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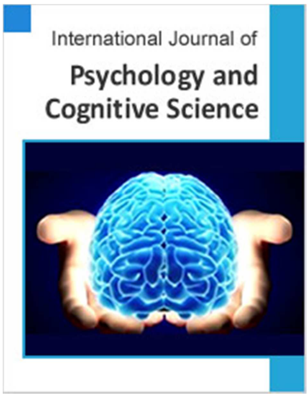

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Cognitive Tools for Intelligent Support of Management Consulting

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Abstract
The paper points out the challenges of management consulting in modern complex and unstable economic conditions. The authors emphasize the need for management consulting support tools that would be adequate to the hyper-turbulent nature of modern business environment and consider the possibility of developing such tools based on the ideas and methods of cognitive modeling. Examples of the use of cognitive tools are given and their prospective applications are discussed, such as the possibility of interdisciplinary integration in a compact and generally accessible form of “best support practices”, the possibility of studying the strategic prospects of enterprises in multifactor, dynamic and uncertain environments, the possibility of creating unified technological platform (engineering) of the “cognitive school” of strategic management.

1. Introduction

The European Federation of Management Consultancies Associations (FEACO) defines management consulting as “the rendering of independent advice and assistance about management issues, including identifying and investigating problems and opportunities, recommending appropriate action and assistance with the implementation of the recommendations” (FEACO Information Document 1994). This definition is shared by the Association of Consulting Management Engineers (ACME) and the Institute of Management Consultants (IMC).

According to the official data, management consulting currently exists as a separate service sector in the majority of developed countries of the world. Its turnover is $14 billion in the U.S., $8 billion in Europe, $2.5 billion in Japan, and $2 billion in the rest of world all together. Note that the above figures indicate net turnover of management consulting; with other professional services (such as audit, legal, training, engineering, investment, information and advertising services) taken into account, the total turnover grows manifold. For instance, the annual turnover of the entire industry of professional management consulting services in the U.S. amounts to $50 billion.

According to the classification of the European Directory of Management Consultants published under the auspices of FEACO, the priority objective of management consulting is to select enterprise’s development strategy.

One of the most difficult problems for a management team working on this objective is understands the complex causal chains that determine the impact of enterprise’s external and internal conditions on the goals and properties of the strategy being developed. It is extremely difficult to see and understand the logic of the progression of events here. The problem is aggravated by the growing complexity and instability of the economic environment, leading to numerous uncertainties and risks.

In these conditions, the use of known support tools (TQM Total Quality Management, BPR Business process reengineering, BSC Balanced Score Card, Six Sigma, BPM Business Performance Management, BI Business Intelligence, DSS Decision Support System, SP Strategic Planning, etc.) is accompanied with serious difficulties and constraints. Need new tools — tools that would be relevant to the *creative* nature of today's management (IBM 2010) and based on the research approach and long-term dynamic analysis of strategic decisions.

Ideas and methods of cognitive management, a new trend in the theory of management of complex ill-structured (Simon, 1973) problem situations, offer many opportunities to create such tools (Walliser, 2008; Hodginson, 2011; Narayanan, 2011; IEEE Proceedings, 1996-2016).

The key concepts of cognitive management are described in the following paragraphs. We also give examples of the use of cognitive management elements as management consulting tools and discuss their application capabilities.

2. Key Concepts of Cognitive Management

Cognitive management is management of problem situations (PS) via building a model of PS in the form of a cognitive map.

A cognitive map is formalized representation of the management team's opinions ("mental models" (Johnson-Laird, 1980)) about the structure of PS, the patterns of its functioning and development. The main elements of a cognitive map are basic factors and cause-and-effect relations between them. In terms of content, *basic factors* are the factors that define and bind observable phenomena and processes of PS and its environment. They are interpreted by management subjects as essential, key parameters (attributes) of those phenomena and processes.

The most common representation of a cognitive map these days is a directed graph *(X, W)*, where $X = \{x_i\}$ is the set of the basic factors of the problem situation; $W = \{w_{ij}\}$ is the set of cause-and-effect relations that determine the sign and intensity of impact of casual factors on effectual factors, $w_{ij} \in [-1; +1]$. The ordered set of linguistic values Z_i and a scale representing those values at a point of the number line, $\varphi: Z_i \to X_i$, are determined for the factor x_i.

The factors can be external environmental factors, target factors of PS, controllable and uncontrollable factors of PS. By manipulating controllable factors, one can take the situation from some initial state to the target state.

An analysis of interaction of the factors allows us to estimate the distribution of impact across the cognitive map and to solve a wide range of problems related to assessing the cross-impact of factors and the attainability of management objectives, developing scenarios and management strategies, and searching for optimal (in one sense or another) management strategies, etc. (Dorner, 1997).

Analysis objectives are divided into two types: static and dynamic. *Static analysis*, or impact analysis, is a set of objectives aimed at studying the structure of mutual interaction of the factors of a cognitive map. *Dynamic analysis* underlies the generation and analysis of possible situation development scenarios. Dynamic analysis is performed using the apparatus of linear dynamic systems (Roberts, 1976). Dynamics is simulated by setting the successive impulse actions directed at the controllable factors (causal factors) in sequential time pulses $t = 0, 1, 2,...$ and modeling the influence wave of these impacts on the target factors (effectual factors). The variation of the values of the effectual factors is determined by the "rule of the impulse process" (Roberts, 1976).

In dynamic simulation, along with the values of factors, variation trends of those factors can also be used. A situation development forecast is obtained in the form of vectors of the situation state at successive discrete instants of time *t, t+1, ..., t+n*, where *t* is the number of the simulation step (time-step).

The objective of situation management consists in taking the situation from the initial state to the target state corresponding to the *target image* of the PS.

The *target image* determines the desired changes in the state of the PS from the perspective of management subjects and is formally represented as

$$C=(X^C,R(X^C)),$$

where X^C is the target factors, which is the subsets of basic factors of the cognitive map ($X^C \subseteq X$);

$R(X^C)$ is the vector of the estimates of the dynamics of the target factors establishing the desired changes in these factors, i.e.

$$R(x(t)) = \begin{cases} +0,7, \textit{ if a SIGNIFICANT growth of factor } x_t \textit{ is desired,} \\ 0, \textit{ if stabilization of factor } x_t \textit{ is desired,} \\ -0,3, \textit{ if an INSIGNIFICANT growth of factor } x_t \textit{ is desired} \end{cases}$$

Management strategy S consists of the strategic steps S_i that determine the sequence of the transition of the situation from the initial state S^0 to the target state S^C corresponding to the target image.

The process of building a strategy is by nature an iterative search and it ends once a satisfactory result is obtained, which consists in achieving the state corresponding to the target image under the given constraints (for certain PS factors). However, cases are possible, necessitating the return to the stage of formation of the target image (retransfer: mission-goals) or to the complete abandonment of further search.

3. Cognitive Analysis of Enterprise Development Strategy

Let us consider the possibilities of using the cognitive modeling technology in solving the problem of strategic choice.

Let us illustrate the above with the example of the cognitive map (Figure 1) built for analyzing a customer relations management strategy (the "client" level of Norton and Kaplan's strategy map (Kaplan and Norton, 1996)).

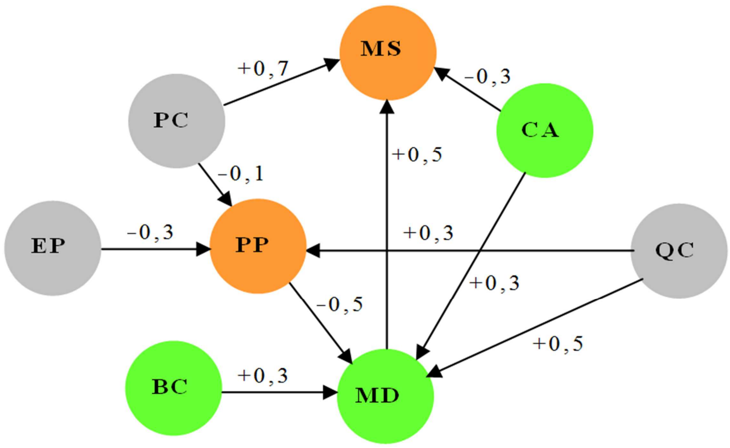

Figure 1. *Cognitive map for enterprise development strategy analysis (demo version).*

The following elements are taken as the basic factors of the cognitive map: Product competitiveness (PC), Enterprise productivity (EP), Business conditions (BC), Market demand (MD), Product price (PP), Market share (MS), Quality control (QC), Competition's advertising (CA).

On the set of basic factors, we have:

Target factors (brown nodes) – <MS, PP>,

Controllable factors (gray nodes) – <PC, QC, EP>,

External environmental factors (green nodes) – <BC, CA, MD>.

Such a breakdown of factors allows for a wide range of model experiments, such as

● designing possible strategy variants ("self-development" strategy, various "managed development" strategies),

● forecasting the behavior of the enterprise for each of the strategy variants,

● forecasting the behavior of the enterprise under different dynamics of external environmental factors, etc.

By way of illustration, we present the results of model experiments with different variants of a customer relations management strategy. To do this, we investigate the dynamics of the given fragment of the strategy for different initial states (activity levels) of the factors.

The activity levels of the factors and the intensity of their interaction will be estimated, using the linguistic scale in Table 1.

Table 1. *The linguistic scale for estimating the values (activity levels) and the intensity of interaction of factors of a cognitive map.*

X	Linguistic values (Z)	Points
0.1	VERY_LOW | VERY_POOR | VERY_WEAK	0-1
0.3	LOW | POOR | WEAK	2-3
0.5	AVERAGE | MODERATE	4-5
0.7	HIGH | GOOD | STRONG	6-7
0.9	VERY_HIGH | VERY_GOOD | VERY_STRONG	8-10

Notes:

1. For the factors that can be estimated quantitatively, each linguistic value is put in correspondence with the value of a factor from the "object scale", e.g.: "Market share" VERY_LOW – below 4%, LOW – 5-10%, AVERAGE – 11-20%, HIGH – 21-40%, VERY_HIGH – over 40%

2. The values of factors and characteristics of interfactorial relations are set for a specific enterprise and for a specific period of time (horizon of analysis).

Example 1. Assume that the management goal in the strategy fragment in Figure 1 is to seek and implement such management (changing the controllable factors) that would lead to an increase in the "Market share" of the enterprise. The possibility of achieving this goal is influenced by: 1) the initial state of the internal and external factors forming the analyzed strategy fragment, and 2) management implemented by the enterprise's management team through changes in the dynamics of the controllable factors.

Scenario. Assume that at the initial moment of time the enterprise introduces a new product to the market, i.e. its "Market share" for this product is almost unnoticeable to the market. This condition is simulated by specifying the activity of the "Market share" factor as = 0.1 (VERY_LOW). The enterprise introduces a new product to the market in stable economic conditions, which is simulated by setting a high level of activity in the "Business conditions" node = 0.9 (VERY_GOOD). These conditions create a high demand for the product. Accordingly, the activity of the "Market demand" factor is = 0.7 (HIGH). The objective of determining the optimal strategy is to find such dynamics of management of internal factors that would increase the "Market share" of the enterprise without increasing or even lowering the activity of the "Product price" factor.

Such management is shown in Figure 2a. It reflects the dynamics of the activity of "Quality control", "Enterprise productivity" and "Product competitiveness" factors, which are gradually improving over time (the activity of these factors is growing). The result of such management is the growth of the "Market share" of the enterprise, on the one hand, and the drop in "Product price" on the other (Figure 2b).

It is clear from Figure 2a that in order to increase the "Market share" of the enterprise and reduce the "Product price" for the product being introduced, it is necessary to increase the activity of all three controllable factors, but in different order and to different degrees. First of all, we must significantly increase the "Enterprise productivity" in terms of output. The primary efforts should be focused on the outstripping growth of this controllable factor; the growth of the factor activity has to be at its fastest and best (reaching a level above 0.9) by the end of the simulation period.

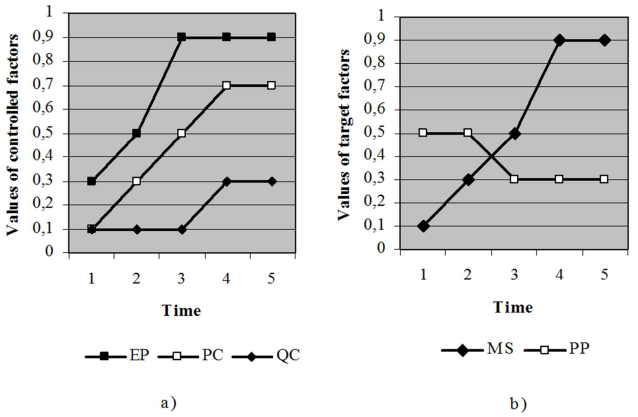

***Figure 2.** A variant of management strategy for the introduction of a new product by an enterprise with a small market share.*

The remaining controllable factors are distributed as follows in terms of their impact on the result. The second most important factor is “Product competitiveness” in the market of similar products. At the very beginning of the simulation, the activity rate of this factor is somewhat inferior to that of the “Productivity” factor, but it significantly exceeds the rate of the “Quality control” factor. To achieve the desired result (increase in the “Market share” when the new product is introduced), “Quality control” should be focused on only in the third step of the simulation, when the initial increase in the market share will be achieved. After the fourth step, the requirements for the activity of the “Quality control” factor can be lowered again (after this moment, the growth rates of “Product competitiveness” and “Quality control” factors are equalized).

The results of modeling with the cognitive map in Figure 1 show that its expansion is possible even for an enterprise with a small market share. This requires stable economic conditions and a certain sequence of steps to control and regulate the control actions on internal factors of the “client” level.

Example 2. Let us now model a strategy aimed at preserving the enterprise's market position, using the same cognitive map (Figure 1).

Scenario. The enterprise markets a new product that already has a rather high market share, which is simulated by setting the initial activity of the “Market share” factor as = 0.7 (HIGH). Similar to the previous example, the simulated strategy is implemented in stable economic conditions (continuously high level the level of activity of the “Business conditions” factor throughout the model experiment, = 0.9 (VERY_GOOD)).

The *results* of this model experiment are shown in Figure 3. As we can see, in order to implement the strategy of keeping up the market share, another sequence of steps is needed, the comparative significance of which is different from the previous example.

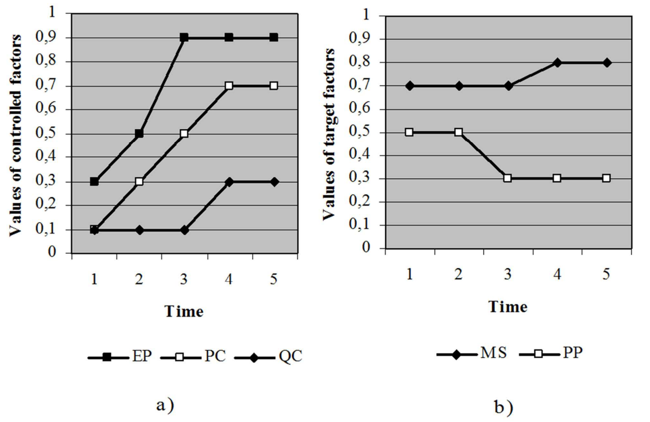

***Figure 3.** A variant of the management strategy for the introduction of a new product by an enterprise with a high market share.*

Similar to the previous example, we managed not to reduce the market share (this factor even grows slightly during the simulation) and to reduce the cost of the product. But the implementation of the scenario shown in Figure 3b requires a different sequence of steps. First, the most significant factor in the implementation of the strategy is “Quality control”. The dynamics of this factor slowed only after the third step of the simulation. “Enterprise productivity” in the context of the new product, unlike the previous example, is the least significant factor, and its role further decreases after the fourth step of the simulation.

Conversely, to implement the dynamics of the target factors (“Market share” and “Product price”) shown in Figure 3b, the management has to make efforts after the fourth step of the simulation to increase the importance of the “Product competitiveness” factor of the product being introduced.

A comparison of the figures reveals another peculiarity. The weaker the position of the enterprise, the more efforts it takes its management team, other conditions being equal, to achieve the targets. Thus, the curve slopes of the desired dynamics of the control variables in Figure 2 are much steeper than in Figure 3.

4. Application Capabilities of Cognitive Tools

1. These examples are demonstrative. In real projects, cognitive maps can have a more complex structural and functional organization. The variety of interfactorial relations encountered in business practice can require special cognitive maps based, for instance, on production rules, relational matrices, genetic and semantic networks (Karayev, 2004; Karayev et al., 2014; Karayev et al., 2010; Karayev, 2015). Dynamics of the business situation in such maps can no longer be simulated by means of the apparatus of linear dynamic systems. It requires developing a special apparatus that reflects the non-linear (non-monotonous) dynamics of the macroeconomic environment characteristic of today’s business practices (jumps in resource and energy prices, inflation, technological innovations, introduction of foreign

competition, changing tax, customs and corruption pressure, etc.).

2. As with other intelligent support technologies, the effectiveness of cognitive technologies is largely determined by the reliability of cognitive maps. It is introduced in the initial heuristic stages of the construction of these maps (identification and conceptualization stages (Waterman, 1986; Karayev, 2015)).

Unfortunately, in many publications and reviews, carried out primarily by mathematicians, economists and psychologists, little attention has been paid to this issue.

At the same time, various versions of SWOT analysis, PEST analysis, models of strategic and scenario planning, methods of project analysis, methods of experimental psychosemantics and multidimensional non-metric scaling, expert knowledge acquisition methods developed and well-tested in knowledge engineering (Waterman, 1986; Milton, 2007) can be useful tools in solving this problem.

The leading role in the heuristic stages should be assigned to "knowledge engineers"

3. Cognitive tools open up new (possibly unique) perspectives for management consulting, making it possible to:

a. identify contradictions in the strategic goals of stakeholders and support the procedure for coordinating these goals,
b. explore the “dynamic sustainability” of strategies in an unstable long-term perspective,
c. discover and explore new non-obvious strategic decisions,
d. conduct an extended divergent analysis (Jones, 1982) of these decisions, which is extremely important in the context of uncertainty and growing risks (Mintzberg, 1994).
e. investigate the extremely important topic of modern management, the issue of the impact of the multifactor hard-to-measure "institutional shell" (Polterovich, 1999) (corrupt authorities, inadequate judicial process and law enforcement, business conditions, pressure from mafia formations, tightening of environmental standards, mentality and qualifications of managers and local specialists, etc.) on the strategic prospects of the enterprise.

Now it is self-evident that in the strategic analysis, in addition to purely economic factors, informal institutions (Balatsky, 2006) become of paramount importance. It is practically impossible to take them into account in the framework of the traditional economic and mathematical paradigm is, and a disregard of them can affect the fate of the enterprise and its staff in the most negative way.

5. Conclusion

Cognitive tools give a new interpretation to the leading postulate of modern management formulated by P. Drucker. Paraphrasing it, a manager today is a person who makes knowledge work (Drucker, 2012). The obvious question here is “where does this knowledge come from, and how can one make it work?”

The main paradox of modern management is that in real practice, enterprise management is not based on the laws of economics or theoretical knowledge, but on arbitrarily interpreted precedents of business life, i.e. on empirical knowledge developed in the course of practical activity (Fatkin, 2006). The cognitive approach makes it possible to carry out cognitive (cognitive-objective) identification and formalization of this knowledge and “make it work” in the form of accessible support tools.

Such tools allow solving critical management issues related to the generation of alternative strategies and evaluation of their quality in the context of nonlinear (non-monotonous) dynamics of the internal and external conditions of the enterprise. This significantly expands the tool base of management consulting, which is based primarily on the static prescription paradigm these days.

The U.S. National Science Foundation, under whose auspices most of scientific research is carried out in the U.S. issued a report in 2006, predicting science development in the next 50 years (Converging 2003). The report, *Managing Nano-Bio-Info-Cogno Innovations: Converging Technologies in Society* (Nano — Nanotechnology, Bio — Biotechnology, Info — Information technology, and Cogno — Cognitive science), defined the principal trends of the world science for decades to come.

The information technology revolution began as early as in the 1960s; the rapid progress of biotechnology unfolded in the 1990s and the progress of nanotechnology in the beginning of this century. Today, cognitive technologies begin to develop rapidly, including cognitive technologies for managing social and economic objects, forming the technological platform (engineering) of creative management.

Acknowledgements

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