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Factors used for modeling process of forming ecological management instruments of industrial enterprise based on cognitive cards

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Abstract. The article is devoted to the process of forming ecological management instruments of industrial enterprise which belongs to weak-structured problems that are complex in nature and those that are different in qualitative dependencies between structural elements. The essence of cognitive cards is searched as a subjective model of the situation (process), based on the expertise and knowledge. Factors that are used to simulate the process of forming industrial ecological management instruments are marked on the basis of cognitive cards, in terms of achieving the overall socio-ecological-economic efficiency of its operations and its stated requirements. The character, composition and direction of the relationship between indicators within the proposed factors are defined.

Key words: weak-structured problems, ecological management instruments, cognitive cards, factors, socio-ecological-economic efficiency of industrial enterprise activity.

INTRODUCTION

It is necessary to solve weak-structured problems in many areas of human activity. Problems and their solutions are the most common issues in management literature. However, most relevant research has narrowly substantive nature. Problems are discussed in just an economic or in sociological or psychological viewpoints [16]. As a rule researchers do not see the problem as a multi-faceted integrated system. The development of social and economic facilities that may also include industrial enterprises in the environment is a typical situation for weakly structured problems appearance.

The purpose of the article is to determine the indicators of the process of forming ecological management instruments of industrial enterprise as weakly structured problems through the use of cognitive cards.

MATERIALS AND METHODS

The nature of the problems is the basis of systems analysis use as a method of management decisions. Due to its use there are three types of problems:

well structured;
weakly structured;
unstructured.

Restructuring means the opportunity of quantitative expression relationships between elements of the situation. The degree of the problem formalization as a typing feature was first proposed by U.S. cexperts G. Simon and A. Newell [12, 13, 17].

Problems in which the relationship between the elements of the situation can get quantitative estimates are well structured. In solving these problems methods of quantitative analysis are used: linear, nonlinear, dynamic programming, queuing theory, game theory, which methodology is known as "operations research".

Weakly structured (mixed) problems are usually complex, differing primarily in qualitative dependencies between the elements of the situation. Moreover, these elements may be both qualitative and quantitative. This is the area of a systematic analysis. In addressing such problems a combination of quantitative and heuristic methods is used.

Unstructured (or expressed qualitatively) problems have only descriptions of the most important resources, features and characteristics, quantitative relationships between them are completely unknown. Solution of unstructured problems is made using heuristic methods based on intuition, logic, theoretical reasoning,

experience, professionalism individual or collective body regulator [20].

In the process of structuring the problem it is necessary to minimize the number of informal elements in such a way that the problem has more definite character. In management practice often instead of tasks and problems they prefer to talk about problem situations in which the problem exists, but is not clearly separated. Decisions are often based on an incorrect understanding of the causes and consequences of the problem, because the problem is not analyzed in the complex. The issue of identification problems, formation of goals and a set of alternatives to achieve them are often left behind. In real management situations often arise tasks that are not so much to make a choice between alternative solutions, as is to analyze the situation to identify the real problems and causes of their occurrence. Understanding the problem is mandatory precondition of finding an acceptable solution. This typical problems that are difficult isolation in the study of managerial situation limits the use of traditional methods of finding optimal (or satisfactory) solutions in problems of managing such systems [1, 4].

There is a need of development and research of formal methods, which are based on mathematical apparatus, based on the expert knowledge representation, together with comprehensive (qualitative and quantitative) information in the form of cognitive cards. Cognitive cards and models based on them are used for structuring expert knowledge, build consensus view of the panel or the analysis of differences in such opinions, analysis of weakly structured (problem) situations in the development of enterprise-based simulation, training management decisions (as policies) based on solving inverse problems and structural analysis of the target and so on [19].

When making decisions under uncertainty experts and analysts rely on their own experience and intuition, creating a subjective model of this situation, based on the expertise and knowledge. In this case analysis and decision support modeling methodology based on cognitive cards [5, 8, 15]. Within the modeling methodology cognitive cards solved the problem of structuring ill-defined domain, constructing models of subjective situation obtaining forecasts of the situation, make recommendations to manage the situation.

To estimate the effect of individual factors on the formation of ecological management instruments of industrial enterprises is difficult, but visualize a system of interrelated factors and their impact on the aforementioned process by using cognitive cards. Cognitive approach to modeling economic processes focused on how to strengthen intellectual processes of the subject and help him fix his understanding of the problem situation in a formal model.

Cognitive card contains a hypothesis about the system (the development process). In terms of the formal description of cognitive cards is often represented as balanced directed graph.

Technology of cognitive modeling problem situation or a process is a sequence of stages, namely:

selection of a set of the most important factors that describe the problem situation;

selection of target-driven factors;

establishment of causal relations between the factors;

construction of cognitive process cads;

construction of matrix interference factors;

assignment of initial conditions and impulse actions;

calculation of predictive values of target factors according to the rule given impulse distribution process.

The problems of the study of complex economic systems are caused by the number of features. First, the interconnectedness of the processes occurring in them and their multidimensional nature, because it is impossible to isolate and detailed study particular phenomena (e.g. only economic or social) – all phenomena occurring within the economic system should be considered and explored together. Secondly, the lack of sufficient quantitative information about the dynamics of the processes in a system that is modeled, which makes use along with a quantitative and qualitative information in describing such processes. Thirdly, most processes are not stationary, and the change in certain characteristics of processes is often unknown, making it difficult to build their quantitative models. Such systems are called weakly structured (weakly formalized). They cannot be the traditional mathematical (economic, sociometric, etc.) approach to the analysis of processes for the production of complex (i.e. those that deal with various aspects of the system) solutions. For the modeling of complex systems using poorly formalized cognitive approach based on cognitive aspects. These aspects include the processes of perception, thinking, learning, explanation and understanding.

The term cognitive card as a model of knowledge experts on poorly defined dynamic situations was proposed in work [3]. As a model of knowledge cognitive card is a homogeneous semantic network in which many factors related causal relationships of two types: positive and negative. Structure of the situation can be represented in the form of oriented immersed graph G (F; W), if F – set of factors, W $W \subseteq F \times F$ – oriented arcs of the graph loaded with impact of $w_i \in W$.

Cognitive card is based expert way. Expert highlights the many factors of the situation, the causal relationships between them, because of the influence

factors and their scale. Usually cognitive card is represented as a directed graph.

As for the simulation of forming ecological management instruments of industrial enterprises by constructing cognitive cards, it starts with the selection of a set of the most important factors that describe the problem situation. The purpose of the formation of corporate of ecological management instruments is to achieve a high overall efficiency of industrial enterprises through management of ecological aspects on the basis of information contained in such instruments. That is the main factor in the formation of targeted instruments of ecological management is the overall efficiency of the industrial enterprise, ensuring its sustainability.

From the organizational point of view the state of sustainable enterprise development through achieving the overall efficiency of its operations must meet three key criteria. This means that the enterprise as a system should be:

1) viable – may pay for their operation (costs covered by income);

2) sustainable – may support long-term viability (long-term viability) of their ecosystems;

3) desirable – equally satisfy cultural, material and spiritual needs of staff and the public area business location [11].

Sustainable industrial enterprise is possible only when a complex socio-ecological-economic efficiency of its operations.

General socio-ecological-economic efficiency of industrial enterprises depends on three components: social, economic and ecological efficiency, which in turn consist of a number of indicators (fig. 1).

Factors used to construct cognitive cards of the formation of ecological management instruments of industrial enterprises must meet the list of requirements, among which are the following:

relevance, i.e. corresponding to the task that has to be solved with a particular factor;

accessible to perception – factor must be understood by all members of the target group (managers, experts and other users);

validity and ease of interpretation;

flexibility to adapt to new situations;

adapted to describe the interconnections of phenomena – factors should show the link between economic, social and ecological aspects of the company;

scale and dynamism – factors should have sufficient measurement range of parameters and trends of their changes over time;

reliability – factors should be based on actual data (which does not always mean a high degree of accuracy);

efficiency – the ratio of costs and benefits of data access must be reasonable, the data should be standardized, quality and renewable, they carry timely information to help in time to prevent or solve problems;

comparability – factors should allow to make comparisons. This should be taken comparable intervals or units;

continuity – the factors to be measured continuously or frequently to ensure timely response to changes.

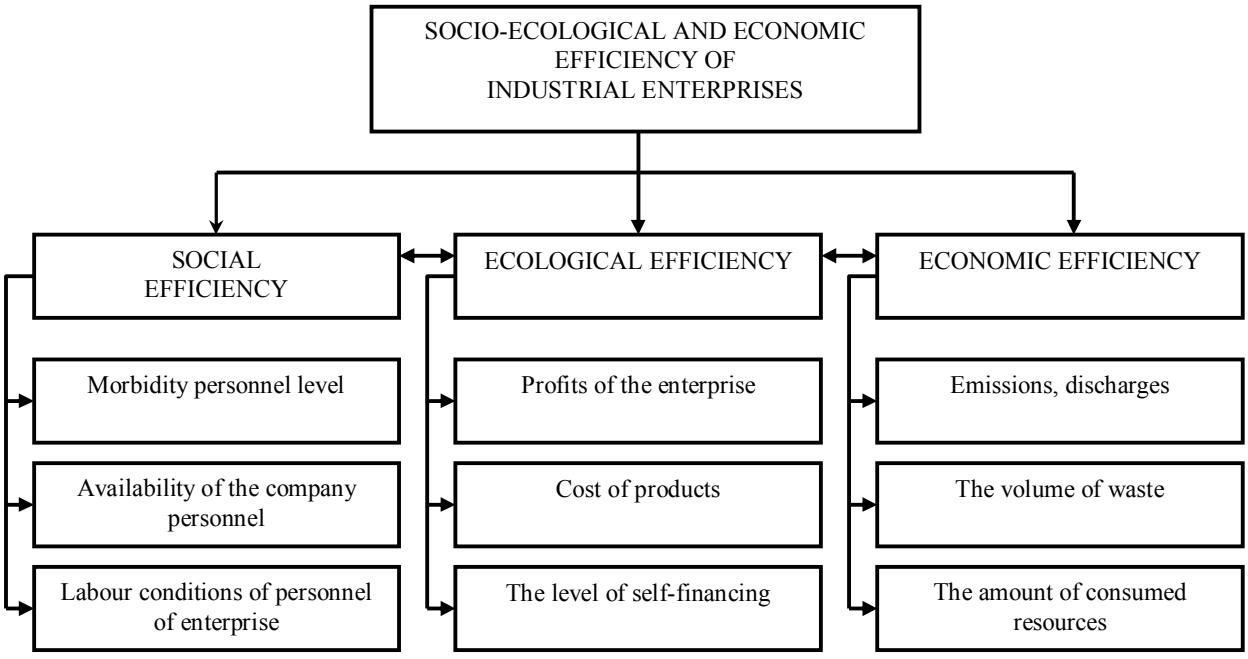

Fig. 1. Indicators of general socio-ecological-economic efficiency of industrial enterprises
Source: Author's own research results

Table 1. Factors influencing the formation of ecological management instruments of industrial enterprises

№	Name of factor	The nature of the factor	The factor's structure
External Factors			
I. Political and legal			
1.1	Ecological product certification	simple / qualitative	-
1.2	Environmental legislation	simple / qualitative	-
1.3	Sanitary-hygienic norms	complex / quantitative	Maximum allowable concentration (MAC); Maximum permissible emission (MPE); Maximum permissible discharge (MPD); noise level; level of electromagnetic radiation, etc.
II. Economic			
2.1	Ecological contributions	complex / quantitative	limits on environmental pollution and use of natural resources; payment standards for environmental pollution and use of natural resources; fines for above-limit environmental pollution and use of natural resources; adjustment factors
2.2	Prices of resources	simple / quantitative	-
2.3	Benefits for environmental-oriented enterprises	complex / quantitative	exemptions from income tax, including a so-called "tax holidays" for a certain period; benefits for VAT payments; exemption from customs duty on import of environmental equipment not produced in Ukraine; preferential lending; government subsidies and subventions; accelerated depreciation of fixed production assets
III. Social			
3.1	Quality of life	complex / quantitative	household incomes; costs of living; household consumption; basic integral indicators of living; providing and scope of population by the infrastructure objects and the technical equipments of branch social sphere; demographic parameters; security
3.2	Morbidity of population	simple / quantitative	level of morbidity
3.3	Social and ecological associations activity	simple / qualitative	activity level of social and environmental associations
IV. Ecological			

4.1	Environmental pollution in the region	complex / quantitative	level of atmosphere pollution; level of hydrosphere pollution; level of land pollution; volumes of waste disposal, etc.
4.2	Provision of regional natural resources	complex / quantitative	level of provision of energy resources (combustible minerals, hydropower, biofuels, etc.); level of provision of non-energy resources (minerals, water, land)
4.3	Number of polluting enterprises in the region	simple / quantitative	–
V. Scientific and technical			
5.1	Development of clean and resource-saving technologies	simple / qualitative	–
5.2	The development of alternative energy	simple / qualitative	–
Internal			
6.1	The used technology	simple / qualitative	–
6.2	Machinery and used equipment	simple / qualitative	–
6.3	Corporate culture	simple / qualitative	–
6.4	Style guide	simple / qualitative	–

Source: Author's own research results

Cognitive approach to study the formation of ecological management instruments of industrial enterprise as socio-ecological-economic system to describe its structure and various processes within it, their interaction with the environment, to detect the influence of the environment at management of the current situation in the system and is on this basis justify the necessary management decisions to solve problems that arise in such weakly structured systems. The cognitive card depicts the main groups of factors and relationships arising from the sustainable economic development of the system. Factors describing the situation may be complicated structure. In particular, they may consist of a set of parameters that affect the value factor. For example, the factor "environmental charge" reflects the amount of environmental charges businesses that it pays for environmental pollution and use of natural resources as within its limits, and above-limit environmental pollution and use of natural resources. It includes such factors as limits on environmental pollution and use of natural resources, environmental pollution norms paying and use of natural resources; fines for above-limit environmental pollution and use of natural resources; adjustment factors. For such complex factors it is necessary to find their meaning on the basis of available estimates of indicators that make up this factor.

Description of factors influencing the formation of ecological management instruments of industrial enterprises is presented in Table 1.

Table 1 shows, that the factors are both quantitative and qualitative. Quantitative factors are based on a numerical representation of quantitative information, or are the result of some calculations. To describe the quality factor values a set of relevant linguistic variables is selected. Selecting shades from the values of linguistic variables allows to give the required level of detail – "weak-medium-strong" or more detailed "very weak-weak-medium-strong-very strong" and so on. Each linguistic variable corresponds to a number on the scale [0, 1], which is the numerical equivalent of this variable [9, 10]. These numerical equivalents are called qualitative variables. For example, the factor of "the development of alternative energy" describes the linguistic variable "level of development of alternative energy" with linguistic values α1 = "low", α2 = "middle", α3 = "high", each of which is a fuzzy set with domain T_{F_i} = [-1, 1] and membership function μ_α: $T_{F_i} \rightarrow$ [0, 1]. It should be noted that the nature of qualitative indicators is different. Each indicator X (F_i)= 1, …, k_i, may be characterized by:

1) linguistic meaning (e.g. very low, low, medium, high, very high);

2) unclear value (e.g. low – 0,3, mean – 0,8);

3) quantitative values defined by ordinal or nominal scale;

4) binary attributes, positive and negative, each of which is characterized by its frequency display [6, 7].

As already mentioned, the result is a formalization of ideas as causal networks, called cognitive cards and has the form (1):

$$G = \langle E, W \rangle, \quad (1)$$

where: $E = \{e1, e2, ..., e_n\}$ – set of factors (which are also called concepts); W – binary relation on the set E, which defines a set of relationships between its elements.

Items e_i and e_j are associated by the ratio W (denoted $(e_i, e_j) \in W$ or $e_i W e_j$), If the change the value of the concept e_i (cause) changes the meaning of the concept e_j (consequences). According to the terminology of cognitive modelling in this case we say that the concept e_i affects the concept e_j. If you increase the value of the concept causes increases the importance of the concept-effect, the effect is positive ("gain") if the value decreases – negative ("inhibition"). Thus, the ratio of W can be represented as the union of two disjoint subsets: $W = W^+ \cup W^-$, де W^+ – many positive and W– many negative connections [2, 6]. Most concepts thus can set as relative (qualitative) indicators (management style, organizational culture), and absolute, measurable terms – for example, the level of morbidity, cost, profit and so on. This model allows us to consider the dynamic system consisting of a set of factors that influence each other. Some components of this system can be introduced perturbation, and the behaviour of the system in this case can be directed to settle the disturbance (negative feedback) or increased disturbance (positive feedback).

CONCLUSIONS

1. The formation of ecological management instruments of industrial enterprises are weakly structured problem due to its complexity, which in turn is characterized by qualitative dependencies between its structural elements.

2. These items can be both qualitative and quantitative, and the internal structure be simple or complex. Therefore, for the simulation of forming of ecological management instruments of industrial enterprise should apply a systematic analysis based on a combination of quantitative and heuristic methods.

3. With a high degree of uncertainty can create subjective model this situation on the basis of expert opinions and knowledge. In this case, analysis and decision support modeling methodology based on cognitive cards.

4. Cognitive cards modeling methodology enables structuring ill-defined domain, constructing models of subjective situation obtaining forecasts of the situation, make recommendations to manage the situation. Cognitive cards can visualize a system of interrelated

factors and their influence on the formation of ecological management instruments industrial enterprise.

5. Factors suggested in the article, and the relationship between them will be further used to model the formation of industrial ecological management instruments on the basis of cognitive cards.

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