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DEVELOPMENT OF THE DECISION SUPPORT SYSTEM IN TRANSIT TRADE OF INDUSTRIAL GOODS ON THE BASIS OF COGNITIVE APPROACH AND LINEAR PROGRAMMING

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ABSTRACT

Currently, the market for industrial goods in Russia has formed a complex mechanism of movement of goods from producer to final consumer. An active role in the goods movement play a small wholesale transit trade companies, which carry out mediation activities. Decision makers are an integral part of the management of these enterprises. Due to a lack of skills and low level of knowledge about the market, lack of skills and gain economic ties with enterprises in particular transport and logistics sector as a whole, these companies become a source of inefficient solutions in the field of logistics of goods delivery, reducing the overall economic efficiency of commodity markets. Developed cognitive method for formalizing the optimization problem based on the development of a cognitive map which quantitative vertices and their relationship justify the selection of optimization model parameters and constraints for industrial goods transit trade.

Keywords: decision support systems (DSS), linear programming, linear optimization, transport logistics, cognitive approach.

1. INTRODUCTION

Industrial goods transit trade - a dynamically growing industry in today's Russia. Companies are forced to quickly adapt to changing economic conditions. Management decision-making in the field of transit trade refers to the problem of decision-making in the semi-dynamic situations. Modern economic and mathematical methods, as well as information and communication technologies provide new opportunities in the field of decision support to optimize the management processes within companies in the transit trade of serial industrial goods, make the development of decision support systems (DSS) in the semi-dynamic situations, the most important [11].

Existing approaches to develop DSS does not fully meet modern requirements - not taken into account the ability to quickly adapt to rapidly changing market conditions, overlooked consideration of relevant factors. In this connection, the growing importance of the development and implementation of DSS, which allow a systematic approach to solving optimization problems of industrial transit trade companies? From the point of view of the successful implementation of the DSS becomes urgent problem of finding the forms and methods of obtaining, structuring and formalization of domain knowledge. From a qualitative description of a problem area, identification of objective functions and constraints depends on the quality of decisions, covering space situational decision-making, the completeness of functionality, choice of tools, the complexity of the development of DSS and its performance. In a dynamically changing market conditions, as well as due to weakly structured transit trade problems, the development of intelligent DSS models with the ability to dynamically change the adaptive mathematical model depending on the market situation.

2. PROBLEM STATEMENT AND PRELIMINARIES

2.1. Problem statement

At the stage of formalizing the formulation of the problem of decision-making process becomes an urgent task selection factors for the sound construction of mathematical models to optimize supply schemes. As methods of mathematical model factors selection commonly used methods of analytic hierarchy process, fuzzy logic, and others. But they require a priori definition of the objectives to produce solutions. Currently are widely used methods of cognitive modeling to analyze situations [1, 2]. These cognitive technologies that belong to the class of intelligent methods are a means to analyze qualitatively representation of experts on the problem area of the object to obtain a full and clear understanding of customer requirements [3]. Thus, the growing importance of the use of intelligent methods based on the theory of cognitive analysis to solve semi structured problems, providing substantial assistance in all phases of modeling and decision support system that can be a key factor in the successful implementation of projects for the development of DSS [11].

Meanwhile, methods and tools for solving this class of problems is not enough developed and need to be adapted to the problem of selecting a scheme of goods delivery in transit companies. Currently, there is a need to create a new class of decision support systems for transit trade industrial goods, based on the application of the cognitive approach.

2.2. Methods and instruments used in the research

As for system-design methodology of the study semi structured problems of complex systems model adopted in the form of the stratified meta-object description:

$$M = \{M_o, M_E, M_{OE}, M_D, M_{HO}, M_{HE}, M_U, M_H, A\} \quad (1)$$

where: $M_O = M_O(X, Y, U, P)$ - identifying the system model (object model), in which the vector X - exogenous values, the vector Y - endogenous variables, $y \in \Upsilon \subseteq E_m$, characterizing the phase state of the object, U - vector controlled variables, $u \in U \subseteq E_r$, P - vector of resources allocated, $p \in P \subseteq E_O$; M_E - a model of the environment; M_Y-interaction model of the object and environment $M_Y = (M_{OX}, M_{OY})$, in which the M_{OX}-model communication with the media at the inlet, M_{OY} - a model of communication with the media outlet); M_D - model the system behavior; M_{HO} and M_{HE} - model for measuring the state of the system and the environment; M_U - model management system (not included in the meta, if only to solve the problem the study site); A - rule selection process changes the object; M_H - a model of "observer" (engineer, experts, researchers) [4, 5, 6].

M defines a meta-system, objects which must not be ignored in a particular process of development and use of model *M* (i.e. the study of ecological and socio-economic system, forecasting, decision-making, management ...). Models of the system, the environment, their interaction - is the cognitive model, models of system behavior - is impulse processes. Introduction to meta-*M* "observer" allows you to build the research methodology and decision-making in view of the process of cognition of the object in the mind of the subject. This model is displayed in the actions of the researcher, including the setting and changes the rules of *A* [13].

Cognitive models are constructed by the expert (expert group) in a particular subject area on the basis of theoretical, statistical, expert and other information about the object of research. It is believed that the adequacy of the model is determined by the fullness of the original productions of knowledge; the model can be refined in the process of research and application, being itself a source of structured knowledge.

Most studies of ecological-socio-economic targets have been used various forms of well-known cognitive models: cognitive map (2), vector functional graph, parametric vector function graph (3), a modified functional graph and their modifications [8].

$$G = \langle V, E \rangle \quad (2)$$

$$\Phi = \{G, X, F, \Theta\} \quad (3)$$

where: G - cognitive map, which, i = 1,2, ... n - the set of vertices (objects in the system studied, for example, production, population, resources, etc.) - the set of arcs - relationship between objects in the system (positive , negative, zero in this situation), g = 1,2, ... k, F = F (X, E) = F (xi, xj, eij) - a functional transformation of arcs that relate to each arc a sign ("+", «-»), a weighting function ωij, f (xi, xj, eij) = fij.

Cognitive model - a structure of knowledge, and formalized a graphical representation of relationships between concepts (the concepts, factors, indicators, interacting systems and their blocks). Defining "suitable" feature of cognitive models is their visual representation. Cognitive studies conducted by the authors include the solution of the complex system problems. The main ones are: 1) identification of the system in the form of a cognitive model developed by the researcher, the Statistical expertise, theoretical data, 2) analysis of the ways and cycles of the cognitive model, and 3) the topological analysis of the structure of the model (analysis of q-connectivity) [4, 5, 6], 4) analysis of controllability and stability (structural, to the disturbance to the initial values), 5) a scenario analysis (by pulsed modeling) [4, 5, 6]; 6) predict development; 7) decision-making and others.

$$x_i(n+1) = x_i(n) + \sum_{j=1}^{l-1} f_{ij} P_j(n) + Q_i(n) \quad (4)$$

Calculation of quantities changes of pulses passing through the vertices of cognitive maps are:

$$x_{n+1} = x_n + AR_n + Q_n$$

where: $R_n = A^{n-1}Q_0 + A^{n-2}Q_1 + ... + AQ_{n-2} + IQ_{n-1}$

I - identity matrix.

Thus, on Figure-2 cognitive model - cognitive map as a sign of a weighted directed graph describing the scheme of the client order [13].

Model was constructed with the help of a software system in cognitive modeling Software System for Cognitive Modeling (SS CM) [4].

3. RESEARCH RESULTS

Developed cognitive method for formalizing the optimization problem based on the development of a cognitive map of the lower level, you can use it quantitative vertices and their relationship to justify the selection of parameters and constraints optimization model for transit trade in manufactured goods.

The proposed cognitive method for formalizing the optimization problem is used in the module area of cognitive modeling optimization (Figure-1) to harmonize the knowledge of experts in the field of transit trade in industrial goods and specialists in the field of mathematical (linear) programming [12].

Despite the variety of optimization problems, to construct a mathematical model for the use of the mathematical apparatus of any operational research passes through the stage of construction of the content (verbal) model of the object (process). At this stage, the formalization of the goal object management, allocation of possible control actions that affect the achievement of stated goals, as well as the system of constraints on control actions for the subsequent transfer of the verbal model

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constructed in the form in which to study it can be used mathematical instruments.

Thus, in this article gives a review pre-formalization stage, i.e., method of formalization linear programming problem on the step of selection: the number of variables X, the number of constraints, the coefficients of the variables in the constraints, the number of resources - i.e. all the parameters and variables of the optimization model.

This stage of the mathematical formulation and solution of linear programming problem usually has no attention. It can be seen that in the modern business analysis put the problem of determining and selecting variables, etc., but the purpose of this analysis is not a mathematical formalization of a linear programming problem. In the studied literature failed to find solutions to problems of the mathematical formulation stage pre-formalization linear programming variables and constraints. A consequence of the incomplete definition of parameters and variables of the model may be inaccurate or poorly effective management decisions.

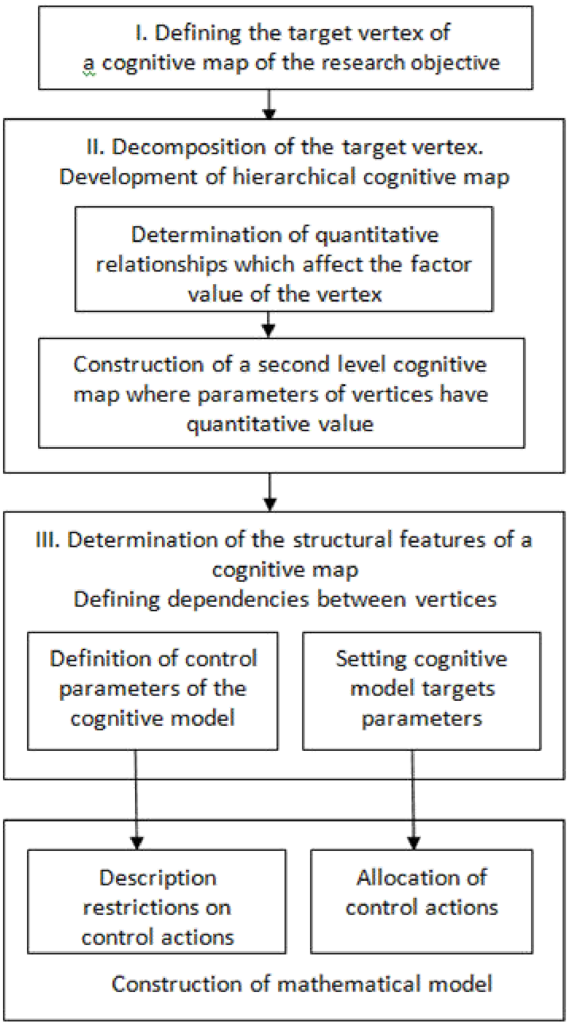

Figure-1. Cognitive method for formalizing the optimization problem.

The practice of setting multi-index linear programming problems under specific conditions depends on the knowledge domain experts, but business experts are not experts in linear programming. The coordination of knowledge domain experts and specialists in the field of LP is one of the important tasks of cognitive structuring the knowledge of experts, whose solution is to develop a cognitive map, which serves as a basis for developing a LP model. Cognitive map reflects the factors that are important in the period under review, and may be of value in the other period. Cognitive map is also the basis and rationale for the sensitivity analysis LP solutions, assuming the possibility of variation of its parameters, variables and constraints.

It is proposed to use a cognitive approach based on cognitive structuring of knowledge experts, simplifies and speeds, reducing the number of iterations to find a suitable LP model pre-formalization stage. Defining the target vertex - delivery scheme, thereby determined goal - the use of optimization models to improve the effectiveness of the decisions in determining the supply chain in the processing of customer orders enterprises of industrial goods transit trade. As a result, cognitive modeling scheme of the client order, including the schema definition of delivery and vendor selection decision maker in the company of transit trade in industrial goods, construct a graph - a cognitive map of the second level [9, 11].

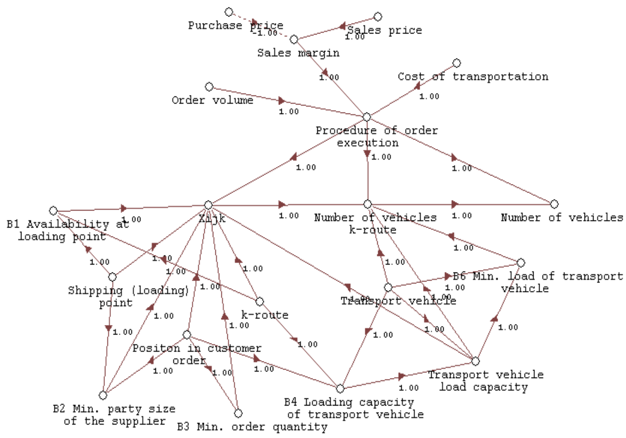

Figure-2. The cognitive map "Scheme of the Order of the client".

Cognitive map is a functional graph, the vertices of which are functions of the parameters and constraints of a linear function.

As a result, the objective function is constructed multi-index problem of linear programming to determine the optimal scheme of delivery on a specific transaction transit delivery, which is a function of calculating the cost for solving the optimization problem of the purchase price (with the aim of minimizing) or a function for calculating trade margins provided for solving the problem in order to maximize the amount of trade margin. This mathematical

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model is the basis of mathematical modeling module optimization problem proposed DSS.

The linear function to minimize the cost of purchase:

$$f(x,y) = \sum_{i}^{n}\sum_{j}^{m}\sum_{k}^{l} a_{ij}x_{ijk} + \sum_{k}^{l} b_k y_k \quad (5)$$

$f(x, y) \rightarrow$ min, where

$\boldsymbol{x_{ijk}}$ - quantity in the units specified in the customer order *i* - position, $i = 1,2, ..., n$, *j*- point of shipment, $j = 1,2, ..., m$, *k* - route of particular vehicle type , $k = 1,2, ..., l$;

$\boldsymbol{y_k}$ - the number of vehicles *k*- route;

$\boldsymbol{a_{ij}}$ - purchase price of the *i* - position of the ordering of *j*- point of shipment;

$\boldsymbol{b_k}$ - the cost of transportation in the *k* - route a particular type of transport.

The linear function of maximizing margins in the transaction (profit):

$$f(x,y) = \sum_{i}^{n}\sum_{j}^{m}\sum_{k}^{l} (c_i - a_{ij})x_{ijk} - \sum_{k}^{l} b_k y_k \quad (6)$$

$f(x, y) \rightarrow$ max, where

c_i - sale price of *i* - position of the order.

Analysis of adjacent vertices cognitive map shown in Figure-2, as well as business-logic tasks allow deriving the following constraints of a linear function:

a) The number of vehicles of the same type is:
Int y_1, y_2, ..., y_k;

b) The vertex B3 "Min. order quantity" is the restriction of the function at the minimum volume V_i required for i-order product items:

$$\sum_i^n \sum_j^m x_{ijk} \geq V_i \quad (7)$$

c) The vertex B1 "Availability at the loading point" constitutes a restriction on the availability of the required number of Q_i provider *i*-positions of the goods on all routes passing through the j-shipping point:

$$\sum_k^l x_{ijk} \leq Q_i \quad (8)$$

d) The vertex B4 "Loading capacity of transport vehicle" is a restriction on the load (capacity) of the vehicle a certain carrying capacity d_k:

$$\sum_i^n \sum_j^m \frac{d_k}{\alpha_{ik}} x_{ijk} \leq d_k y_k, \quad (9)$$

α_{ik} - weighting minimum-duty positions in the *i*- position in *k* - vehicle

e) The vertex B6 "Min. load of transport vehicle" is a restriction on the minimum load of the vehicle:

$$d_k y_k - \sum_{i}^{n}\sum_{j}^{m} x_{ijk} \leq (1-\beta_k) \times d_k y_k, \quad (10)$$

d_k - transport vehicle load capacity;

β_k - capacity rate of the vehicle;

6) The vertex B2 "Min. party size of the supplier" is a restriction on the minimum lot size G_j supplier:

$$\begin{cases} bin\ c_k \\ y_k - c_k \geq 0 \\ \sum_{i}^{n} x_{ijk} \geq c_k\, G_j \end{cases} \quad (11)$$

Thus, the most important task of the analyst (expert on decision-making) is the study of the preferences of the decision maker and the construction of decision rules that reflect these preferences. The analyst cannot do without the study of objective parameters of the model, without studying the organization that owns the decision maker, the external environment. As a decision-maker in such problems is usually considered a leader, we formulate the problem and who is responsible for solving it. The cognitive approach as the direction continues to develop rapidly, adding to the arsenal of approaches to the formalization and problem solving multi objective optimization.

CONCLUSIONS

Developed cognitive method of formalizing the optimization problem based on the development of a cognitive map of the lower level, you can use it quantitative peaks and their relationship to justify the selection of parameters and constraints optimization model for transit trade in manufactured goods.

DSS has been tested in the field of metal trading. As a result of testing proved the possibility of DSS application developed under the dissertation research tool for businesses of transit trade of manufactured goods. Efficiency and effectiveness of the methods and models DSS confirmed improved economic efficiency. The company operated for six months DSS, which was integrated with the program used in the company's accounting orders of its own design. As a result of 86% increased overall sales to small wholesale delivery, usually by road with high complexity orders - the average number of order items 4.35. Increase in the gross trading margin was 103%. Growth rates in sales associated with the growth of labor productivity of employees responsible for sales and purchases by increasing the number of transactions, as well as due to growth in average trade margin on sales of 26%.

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