Modeling a balanced scorecard of an enterprise: The scenario approach

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Abstract

Implementation of a balanced scorecard in an enterprise requires a significant investment of time and resources. Modeling parameters substantially improves their design process and allows us to specify a situation and to track changes adjusting the strategy in parallel. It is possible to identify and, if necessary, to correct causal relationships of a complex of strategic goals, as well as to pre-define actions, resources, timelines and responsibility necessary to implement the defined goals. In this case, the analysis of scenarios obtained when modeling allows us to choose an optimal trajectory for developing the enterprise over a certain period.

Using of the method of cognitive modeling opens the possibility to create a simple and intuitive algorithm to achieve this goal. This is a safe way to form an image of its future, to see the possibilities and consider the risks before beginning active operations.

This method of modeling facilitates combination of elements of the enterprise's internal and external economic environment into a single system, as well as analysis of the system as a whole and of its separate components without losing the relationships between them and taking into account both quantitative and qualitative characteristics of the processes.

Key words: balanced scorecard, enterprise, cognitive modeling, development scenario.

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Introduction

The Balanced Scorecard (BSC) methodology was proposed by D.P. Norton and R.S. Kaplan in 1992 to supplement the limited representation of the organization's effectiveness only on the basis of measuring its financial performance. It is proposed to measure in BSC the performance of a company in three additional areas, outside the sphere of finance (customers, internal business processes, training and development) to get a more balanced view of development of the organization [1].

Quality measurement of work in these areas expands the factor space to evaluate enterprise performance. BSC complements the financial parameters system as already accomplished, and also indicates the origin of revenue growth, which clients provide it and why, what key business processes the company should focus on for improvement in order to convey its unique proposition to the client. BSC helps to direct investments and orient work with personnel in this direction, as well as development of internal systems, corporate culture and climate [2].

BSC development entails formulating strategy in several outlooks, setting strategic goals and measuring the achievement of these goals by using indicators. BSC is projected onto the entire organization through development of individual goals within the framework of the already developed corporate strategies and stimulates the understanding by employees of their place in the company's strategy.

By using BSC, it is possible to implement the strategy with regular activities of all units managed through planning, accounting, control and analysis of the balanced scorecard, and motivating staff to achieve them.

When designing BSC, developers actually model situations of implementing possible strategic goals on strategy maps describing scenarios as a set of strategic goals and causal relationships between them. However, the vast majority of tools that implement the concept of Business Process Management (BPM), cannot model BSC for assessment of possible development of processes in the enterprise that would enable us to choose the effective scenario and most precisely match the strategic goals [3, 4].

The situation described exists in the framework of the methodology of "soft" system analysis [5]. Formalization of "soft" systems is not based on accurate quantitative measurements but on qualitative, fuzzy and hypothetical concepts about the system in the form of expert assessments and on heuristic reasoning [6]. The task of management decision-making support in the "soft" dynamic situation is defined as development of a strategy to transfer a situation from its current state to the target on the basis of a subjective model of the situation. This model includes expert measured values of factors of the situation and a functional structure which describes the laws known to the analyst and regularities of the situation observed. This subjective model is recorded as a directed signed graph – cognitive map [7].

1. Proposed methods and approaches

Due to the fact that in BSC there are both quantitative and qualitative characteristics, the estimation of efficiency of the enterprise by modeling becomes an extraordinary task. Analysis of the modeling methods shows that this task can be solved only by cognitive models, which allow us to combine elements of internal and external economic environment of the enterprise into a single system, as well as to analyze the system as a whole and in its separate components without losing the relationships between them. In addition, the model can incorporate both quantitative and qualitative characteristics of processes [8].

When doing cognitive modeling, the following sequence of actions is usually applied [9, 10]:

✦ determination of initial conditions, trends characterizing development of the situation at this stage, which is necessary to ensure the appropriateness of the model scenario to the real situation;

✦ setting desired target directions (increase, decrease) and strength of process trend changes (weak, strong);

✦ selection of a set of measures (combination of control factors), determination of their possible or desired strength and direction of impact on the situation;

✦ selection of a complex of possible influences on the situation (activities, factors) the strength and direction of which must be defined;

✦ selection of observable factors (indicators) that characterize development of the situation is carried out depending on the purposes of the analysis and user's desires.

The aforementioned stages of cognitive analysis are basic and are successfully implemented by using existing software systems, such as "Situation", "Compass", "KIT" (V.A. Trapeznikov Institute of Control Sciences, Russian Academy of Sciences), systems of decision-making support based on cognitive modeling "Igla" [11], the Software System of Cognitive Modeling (SS CM CogMap TTI Southern Federal University) [12] and many others [13]. In the present study we used for our modeling processes SS CM CogMap.

The simplest cognitive model is a sign directed graph – cognitive map [10]:

$$G = <V, E>, \text{ where}$$

V is a vertex set, wherein vertices $V_i \in V$ ($i = 1, 2, ..., k$) are elements of the system under investigation – strategic goals;

E is an arc set, wherein arcs $e_{ij} \in E$ ($i, j = 1, 2, ..., N$) reflect the relationship between vertices V_i and V_j (positive relationship: when increasing the value of one factor, the value of the other increases; negative relationship: when increasing the value of one factor, the value of the other decreases and vice versa).

The cognitive map is a result of cognitive-targeted structuring of knowledge about strategic goals of the enterprise and external environment that allow us to identify and systematize internal and external factors that have quantitative and qualitative certainty (vertices V_i), as well as setting causal relationships (arcs e_{ij}) between them.

The constructed directed graph reflects the influence of factors taking into account arc weights w_{ij} (for example, from interval –10 to +10) established by experts. The arc weights can be determined on the basis of functional dependence (if any), as well as a coefficient b_{ij} of linear regressive dependence of factors like $y_j = a + b_{ij}x_i$ [12].

Thus, the direct (quantitative) and indirect (qualitative) influence of factors on the indicators selected for effectiveness evaluation are taken into account. This makes it possible to provide a substantially more complete description of the problem area and resultant effect of implementing certain activities or projects.

2. Example of BSC modeling of a company. Development scenarios

In the beginning of BSC design, a base scenario was determined which includes certain concepts of the BSC model of the enterprise established by expertise and the relationships between them (*tables 1 and 2*) [14, 15]. The base scenario includes what the developer understands to be a full understanding of the set of the strategic goals of enterprise development.

Table 1.

Concepts of a model

Prospects	Vertexes	Contents of the Vertex
Finance	v_1	Profit
	v_2	Costs
Clients	v_3	Number of clients
	v_4	Client satisfaction
Processes	v_5	Control of construction and installation works (CIW)
	v_6	Purchase of quality materials, components, tools (MV)
	v_7	Timely shipping of MV
	v_8	Optimization of MV inventory
	v_9	Quality of project works
	v_{10}	Accurate project planning
	v_{11}	Introduction of process management
Training and development	v_{12}	Qualified employees
	v_{13}	Creation of a corporate training center
	v_{14}	Development of corporate information systems (CIS)

Figure 1 shows a cognitive BSC model of the enterprise for the base scenario.

The next step is modeling the possible impulse processes in vertexes V of the built card when introducing perturbations (pulses $q_i = \pm 1$) and the variations of the arcs conversion functionality of the cognitive map $f(x_i, x_j, e_{ij})$.

The impulse process on the graph in this software system is described by the formula proposed by F.S. Roberts [16]:

$$x_{v_i}(n+1) = x_{v_i}(n) + \sum_{v_j : e=e_{ij} \in E}^{k-1} f(x_i, x_j, e_{ij}) P_j(n) + Q_i(n+1),$$

where $x_i(n)$, $x_i(n+1)$ – value of parameter x_i at vertex v_i in the simulation moments n and $n+1$ respectively;

$f(x_i, x_j, e_{ij})$ – arcs conversion functionality of the cognitive map (in the particular case it can be function f_{ij} or weight coefficient w_{ij}), where x_i – parameters of vertices v_i , x_j – parameters of vertices v_j , vertex $v_{ij} \in V$, $i, j = 1, 2, ..., k$, e_{ij} – arc reflecting the relationship between vertices v_i and v_j , rcs $e_{ij} \in E$, $i, j = 1, 2, ..., N$;

P_j – value of impulse at vertex v_j;

$Q_i(n)$ – perturbations coming to vertices v_i .

Implementation of this phase is carried out by defining a list of possible control actions on internal sources

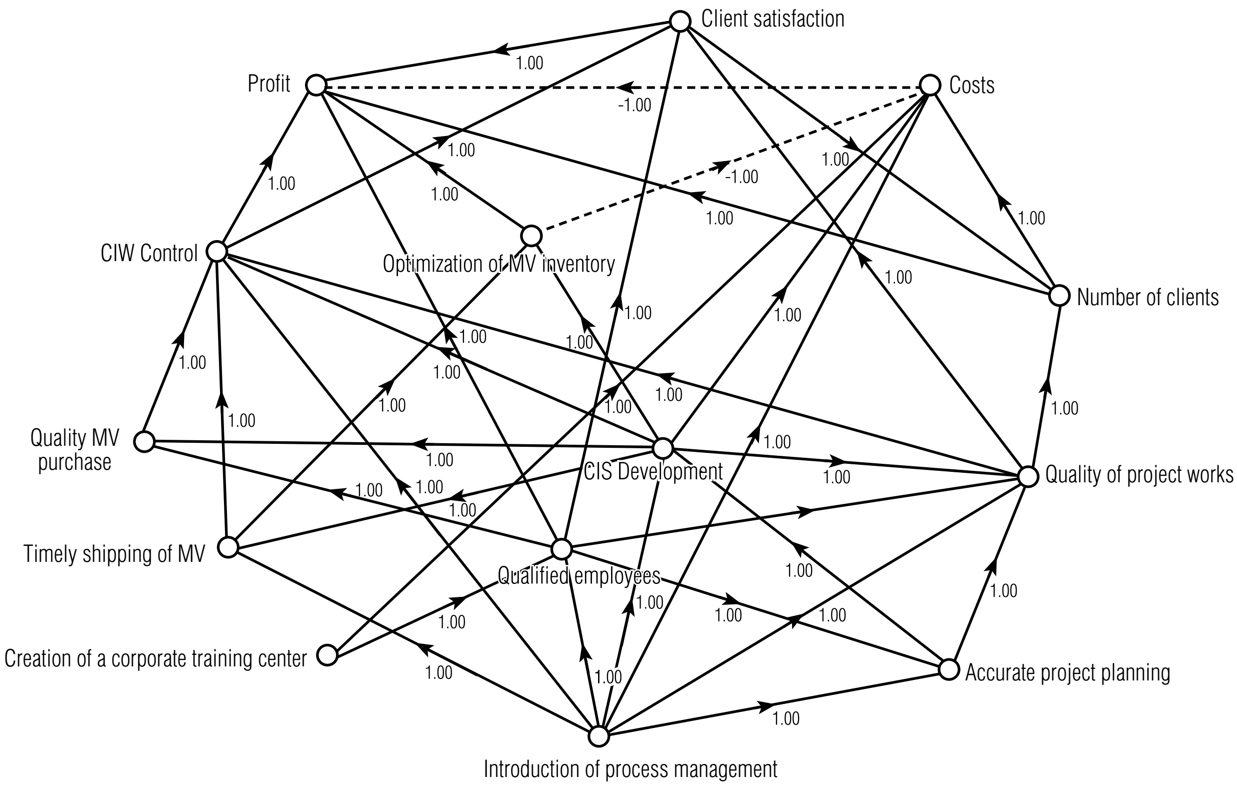

Fig. 1. Cognitive BSC model of the enterprise

Table 2

Cognitive map of a model

	v_1	v_2	v_3	v_4	v_5	v_6	v_7	v_8	v_9	v_{10}	v_{11}	v_{12}	v_{13}	v_{14}
v_1														
v_2	–													
v_3	+	+												
v_4	+		+											
v_5	+			+										
v_6					+									
v_7					+			+						
v_8	+	–												
v_9			+	+	+									
v_{10}									+					
v_{11}		+			+		+		+	+		+		+
v_{12}				+		+			+	+				
v_{13}		+										+		
v_{14}		+			+	+	+	+	+	+				

of factors and further analysis of scenarios of possible development of situations under the influence of simulated perturbations.

The impulse modeling when introducing perturbations q_i at vertex of the cognitive map (v_i) allows us to obtain a sufficient number of realizations of random processes. Existence of such realizations allows us to set up and solve the task of optimum nominal proposed by D.V. Svecharnik for analysis of economic situations selected as the "best" impulse process. These can later be adopted as the desired development strategy of the investigated object [17, 18].

If there is a sufficient amount of statistical or expert data on possible quantitative values of effects (e.g., the volume of investment, volume of production), then when interpreting the results it is possible to speak about a specific quantitative change in the parameters of the vertex of the graph. In this case, a scenario calculation is performed to analyze possible dynamics of development of the process being studied. The arc weights of the graph when qualitative simulation of development scenarios of the object are not set, and impulses are assumed to be equal to fixed values[1]. In this case, the results of impulse modeling reflect only possible trends of the development process.

Thus, under the influence of various disturbances, the values of variables at vertices of the graph may change and the signal received at one of the vertices apply the chain on the rest, amplifying or fading.

As a result of impulse modeling (10 stages), the following process development scenario is received (*figure 2a*).

The graph shows that in this scenario, at first stages all modeling parameters selected for display have a tendency to increase, and at later stages they stabilize.

Other scenarios of processes developing in the enterprise were obtained by successive exclusion of certain strategic goals from the cognitive map and, respectively, from the model:

✦ scenario S_1 – vertex v_{13} "Creation of a corporate training center" is excluded from the base scenario;

✦ scenario S_2 – vertex v_{14} "CIS Development" is excluded from scenario S_1, during which we assumed the implementation process, automation of such business processes as CIW control, quality MV purchase and timely shipping control, optimization of MV inventory, quality control of project works, implementation of programs supporting process management.

The results of the impulse modeling (10 stages) of process development scenarios S_1 and S_2 are shown in the graphs (*figures 2b* and *2c*, respectively).

Visual analysis of the graphs allows us to build a chain of priorities resulting in scenarios according to their effectiveness $S_0 > S_1 > S_2$. Later, the results of development processes can be used for in-depth analysis on the optimum for the selected criteria.

[1] In our example, to reduce the scale of the display indicators, it is taken that: $q_i = \pm 0{,}1$

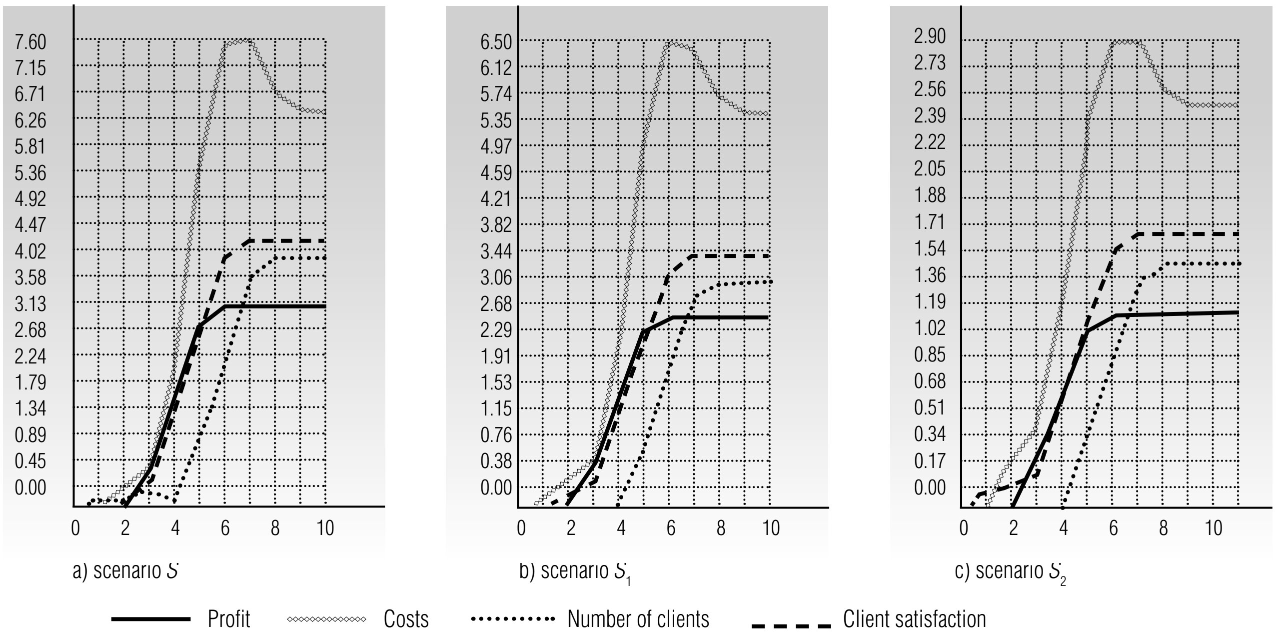

Fig. 2. Dynamics of indicators of BSC modeling of the enterprise for different scenarios

Conclusion

By itself, developing the strategy of an enterprise is a very important stage of management, and starting this process tells us about its maturity and relatively high achievements. Once they have developed a strategy and realized it, enterprises are faced with the need to assess the success of their efforts; particularly as the development process of strategy is cyclical. At this point, the problem of specific change evaluation appears, whether positive or negative, as well as what it should be compared with. In the absence of appropriate data, these questions remain unanswered.

In this case, BSC modeling of the enterprise enables us to:

✧ specify a situation and to track changes in parallel adjusting the strategy;

✧ determine and, if necessary, correct causal relationships of the combination of strategic objectives;

✧ pre-define activities, resources, timing and responsibilities required to implement the established goals.

BSC implementation is a process that requires a significant investment of time and resources. BSC modeling of an enterprise enables us significantly to improve their design process in time and labor. Cognitive modeling is the ability to create a simple and intuitive algorithm to achieve this goal, a safe way to form an image of its future, to see the possibilities and consider risks before beginning active operations.

It has been shown that the BSC cognitive modeling allows us to combine elements of the internal and external economic environment of the enterprise into a single system, as well as to analyze the system as a whole and in its separate components without losing the relationships between them, taking into account both quantitative and qualitative characteristics of the processes. ■

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Моделирование сбалансированной системы показателей предприятия: Сценарный подход

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Аннотация

Внедрение сбалансированной системы показателей на предприятии требует значительных затрат времени и ресурсов. Моделирование показателей существенно улучшает процесс их проектирования и позволяет конкретизировать ситуацию и отслеживать изменения, параллельно корректируя стратегию. Появляется возможность определить и, при необходимости, откорректировать причинно-следственные связи совокупности стратегических целей, а также предварительно определить мероприятия, ресурсы, сроки и ответственность, необходимые для реализации установленных целей. При этом анализ получаемых при моделировании сценариев позволяет выбрать оптимальную траекторию развития предприятия на определенный период времени.

Использование метода когнитивного моделирования открывает возможность создать простой и понятный алгоритм достижения поставленной цели, безопасный способ сформировать образ своего будущего, увидеть возможности и учесть риски, до начала активных действий.

Данный метод моделирования позволяет объединить элементы внутренней и внешней экономической среды предприятия в единую систему, а также проанализировать систему в целом и отдельные ее компоненты, не теряя взаимосвязей между ними, с учетом как количественных, так и качественных характеристик процессов.

Ключевые слова: сбалансированные показатели, система, предприятие, когнитивное моделирование, сценарий развития.

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