2 belonging to the set of «large numbers (equals) 0.5» must meet the following condition: at the point $u = 0,5$ the function φ_2 has the value close to 1 ($\varphi_2(0,5) \approx 1$). This means, if $u < 0,5$, then $\varphi_2(u) < 1$, if $u \geq 0,5$, then $\varphi_2(\mathrm{u}) \approx 1$.

Parameters of the function φ_2 were selected based on these conditions.

We would like to stress that the membership function $\varphi_1, \varphi_2, \varphi_3$ can be written using other mathematical expressions, in particular – special computer software systems designed to work with fuzzy logic [5].

In order to assess the level of achievements of KPIs their target values we should use defined earlier membership functions. Those functions $\varphi_1, \varphi_2, \varphi_3$ on the segments $\in \left[0;0,1\right]$, $u \in \left[0,1;0,5\right]$, $u \in \left[0,5;1,0\right]$, $u \geq 1$ set the sum of functions $\varphi_1 + \varphi_2 + \varphi_3$ and have the following characteristics (fig.2):

$$\begin{aligned}
&\varphi_1(u) + \varphi_2(u) + \varphi_3(u) < 1, \text{if } 0 < u \leq 0,1; \\
&\varphi_1(u) + \varphi_2(u) + \varphi_3(u) \approx 1, \text{if } 0,1 < u \leq 0,5; \\
&\varphi_1(u) + \varphi_2(u) + \varphi_3(u) \approx 2, \text{if } 0,5 \leq u < 1,0; \\
&\varphi_1(u) + \varphi_2(u) + \varphi_3(u) \approx 3, \text{if } u \geq 1,0;
\end{aligned} \quad (14)$$

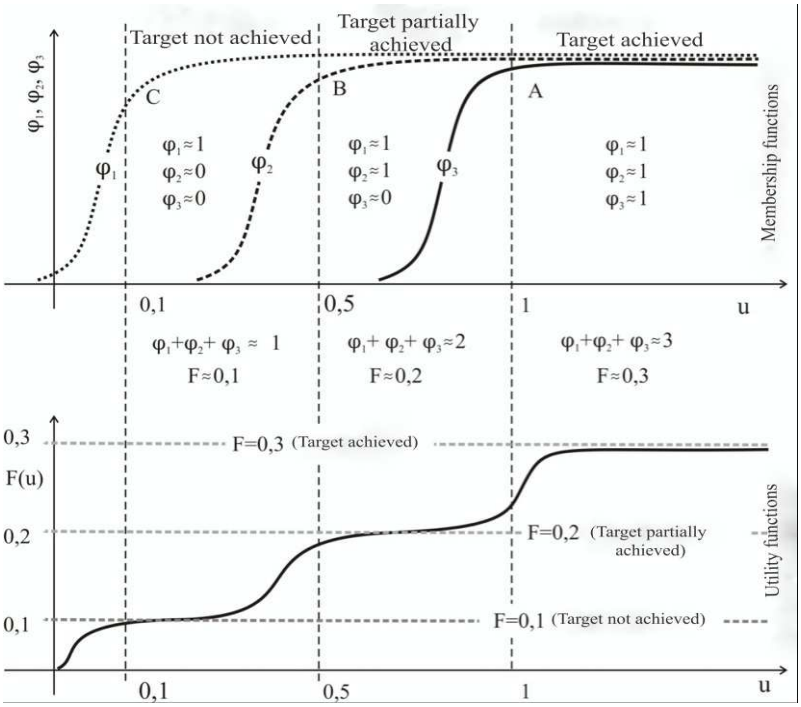

Figure 2. Schematic relationship of membership functions and utility functions*

Рисунок 2. Схематичний взаємозв'язок функцій приналежності і функції корисності*

*Source: Developed by the author's
*Джерело: розроблено авторами

Consequently, the sum of functions $\varphi_1 + \varphi_2 + \varphi_3$ describes the desired level of KPIs value achievement. Functions that describe such level are called utility function. Comparing the value of score evaluations (3) with the sum values described above $\varphi_1 + \varphi_2 + \varphi_3$, we should stress:

$$\begin{aligned}
&\frac{\varphi_1(u)+\varphi_2(u)+\varphi_3(u)}{z_{ij}^1} = \frac{1}{0,1} = 10, if\, 0,1 < u < 0,5;\\
&\frac{\varphi_1(u)+\varphi_2(u)+\varphi_3(u)}{z_{ij}^2} = \frac{2}{0,2} = 10, if\, 0,5 \le u < 1,0;\\
&\frac{\varphi_1(u)+\varphi_2(u)+\varphi_3(u)}{z_{ij}^3} = \frac{3}{0,3} = 10, if\ u \ge 1,0;\\
&(\mathrm{i} = 1,...,\mathrm{n};\ \mathrm{j} = 1,...,\mathrm{m}_i)
\end{aligned} \tag{15}$$

This means that on four intervals the values of the argument u, where $u \in [0;0,1]$ $u \in [0,1;0,5]$, $u \in [0,5;1,0]$, $u \ge 1$ set the sum of functions $\varphi_1 + \varphi_2 + \varphi_3$ is related to the score as one to 0,1:

$$\frac{\varphi_1 + \varphi_2 + \varphi_3}{score} = 10 \tag{16}$$

If scores (3) are replaced by the utility function, which continuously depends on the argument *u*, then this ratio should be maintained:

$$\frac{\varphi_1 + \varphi_2 + \varphi_3}{score} = \frac{\varphi_1 + \varphi_2 + \varphi_3}{utility\ functions} = \frac{\varphi_1 + \varphi_2 + \varphi_3}{F(u)} = 10 \tag{17}$$

This leads us to:

$$F(u) = \frac{\varphi_1(u) + \varphi_2(u) + \varphi_3(u)}{10} \tag{18}$$

Consequently, the sum of membership functions describes the level of achievement of KPIs its target value (3) with accuracy up to a multiplier 1/10. We would like to point out that the function $u \in [0;0,1]$ has a small value and increases, which does not contradict the utility function characteristics. Thus, the utility function $F(u)$, which describes to which extent KPIs reach their target values are is equal to:

$$F_{ij}(x_{ij}, y_{ij}, q_{ij}) = \frac{1}{10}\sum_{k=1}^{3}\varphi_k\left(\left[x_{ij}/y_{ij}\right]^{q_{ij}}\right) \tag{19}$$

where F_{ij} – utility function that describes the extent the KPI achieved of its target value; $i = 1,...,n; j = 1,...,m_i; \varphi_k\ (k = 1,2,3)$ – membership function

Based on the above membership functions we were able to establish utility function whose graph is shown in fig.3. Utility function (19) is continuous and substantially independent of small changes in its arguments. By using it the errors in determining the score evaluations are avoided. In practice, this leads a higher accuracy and efficiency of strategic goals achievement monitoring systems.

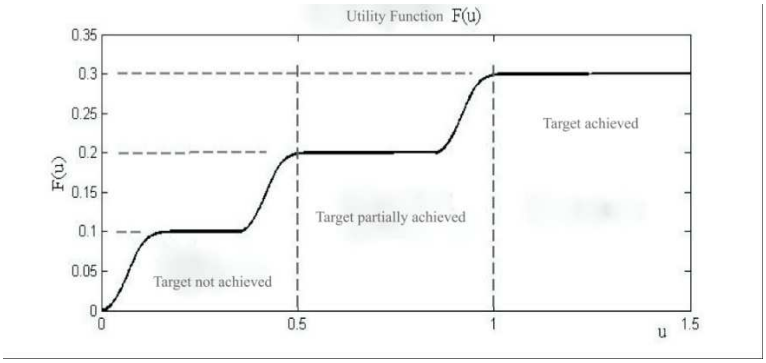

Figure 3. Utility function used to calculate the coefficient of achieving strategic goals*

Рисунок 3. Графік функції корисності, застосованої для обчислення коефіцієнта досягнення стратегічних цілей

* Source: Developed by the author's
*Джерело: розроблено авторами

Based on the utility function, which depends on the actual values of individual KPIs, integral indicators of strategic objectives achievement are calculated.

$$K_i = \frac{1}{0{,}3 \times m_i} \sum_{j=1}^{m_i} [F_{ij}(x_{ij}, y_{ij})], q_{ij} (i = 1, \dots, n) \quad (20)$$

Consolidated integral index, which reflects the average level of strategic goals of the company can be estimated by formula (7).

The results using the described earlier methods using key performance indicators for financial aspects of management are summarized in tables 1, 2.

In the first table (table 1) using formula (11–13) the value of membership functions φ_1, φ_2, φ_3. On this basis the utility function was defined $F(u)$ (table 2).

Table 1

The value of membership functions for key performance indications

Таблиця 1

Значення функцій приналежності для ключових показників ефективності, що характеризують фінансові аспекти діяльності підприємства

№ KPI	Name of KPI	Actual value of KPI	Target value of KPI	«Orientation» coeficient	u	$\varphi_1(u)$	$\varphi_2(u)$	$\varphi_3(u)$
1	Share of current liabilities in debt capital	100,0	100,0	+1	1,000	1	1	0,98742
2	Coefficient of autonomy	0,46	0,46	+1	1,000	1	1	0,98742
3	Financial leverage ratio	1,16	1,16	+1	1,000	1	1	0,98742
4	Share irreversible investment, %	33,4	30,0	+1	1,113	1	1	0,99742
5	Share of operating capital, %	66,6	70,0	+1	0,951	1	1	0,82018
6	Overall liquidity ratio	1,38	1,40	+1	0,985	1	1	0,98393
7	Turnover ratio of current assets	5,8	6,0	+1	0,967	1	1	0,91064
8	Gross profit margin, %	2,9	5,0	+1	0,580	1	1	0
9	The cost of capital, %	17,25	14,64	-1	0,849	1	1	0

Source: Developed by the author's
Джерело: Розроблено авторами

The integral index, which reflects the level strategic goals achievement as calculated per formula (20). Its value is given in the last row of the table 2.

Table 2

The value of utility functions

Таблиця 2

Значення функцій корисності для оцінювання рівня KPI, що характеризують фінансові аспекти діяльності підприємства

№ KPI	Name of KPI	$\varphi_1(u)$	$\varphi_2(u)$	$\varphi_3(u)$	$F(u)$
1	Share of current liabilities in debt capital	1	1	0,98742	0,29874
2	Coefficient of autonomy	1	1	0,98742	0,29906
3	Financial leverage ratio	1	1	0,98742	0,29874
4	Share irreversible investment, %	1	1	0,99742	0,29874
5	Share of operating capital, %	1	1	0,82018	0,28202
6	Overall liquidity ratio	1	1	0,98393	0,29839
7	Turnover ratio of current assets	1	1	0,91064	0,29106
8	Gross profit margin, %	1	1	0	0,2
9	The cost of capital, %	1	1	0	0,2
Level of strategic goal achievement (K_1)					0,90213

The described method of strategic objectives evaluation and strategic goals achievement based on fuzzy logic is summarized below:

1. All actual and target values of KPIs must be established (1) as well as their parameters (2), which describe the desired direction of change.

2. The membership functions $\varphi_1, \varphi_2, \varphi_3$ must be set, which describe respectively the set of numbers «larger (equal) by 0,1», «larger (equal) for 0.5» and «larger (equal) to 1».

3. According to the formula (19) calculate the utility function of individual KPIs that describe the level of target values achievement.

4. According to the formula (20) determine the integrated parameters that describe the level of strategic objectives achievement.

5. According to the formula (6) find a combined integral index, this reflects the average level of strategic goals achievement.

6. Perform qualitative analysis of the results and compare them with the results of control obtained by the method of score evaluations.

Reasonably, in order to determine the achievement of a strategic goal its desired level is an important information, which can be calculated using different methods that

combine ease of data entry with the flexibility of mathematical processing as well as available means of controlling the intermediate results of calculations, built-in mathematical functions for fuzzy logic and are ready for integration into the information system of the company.

These requirements are met by a system of mathematical calculation Matlab, in particular – function from its library Fuzzy Logic Toolbox. With these tools, one can design a software to determine the level of strategic goal achievement. In comparison with such well-known Microsoft Excel spreadsheet, Matlab simply adapts to any variations connected to a possible change in a set of KPIs. Due to this, the change in the structure of the «dashboard» will have no influence on designed software.

In addition, the application of fuzzy calculations tool for the relevant software (with which system Matlabs equipped), reduces the development of appropriate programs, facilitating their introduction into operation, simplifies maintenance.

Conclusion. Management decisions making process in strategic planning usually occurs under conditions of uncertainty, characterized by inaccurate raw data through the use of peer review, random effects of external factors, making it impossible to use traditional mathematical models. In this regard, the probability of risky, dangerous decisions can take place, which in the long run can lead to negative or even disastrous consequences. Using «dashboards» to determine the level of strategic goals and objectives achievement can compensate these defects as well as the method of score evaluations should be enhanced by mathematical methods of fuzzy logic based on the theory of linguistic variables and fuzzy sets using a software mathematical calculations MATLAB. On this basis inaccurate data and subjective expert studies can be used to evaluate key performance indicators, formalize linguistic (verbal) descriptions of complex processes in the absence of traditional mathematical models of system management.

Висновки. Прийняття управлінських рішень у стратегічному управлінні відбувається за умов невизначеності, яка характеризується неточністю первинних даних за рахунок використання експертних оцінок, випадковим впливом зовнішніх чинників, що робить неможливим використання традиційних математичних моделей. У зв'язку з цим зростають ризики прийняття необґрунтованих рішень, які можуть призвести до негативних наслідків. З метою їх компенсації при використанні «інформаційних панелей», що містять ключові показники ефективності та інтегральні показники оцінювання рівня досягнення стратегічних цілей підприємства за окремими аспектами діяльності, метод бальних оцінок варто доповнювати математичними методами нечіткої (розмитої) логіки, що ґрунтуються на теорії лінгвістичних змінних та розмитих множин. Використання програмної системи математичних обчислень MATLAB дозволить застосовувати для оцінювання ключових показників ефективності неточні та суб'єктивні дані експертних досліджень, формалізувати лінгвістичні (вербальні) описи складних процесів за відсутності традиційних математичних моделей функціонування системи управління.

Literature

1. Дерев'янко, Т. Ґенезата еволюція моделей розрахунку й оцінки результатів діяльності підприємства [Текст] / Т. Дерев'янко // Економіка. – 2009. – № 4 (95). – С.9–11.

2. Заде, Л.А. Понятие лингвистической переменной и его применение к принятию приближенных решений [Текст]/ Л.А. Заде. – М.: Мир, 1976. – 165 с.

3. Каплан, Р. Стратегическое единство. Создание синергии организации с помощью сбалансированной системы показателей [Текст] / Р.С. Каплан, Д.П. Нортон; пер. с англ. – М.: Вильямс, 2006. – 384 с.

4. Кэмпбел, Д. Стратегический менеджмент: учебник [Текст]/ Д. Кэмпбел, Дж. Стоунхаус, Б. Хьюстон; пер. с англ. Н. И. Алмазовой. – М.: ООО «Издательство проспект», 2003. – 336 с.

5. Леоненков, А.В. Нечеткое моделирование в среде MATLAB и fuzze TECH [Текст] / А.В. Леоненков. – СПб.: «БХВ Петербург», 2005. – 736 с.

6. Недосекин, А.О. Применение теории нечетких множеств к задачам управления финансами [Электронный ресурс] / А.О. Недосекин // Аудит и финансовый анализ. – 2001. – №2. – Режим доступа: http://www.cfin.ru/press/afa/2000-2/08.shtml

7. Пономарев, А.С. Нечеткие множества в задачах автоматизированного управления и принятия решений [Текст] / А. С. Пономарев. – Харьков.: НТУ «ХПИ», 2005. – 234 с.

8. Попов, Д. Эволюция показателей стратегии развития предприятия [Электронный ресурс] / Д. Попов. //Управление компанией. – 2003. – №2. – Режим доступа: http://www.management.com.ua/strategy/str070.html

9. Рамперсад, Х. Универсальная система показателей: как достигать результатов, сохраняя целостность [Текст] / Х. Рамперсад; пер. с англ. – Изд. 3-е. – М.: Альпина Бизнес Букс, 2006. – 352 с.

10. Рыжов, А.П. Элементы треории нечетких множеств и измерения нечеткости [Текст] / А. П. Рыжов. – М.: Диалог-МГУ, 1998. – 81 с.

11. Самусенко, С.А. Показатели эффективности компании: вопросы систематизации и эволюции [Электронный ресурс] / С. А. Самусенко // Экономические проблемы и решения. – 2006. – № 5. – С. 44–45. – Режим доступа: http://old.lib.sfu-kras.ru/resources.php3?menu1= soceps&menu2 =2006-5

12. Courntey, H.G. Strategy under uncertainty [Text] / H.G. Courntey, J. Kirkland, S.P. Viguerie // McKinsey Quarterly. – 2000. – № 3. – Pp.66–81.

Отримано 29.10.2014