

COGNITIVE ANALYSIS AND SITUATION MODELLING

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Abstract: Methodology, represented herein, synthesises system and cognitive approaches and represents the universal toolkit for structuring and understanding of complicated socio-economical systems behaviour. *Copyright © 2001 IFAC*

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1. COGNITIVE STRUCTURING OF KNOWLEDGE ABOUT A SITUATION

At the heart of analytical technology of cognitive modelling lays cognitive structuring of knowledge about any object (region, state, etc.) and its external environment (economic, political, etc.), and object and external environment are differentiated "indistinctly".

The purpose of structuring is to reveal the most essential factors describing a "boundary" layer of interaction of object and external environment as a "world model", and establishment of qualitative relationships of cause and effect between them, i.e. what interference is exerted by one factor on an other during their change. Interference of the factors is displayed with the help of a cognitive map (model), which represents a sign (weighted) oriented graph.

Structuring of knowledge about regional economic situation problems includes creation of list of basic concepts, determination of the relations between them, setting of goals and determination of activities to be realised to achieve the goals. In other words, knowledge about a regional situation may be represented as a weighted oriented graph, table, text etc.

2. SPECIALITIES OF SITUATION CONTROL

The following problems are inevitably arise before the user when he analyses the present condition of any complicated socio-economic situation (http://www.ipu.ru/labs/lab51/51_home.htm):

- 1) What modifications of a situation are possible in (nearest) future?
- 2) What controls should be chosen for ensuring the desirable behaviour of the goal factors?
- 3) What problems thus can arise?

Problems of group 1 are connected with forecasting of strategy of possible modifications in a present situation. These modifications can be stipulated by internal reasons (for example, realisation of some control can be connected with the modification of interaction of the factors in a real situation and the similar modification can generate new problems) and by external reasons because a real situation is constantly exposed to exterior perturbations, which sources are not included in cognitive model of the situation to be analysed. The external reasons are divided into predictable, which origin can be foreseen using information from mass media and other

sources, and on unpredictable. Irrespective of the character of changes in a situation, their presence requires modification of initial cognitive model of a situation.

Problems of group 2 are the problems of a routine (operative) economic situation control that is exercised in order to reach the goals. Solution of this problem can be performed by a few variants of “suitable” control. As was initially postulated, each concept of cognitive model, uniquely corresponded to situation specific concept, and the realisation of each variant of control provides realisation of the appropriate specific activities. Here arises a necessity of a comparative estimation of these variants by

- proximity of the results of control to the marked goal (on effectiveness of variants);
- expenditures (financial, physical, moral etc.) to be corresponded to realisation of each variant;
- character of consequences (converted, irreversible) after realisation of the appropriate variants in a real situation, etc.

Problems of group 3 are connected with the cognitive model analysis of the situation and exposition of problems to be generated in it (in particular, possible occurrence of crisis situations). New problems may be connected with ensuring of desirable behaviour of the changed goal factors in the changed situation. Thus analysis and solution of problems corresponding with a possibility of crisis situations should be made before real rise of such situations. That allows the user to undertake anticipatory activities to prevent the crisis situation, or to be “better” prepared for their overcoming.

3. CONCEPT AND COGNITIVE MAP OF REGIONAL SOCIO-ECONOMIC SITUATION

The cognitive map of a situation represents the oriented weighed graph, in which

- nodes are correspond to the basic factors of a situation, in terms of which the processes in a situation are described. The set of originally defined basic factors can be verified with the help of a data mining process, permitting to reject the “surplus” factors “poorly connected” to “kernel” of the basic factors;
- the direct correlation between the factors is determined by reviewing the cause-effect line-ups circumscribing distribution of influences from each factor to the others. It is considered, that the factors included in premise “if...” of the line-up “if..., then...”, influence the factors of a corollary “that...” of this line-up, and this influence can be either strengthening (positive), or breaking (negative), or variable sign depending on possible side conditions.

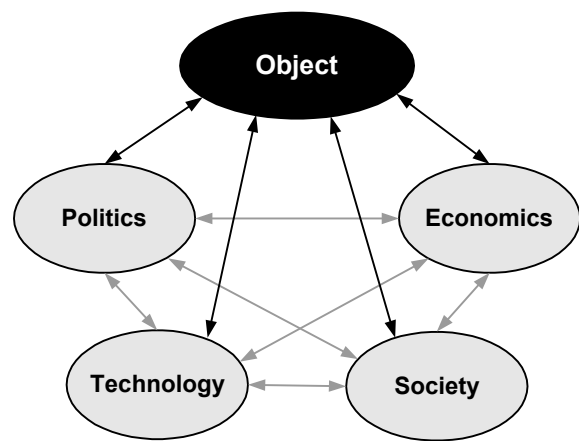


Fig. 1. PEST-analysis

Selection of the basic factors is carried out on the basis of PEST-analysis (Politics, Economy, Society, Technology), by means of which the political, economic, social, cultural, and technological aspects of external environment around of the researched object are analysed (Fig. 1). PEST-analysis is a tool of the usual four-element strategic analysis of external environment. Thus for each specific complex object there is a special set of the key factors, which directly and most significantly influences it. The analysis of each of the allocated aspects is carried out systematically, as far as all these aspects are closely and complexly interconnected. The significant change of any of aspects, as a rule, influences all chain. Such changes in each concrete case can create a threat to the object development, or, on the contrary, a new strategic opportunity of its future successful development.

The cognitive map depicts only the fact of influences of the factors on each other. It does not reflect a detailed character of these influences, dynamics of a situation depending on a modification of a situation and temporal modifications of factors. The account of all these circumstances requires passage to the following level of structuring of the information displayed in a cognitive map, i.e. to the cognitive model. At this level each connection between the factors of a cognitive map is uncovered up to the appropriate equation, which can contains both quantitative (measurable) and qualitative (not measurable) variables. The quantitative variables enter by a natural way as their numerical values. Each qualitative variable puts in correspondence a population of linguistic variables, mapping a various states of this qualitative variable (for example, the consumer demand can be “weak”, “moderate”, “agiotage”, etc.), and the defined numerical equivalent in a scale [0,1] corresponds to each linguistic variable.

The following step is the situation problems analysis or SWOT-analysis (Strengths, Weaknesses, Opportunities, Threats). It consists of the analysis of strong and weak parties of researched object in their interaction with threats and opportunities of external environment (Fig. 2). Using SWOT-analysis the re-

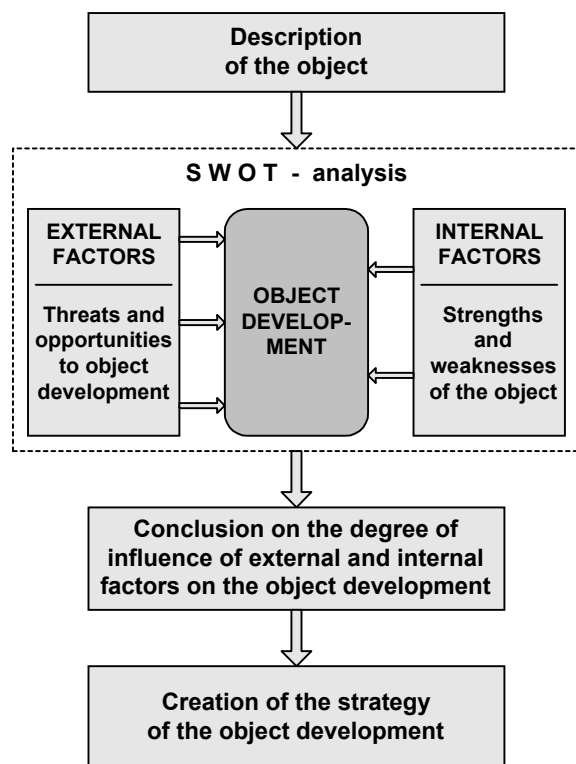


Fig. 2. SWOT-analysis

searcher obtains the possibility to determine urgent problem areas, bottlenecks, chances, and dangers to object under research. Opportunities are defined as something promoting to favourable development of the object. Threats is that can put damage to object, deprive its existing advantages. On the basis of the analysis of various combinations of strengths with threats and opportunities, and also weak parties with threats and opportunities, the problem field of researched object is formed. Problem field is a set of problems existing in the researched object in their interrelation with each other and with the factors of external and internal environment.

Results of PEST- and SWOT-analysis are used for model construction and modelling of control of the object development taking into consideration the model's cognitive "horizons".

The knowledge acquisition process can be divided into more "thin" processes (extraction, acquisition, shaping), having their own specificity. During extraction of knowledge there is an interaction of the expert (source of knowledge) and the cognitologist. It allows to trace a course of reasoning of the experts at decision-making and to reveal structure of their representations about a problem domain. As a result of their co-operation the cognitologist creates a "frame" model of a problem domain using his experience in cognitive psychology, system analysis, mathematical logic, etc.

Cognitive structuring, as far as it promotes the best understanding of problems, detection of inconsistencies and qualitative analysis of the economic, social

or political system, seems to be a convenient tool for research of macroeconomic environment, processes in the financial and credit market, supply and demand, behaviour of the competitors, etc. Practical achievements of the last years in the field of intelligent technologies have created a favourable basis so that the cognitive paradigm became attractive and popular. Now it promptly wins wide gratitude among authorities of states and regions, experts in business and economic management, and etc.

During the process of accumulation of knowledge about a situation under research, it becomes possible to uncover character of connections between the factors in more details. Here essential help can be rendered by use of data mining procedures.

Formally, the cognitive model of a situation may, as well as the cognitive map, be submitted by a graph, however each arc in this graph represents already certain functional association between the appropriate basic factors, i.e. the cognitive model of a situation is represented by a functional graph.

4. PROBLEMS OF PROVIDING OF GOAL BEHAVIOUR IN A COMPLICATED SITUATION

At the analysis of a concrete situation the user usually knows or assumes, what modifications of the basic factors are desirable for him. The factors representing the greatest interest for the user, shall be named goal ones. They are the "output" factors of cognitive model. The solution of control problem in a situation is to provide desirable tendencies of the goal factors, it is the core of control problem. The goal is considered to be correctly preassigned, if the desirable tendency of one goal factor does not cause undesirable tendencies of other goal factors.

In an initial set of the basic factors the population of the so-called controlling factors ("input" factors of the cognitive model) is selected. Control actions in the model are realized via these factors. The control action is considered to be co-ordinated with the goal, if it does not cause undesirable tendency in any of the goal factors.

If the goal of control is preassigned correctly and the control actions are co-ordinated with this goal, the solution of a control problem does not cause any specific difficulties (even in non-linear cognitive model of a situation with constant signs of influences of the factors). In a common case the determination of conditions of goal behaviour in a situation is a stand-alone problem and requires a special reviewing (Maximov V., Kornoushenko E., 2001).

5. MODELLING

Modelling is a mean of detection of economic, political and social regularities, warning and prevention of negative tendencies, deriving of theoretical and practical knowledge about a problem and formulation of practical conclusions on this basis.

Modelling is a cyclic process. Knowledge of a researched problem is extending and specifying, and the initial model is being constantly improved.

Modelling is based on the scenario approach.

Scenario consists of collection of factor tendencies describing a situation at the present moment, desirable goals, a set of activities that are used upon the running of a situation, and system of observable parameters (factors) illustrating behaviour of processes.

Scenario can be simulated in three basic directions:

1. Forecast of a situation self-development (without any actions to modify processes in a situation, when a situation is allowed to run its natural course);

2. Forecast of a situation development with the chosen set of activities (controls) (direct problem);

3. Synthesis of activities set to lead the situation to the desirable state (inverse problem).

Stages of modelling:

1. Definition of the initial conditions - tendencies describing development of a situation before modelling. This is necessary to make the model scenario more adequate to real situation;

2. Definition of goal in terms of desirable directions (increase, decrease) and strength (weak, strong) of goal factors tendencies;

3. Choice of a set of activities (collection of controlling factors) and definition of their possible and desirable strength and directedness of action on a situation;

4. Choice of the observable factors (indicators) describing development of a situation is carried out.

Three directions of modelling are represented in Tab.1.

Table 1

Stages of modelling	Directions of modelling		
	1. Situation self-development (development of a situation without any action on processes in it)	2 Development of a situation under chosen set of activities (controls) (direct problem solving)	3. Synthesis of a set of activities to reach the desirable state of a situation (inverse problem solving)
1. Definition of the initial state of a situation before modelling	+	+	+
2. Definition of goal factors, directions and strength of their tendencies	+	+	+
3. Choice of a collection of the controlling factors and strength of their action		+	
4. Choice of a set of possible actions, the force and directedness of which have to be determined			+
5. Choice of the observable factors (indicators)	+	+	+

6. DIALOG SOFTWARE PACKAGE "SITUATION"

The cognitive modelling technology may be realised with the use of dialog software package (DSP) "Situation" which has been developed for a structuring, qualitative analysis and obtaining of administrative solutions in complicated situations (economic,

socio-political, regional, market, ecological etc.), where is the lack of the complete quantitative or statistical information.

DSP "Situation" allows to describe and justify the usual situation and to offer ways of reaching the goals with consideration of peculiarities of a specific situation on a qualitative level.

DSP "Situation" ensures:

1. Construction of cognitive model of a situation :

- Selection and substantiation of the basic factors of a situation;
- Establishment and substantiation of correlation of the factors;
- Construction of graph model of a situation.

2. Structural interpretation of problems requiring solution in the situation.

3. Searching and substantiation of strategy of goal reaching in stable or changing situations:

- choice and substantiation of the desirable goals in conditions of uncertainty;
- choice of activities (controls) necessary for reaching the goals;
- analysis of basic possibility of reaching of goals from an initial state of a situation with the use of chosen activities;

- analysis of restrictions on a possibility of realisation of the chosen activities in reality;

- analysis and substantiation of a real possibility of goal reaching;

- development and comparison of strategy of goal reaching.

4. Substantiation of possible scenarios of the situation development.

5. Machine generation of the reports and systematisation of results of a problem modelling.

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