

MODEL OF SUPPORT OF DECISION-MAKING FOR DETERMINATION OF EFFECTIVE MANAGEMENT OF THE INDUSTRIAL ENTERPRISE

Annotation: *the model for economic indicators forecasting of the management efficiency on the industrial enterprise, which based on the joint application of interval forecast and fuzzy mathematics, is developed.*

Keywords: *management efficiency assessment, illegible sets, illegible forecasting, illegible interval estimation, linguistic variable, function of accessory.*

Introduction. The problem of an estimation of management efficiency of the enterprise is one of the sharpest, that subjects of managing face in the process of the functioning in the conditions of dynamically changing market environment.

Forecasting is a key moment in the process of making administrative decisions since efficiency of any decision depends on sequence of events which can arise after its acceptance. Opportunity to predict uncontrollable aspects of these events before decision-making allows to make the most expedient choice [1].

Problem definition. For an estimation and forecasting of indicators of effective management of the enterprise in case of considerable information uncertainty expert methods of forecasting get effective application. However, as a rule, various experts differently estimate value of indicators and therefore it is very difficult to set a dot estimation. For similar situations they use the device of illegible sets which operates with indicators in the form of illegible numbers.

Solution methods. In the unfolded form the situation of making the administrative decision is characterized by game model $\langle I, J, \mu \rangle$ [2], where:

- $I = \{1; 2; \dots; i; \dots; k\}$ - known set of indicators of effective management of the enterprise;

- $J = \{1; 2; \dots; j; \dots; n\}$ - known set of scenarios of conditions of efficiency (possible conditions of the economic environment);

- $\mu = \mu_{k \times n} = (\mu_{ij})$ - completely or partly known matrix elements of which - set the corresponding values of estimates of accessory function of an i indicator to a set of the most reliable values in the conditions of j situation.

Let the situation of estimation and forecasting of indicators of economic

efficiency of management be characterized by the following components:

1. $I = \{1;2;3;4\}$ - known set of indicators (criteria) of an estimation ;
2. $J = \{1;2;3;4;5\}$ - a known set of scripts of conditions of the economic environment considered by decision-makers ;
3. $\mu = \mu_{4 \times 5} = (\mu_{ij})$ - partially known matrix which elements set the corresponding values of estimates of accessory function of an i indicator to set of the most reliable in the conditions of j script .

Exact true values of all elements of a payment matrix are unknown, but experts found intervals which possess their values:

$$\begin{aligned} \mu_{11} \in [0,0;0,1], \mu_{12} \in [0,15;0,25], \mu_{13} \in [0,35;0,45], \mu_{14} \in [0,55;0,65], \mu_{15} \in [0,75;0,85] \\ \mu_{21} \in [0,15;0,25], \mu_{22} \in [0,25;0,35], \mu_{23} \in [0,45;0,55], \mu_{24} \in [0,65;0,75], \mu_{25} \in [0,85;0,95] \\ \mu_{31} \in [0,25;0,35], \mu_{32} \in [0,35;0,45], \mu_{33} \in [0,55;0,65], \mu_{34} \in [0,75;0,85], \mu_{35} \in [0,95;1,0] \\ \mu_{41} \in [0,35;0,45], \mu_{42} \in [0,45;0,50], \mu_{43} \in [0,65;0,70], \mu_{44} \in [0,85;0,90], \mu_{45} \in [0,95;1,0] \end{aligned}$$

The sense of a method of illegible forecasting consists in consecutive narrowing of interval expected value to the corresponding illegible number. The initial interval of possible values of an indicator on the period of forecasting is established on the basis of group examination by determination of the minimum and maximum values of the left and right border of an interval of the forecast. This interval is the input parameter of iterative procedure of receiving expected illegible number.

The algorithm of realization of a method of illegible forecasting of indicators of management efficiency has the following appearance [3]:

1. Forecasting problem definition.
2. Formation of expert N number group.
3. Definition on the basis of expert polling of a set A :

$A = \{(\underline{a}_i, \overline{a}_i), i = \overline{1, N}\}$, where $\underline{a}_i, \overline{a}_i$ – correspondingly left and right borders of an expected interval of i expert.

4. Finding of an initial group interval estimation of expected value:

$$(\underline{m}, \overline{m}), \underline{m} = \min \{ \underline{a}_i, i = \overline{1, N} \}, \overline{m} = \max \{ \overline{a}_i, i = \overline{1, N} \}$$

Definition of illegible number \tilde{P} (approximately equals $(\underline{m} + \overline{m})/2$) and its interval β .

5. Check of an enclosure of an interval of expected values of a confidential interval of illegible number $(\overline{m} - \underline{m}) \leq \beta$. If the condition is carried out, transition to a step 12, else – to a step 7.

6. Formation of three alternatives of the interval forecast by breakdown of an initial group interval estimation of expected value into three equal blocked subintervals (with extent of overlapping -50%):

$$A_1 = (\underline{a}_1, \overline{a}_1) = (\underline{m}, \underline{m} + 2\delta);$$

$$A_2 = (\underline{a}_2, \overline{a}_2) = (\underline{m} + \delta, \overline{m} - \delta), \text{ where } \delta = (\overline{m} - \underline{m}) / 4$$

$$A_3 = (\underline{a}_3, \overline{a}_3) = (\overline{m} - 2\delta, \overline{m})$$

7. Formation by experts of individual matrixes of paired comparisons of alternatives in preference degree.

8. Definition of a group matrix of paired comparisons of alternatives by definition of its elements as average geometrical of the corresponding elements of equidistant matrixes of paired comparisons.

9. Calculation a vector of group priorities of alternatives $\overline{p} = (p_1, p_2, p_3)$

10. Definition of the interval forecast $(\underline{m}, \overline{m})$, $\underline{m} = p_1 \underline{a}_1 + p_2 \underline{a}_2 + p_3 \underline{a}_3$

11. Definition of the illegible forecast in the form of illegible number \tilde{P} and its function of accessory.

The analysis of the received results. Lets consider application of this method for the solution the problem of an illegible estimation and forecasting of a financial state of the enterprise.

Stage 1. Creation of linguistic variables: A – "Management efficiency indicators", B – "Reliable states". Analyzing different types of conditions of the linguistic variable "Management efficiency indicators", we will be set by a set $\{\mu\}$, which is suited by five illegible T-numbers of $\{\beta\}$ type $\beta_1 = (0,0;0,0;0,15;0,25)$; $\beta_2 = (0,15;0,25;0,35;0,45)$; $\beta_3 = (0,35;0,45;0,55;0,65)$; $\beta_4 = (0,33;0,65;0,75;0,85)$; $\beta_5 = (0,75;0,85;1,0;1,0)$.

To function of accessory $\mu(V)$ there corresponds the illegible number $\beta = (\alpha_1; \alpha_2; \alpha_3; \alpha_4)$, where $\alpha_1; \alpha_4$ - abscissae of the lower basis of a trapeze, $\alpha_2; \alpha_3$ - abscissae of the top basis of the trapeze setting μ in area with nonzero accessory of the carrier V to the corresponding illegible subset. Numbers β are trapezoid numbers.

Stage 2. Definition of a set of expected values of indicators of management efficiency on the basis of expert polling:

$$\begin{aligned} \mu_{11} &\in [0,0;0,1], \mu_{12} \in [0,15;0,25], \mu_{13} \in [0,35;0,45], \mu_{14} \in [0,55;0,65], \mu_{15} \in [0,75;0,85], \\ \mu_{21} &\in [0,15;0,25], \mu_{22} \in [0,25;0,35], \mu_{23} \in [0,45;0,55], \mu_{24} \in [0,65;0,75], \mu_{25} \in [0,75;0,85], \\ \mu_{31} &\in [0,25;0,35], \mu_{32} \in [0,35;0,45], \mu_{33} \in [0,55;0,65], \mu_{34} \in [0,75;0,85], \mu_{35} \in [0,95;1,0], \\ \mu_{41} &\in [0,35;0,45], \mu_{42} \in [0,45;0,50], \mu_{33} \in [0,65;0,70], \mu_{34} \in [0,85;0,90], \mu_{35} \in [0,95;1,0] \end{aligned}$$

Stage 3. Group interval estimation of expected value, definition of illegible number and its interval β :

$$\begin{aligned} (\underline{m}_1, \overline{m}_1) &= [0,0;0,85], \tilde{P}_1 \approx 0,425, \beta_1 \in [0,0;0,75] \\ (\underline{m}_2, \overline{m}_2) &= [0,15;0,85], \tilde{P}_2 \approx 0,5, \beta_2 \in [0,0;0,85] \\ (\underline{m}_3, \overline{m}_3) &= [0,25;1,0], \tilde{P}_3 \approx 0,625, \beta_3 \in [0,15;1,0] \\ (\underline{m}_4, \overline{m}_4) &= [0,35;1,0], \tilde{P}_4 \approx 0,675, \beta_4 \in [0,25;1,0] \end{aligned}$$

Check of an enclosure in a confidential interval:

$$\begin{aligned} (\overline{m}_1 - \underline{m}_1) &= 0,85 > \beta_1 \\ (\overline{m}_2 - \underline{m}_2) &= 0,8 \leq \beta_2 \\ (\overline{m}_3 - \underline{m}_3) &= 0,75 \leq \beta_3 \\ (\overline{m}_4 - \underline{m}_4) &= 0,65 \leq \beta_4 \end{aligned}$$

Stage 4. As for indicators 2-4 condition of an enclosure carries out, then expected values remain for further calculations. For an indicator 1 condition of an enclosure isn't carried out therefore we will create three alternatives of the interval forecast in the form of three blocked subintervals:

$$\begin{aligned} A_1 &= (\underline{a}_1, \overline{a}_1) = (0,0;0,425); \\ A_2 &= (\underline{a}_2, \overline{a}_2) = (0,2125;0,6375); \\ A_3 &= (\underline{a}_3, \overline{a}_3) = (0,425;0,85) \end{aligned}$$

Stage 5. Definition of a group matrix of pair comparisons of experts' alternatives:

$$A_{y\hat{e}\tilde{n}\tilde{i}} = \begin{pmatrix} [0,285] \\ [0,345] \\ [0,625] \end{pmatrix}$$

Calculation of a vector of group priorities of alternatives:

$$\bar{p} = (0,23;0,27;0,5)$$

Stage 6. Definition of the interval forecast:

$$(\underline{m}_1, \overline{m}_1) = [0,2725; 0,695], (\overline{m}_1 - \underline{m}_1) = 0,4225 \leq \beta_1$$

Thus, we received the illegible forecast of indicators of effective management of the enterprise:

$$\tilde{P} = \begin{pmatrix} [0,27; 0,7] \\ [0,15; 0,85] \\ [0,25; 1,0] \\ [0,35; 1,0] \end{pmatrix}$$

As result of calculations - an interval estimation, it is impossible to estimate unambiguously extent of influence of a concrete indicator on management efficiency. In this regard there is a problem of formalization of an interval indicator of effective management of activity.

It is possible to solve this problem by a quantitative estimation of indicators of efficiency by means of the theory of illegible logic. Illegible representation in structure of model appears in connection with illegible interpretation of level of efficiency.

Criterion of effective management of activity of the enterprise is some number from the range $[0,1]$ which corresponds to "extent of achievement of goals". The more value of criterion is, the higher is effectiveness of activity management of the enterprise.

Effectiveness of the management of the enterprise is described by a linguistic variable X with the name "Effectiveness of the management of the enterprise". Then the four of the remained properties of a linguistic variable $\langle T, U, G, M \rangle$ can be defined so:

1. universal set of $U=[0,1]$;
2. term set $T= \{ \text{"low"}, \text{"average"}, \text{"high"} \}$ with such functions by accessories:

$$\mu_{\text{"low"}} = \begin{cases} 1, & \text{àñëè } 0 \leq u < 0,15 \\ 10(0,25 - u), & \text{àñëè } 0,15 \leq u < 0,25 \\ 0, & \text{àñëè } 0,25 \leq u \leq 1 \end{cases}$$

$$\mu_{\text{"average"}} = \begin{cases} 0, & \text{àñëè } 0 \leq u < 0,35 \\ 10(u - 0,35), & \text{àñëè } 0,35 \leq u < 0,45 \\ 1, & \text{àñëè } 0,45 \leq u < 0,55 \\ 10(0,65 - u), & \text{àñëè } 0,55 \leq u < 0,65 \\ 0, & \text{àñëè } 0,65 \leq u \leq 1 \end{cases}$$

$$\mu_{\text{average}} = \begin{cases} 0, & \text{if } 0 \leq u < 0,75 \\ 10(u - 0,75), & \text{if } 0,75 \leq u < 0,85 \\ 1, & \text{if } 0,85 \leq u \leq 1 \end{cases}$$

3. the syntactic rule G, generating new terms with use of quantifiers "higher", "or", "not", "below";

4. M will be the procedure putting to each new term in compliance an illegible set from X by rules: if terms A and B had functions of accessory $\mu_A(u)$ and $\mu_B(u)$ correspondingly, new terms would have the following functions of accessory set in tab. 1.

"Low" level of efficiency of the activity management of the enterprise means that there is a full confidence that efficiency of carrying out the work within all functional areas is low. Goals aren't achieved. Dynamics of growth is absent.

Level of efficiency of the activity management of the enterprise "below an average" means that it is quite possible, that separate kinds of activity (one or two) are characterized by the average level of efficiency. The enterprise partially achieved the goals. Dynamics of growth is observed, but growth rates are slowed down.

Level of effective management of activity of the "average" enterprise assumes that there is a full confidence, that efficiency of the works performed within functional areas of the enterprise has the average level. The enterprise achieved goals, but costs of their achievement exceeded the planned level. Dynamics of growth corresponds to growth rates.

Level of effective management of activity of the enterprise "above an average" means that the enterprise achieved goals, but the low level of efficiency on separate activities has to cause proper response of the management. Growth rates advance dynamics of growth.

Level of effective management of activity of the enterprise "high" means that the enterprise is effective in carrying out the functions and achieved goals. Constant dynamics of growth rates is observed.

Tab. 1

Functions of accessory for a linguistic variable

Quantifier	Function of accessory
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Below average	$\mu_{\text{below}} = \begin{cases} 0, & \text{åñëè } 0 \leq u < 0,15 \\ 10(u - 0,15), & \text{åñëè } 0,15 \leq u < 0,25 \\ 1, & \text{åñëè } 0,25 \leq u < 0,35 \\ 10(0,45 - u), & \text{åñëè } 0,35 \leq u < 0,45 \\ 0, & \text{åñëè } 0,45 \leq u \leq 1 \end{cases}$
Above average	$\mu_{\text{above}} = \begin{cases} 0, & \text{åñëè } 0 \leq u < 0,55 \\ 10(u - 0,55), & \text{åñëè } 0,55 \leq u < 0,65 \\ 1, & \text{åñëè } 0,65 \leq u < 0,75 \\ 10(0,85 - u), & \text{åñëè } 0,75 \leq u < 0,85 \\ 0, & \text{åñëè } 0,85 \leq u \leq 1 \end{cases}$

Thus, presence of a scale of levels of effective management of the activity of the enterprise created on the basis of the theory of illegible logic gives the chance by identification of a settlement indicator with its interpretations, to determine an actual level of effective management of activity of the enterprise. It, in turn, is justification for development of actions for providing and support the increase of dynamics of growth of effective management of the activity of the enterprise directed on achievement of the common and private goals [4].

The considered mathematical tools allow to estimate qualitatively effective management of the enterprise and it is rational to organize activity of the enterprise.

Conclusions. The device of illegible logic is effectively used for the solution of economic problems of estimation and forecasting of indicators of effective management of the enterprise.

Use of the offered model of an estimation and forecasting of economic indicators of the efficiency management of the industrial enterprise based on combined use of the interval forecast and illegible mathematics allows to resolve an objective correctly. This approach allows to model adequately decision-making process.

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