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Decision Support System for the Expert Assessment of Social Risks

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Abstract: The study is devoted to the development of decision support systems in the expert assessment of social risks. A list of major social risks are exposed to the technosphere and the factors that affect them. Produced by means of a formal hierarchy that reflects the relationship of social risks and the factors influencing them. The choice of the method of decision-making for the implementation of decision support systems and expert group scheme of interaction with the system. A revision of the existing method of valuation of coherence which will improve the validity of recommendations for improving the coherence pairwise comparisons matrix. The proposed approach will enable to implement a decision support system with the expert assessment of social risks.

Key words: Decision support system, expert system, pairwise comparison matrixes conformity, social technologies, social risks

INTRODUCTION

In modern conditions, the risk assessment is an important element of decision theoretical base in policy and economy. Establishment of cause and effect relations between the parameters characterizing heterogeneity of technogenic factors and possible negative social consequences as well as quantitative assessment of the last approach probability allow to organize forecasting of social risks.

Until now, inconsistency of expert positions concerning essence of this process generates separation and discrepancy of approaches to its regulation and improvement. Differences in theoretical positions in this branch of scientific knowledge generates the corresponding problems in social practice. Therefore, the tools allowing to carry out social risks assessment and interrelations between factors on a wide range of criteria are necessary in this situation. These means are also important for the reason that each risk has to be estimated in relation to a certain sphere of personal life. Thus, development of the Decision Support System (DSS) for social risk assessment on the basis of the Analytic Hierarchy Process (AHP) as well as improvement of this method for achieving more reasonable calculations of alternatives is an important task.

MATERIALS AND METHODS

We offer application of AHP (Saaty, 1990a, b) allowing to carry out independent expert assessment both numerical and qualitative to receive the total result considering opinion of all expert groups. For solution of the problem specified methods of the system analysis, decision theory and optimization were used in introduction.

Main part: In practice, application of this method requires creating informational decision support in the form of purposes, criteria and alternatives hierarchies. DSS (Lomakin and Lifirenko, 2014a) allows to make a multi-criteria assessment of alternatives on the basis of expert assessment, empirical and statistical data. Such functionality is provided due to application of hierarchy analysis method and its modifications. The main feature of this system is that output results pay off not only on objective indicators but also on subjective (preferences of people). Thus, under conditions of exact mathematical means lack for the social risk assessment description system offered by us and developments of anti-risk managing decisions mainly is based on formal representation of human experience and intuition.

During the conducted researches (Asadullayev and Lomakin, 2015) the list of the main social risks subjected to influence of techno-sphere was received: demographic situation deterioration; unemployment; population marginalization; the compelled migration; disadaptation; decline in life quality; crime wave; social tension growth; protest activity growth; terrorism wave. The social risk assessment hierarchy, we offered according to analytic hierarchy the process of looks as follows

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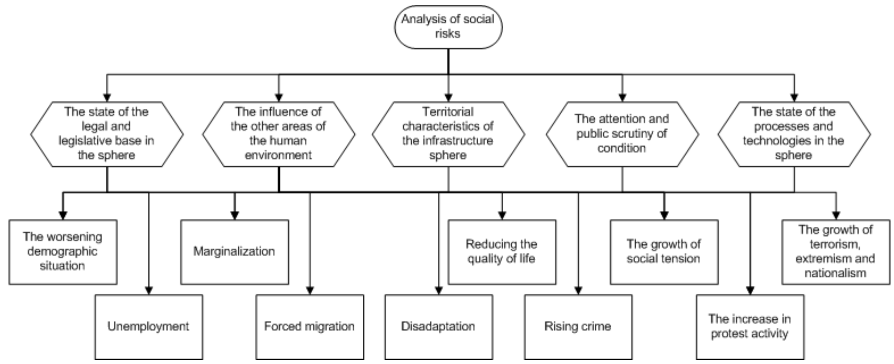

Fig. 1: Hierarchy assess social risks by the analytic hierarchy process

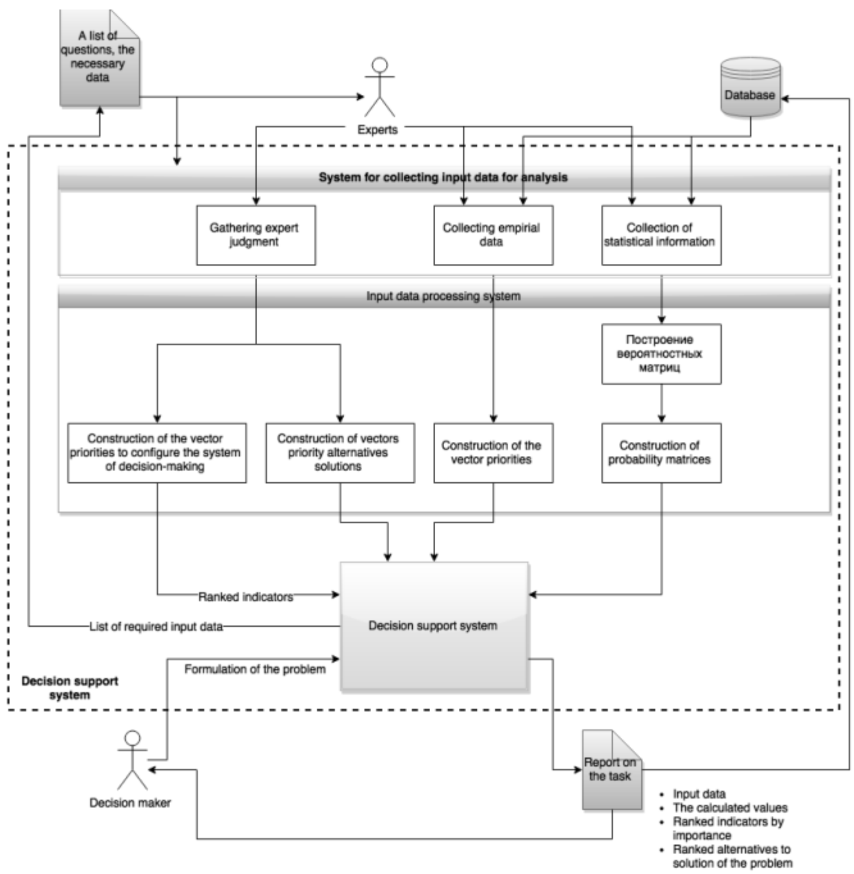

Fig. 2: Scheme of expert decision support system interaction

(Lomakin and Lifirenko, 2014b) (Fig. 1). During the features analysis of AHP (Saaty,1993; Lomakin and Lifirenko, 2014a; Saaty, 1990a) practical applicatio in the social and economic sphere we offered the following scheme of expert interaction with DSS and its separate modules. On the scheme (Fig. 2) separate system blocks are allocated:

- The database stores the saved-up information during system work (assessment, statement, rule, interrelation between entities and data)
- The system of the entrance data collecting for the analysis allows to collect data from three sources: expert assessment, empirical data and statistics
- The system of entrance data processing prepares entrance data for calculations and brings unified look

- The decision support system kernel makes interrelations of the located information among themselves and performs probability or priority calculation for several option

In practical application of AHP with a large criteria and alternatives number as in the case presented by us, difficulties in receiving the coordinated Pairwise Comparison Matrixes (PCM) take place and can influence the accuracy of the calculated ponderabilities. Decision procedure on the AHP basis means carrying out rather large number of pairwise comparisons. The total of pairwise comparisons of N can be calculated by Eq. 1:

$$N = \frac{ekn(n-1)+k(k-1)}{2} \quad (1)$$

Where:

e = Total of experts assessing alternatives decisions on all criteria

k = Amount of criteria by which comparison of alternatives is made

n = Amount of solution alternatives of the considered problem

As the hierarchy offered by us is rather voluminous ($N \geq 470$), it is expedient to apply in the course of poll methods assessment of the expert judgment coherence and methods of coherence degree increase (Cao *et al*., 2008; Ishizaka and Lusti, 2004; Harker, 1987). In the study (Lomakin and Lifirenko, 2013) algorithms allowing to carry out the expert support on increasing the degree of PCM coherence were offered. The offered algorithms were intended for identification and automatic correction of the specific judgments influencing low coherence of pairwise comparisons. Application of these approaches allows to carry out an assessment of separate pairwise comparisons coherence but in practice it did not lead to right results in all cases. The analysis showed that calculation of a matrix of angle cosines on the vectors made only of PCM lines yields less exact result as pairwise comparisons take place. In this regard calculation of an average angle cosine for couples of vectors made of lines and columns of PCM elements is offered (Babaeian *et al*., 2015a-cuses an angle constraint to help to modify the performance of shortest paths.

RESULTS AND DISCUSSION

In that case two angle cosines are previously calculated ψ^{line}_{ij} (between vectors, PCM made of lines) and ψ^{column}_{ij} (between the vectors made of MPC columns) by Eq. 2:

$$\Psi^{line}_{ij} = \frac{\sum_{k=1}^{n} a_{ik} \times a_{jk}}{\sqrt{\sum_{k=1}^{n} a_{ik}^2 \sum_{k=1}^{n} a_{jk}^2}}, \Psi^{column}_{ij} = \frac{\sum_{k=1}^{n} a_{ki} \times a_{kj}}{\sqrt{\sum_{k=1}^{n} a_{ki}^2 \sum_{k=1}^{n} a_{kj}^2}} \quad (2)$$

Then calculation formula of an average angle cosine ψ_{ij} for couples of vectors offered in (Lomakin and Lifirenko, 2013) will change to $\psi_{ij} = \psi_{ij}^{line+}\psi_{ij}^{colum}/2$. Change of a formula will not affect sequence of the further calculations described by Lomakin and Lifirenko (2013) for calculation of the general PCM coherence indicator and carrying out the expert judgments interpretation in need of the automatic or automated correction.

Let us show application of the offered approach on one PCM example. Let us assume that during assessment of alternatives the expert received PCM A_1(CR = 1.045). Here, the mistake is made: a_{13}= 1/8 though it has to be a_{13} = 8:

$$A_1 = \begin{pmatrix} 1 & 4 & 1/8 & 2 \\ 1/4 & 1 & 2 & 1/2 \\ 8 & 1/2 & 1 & 1/4 \\ 1/2 & 2 & 4 & 1 \end{pmatrix} \quad (3)$$

In that case before the expert there is a problem of matrix correction since Conformity Relation (CR) is high. Let us calculate matrixes of angle cosines; it is comparable to the corrected PCM received with their help with the described algorithm of automatic adjustment (Lomakin and Lifirenko, 2013):

$$\Psi^{line} = \begin{pmatrix} 1 & 0.52 & 0.287 & 0.52 \\ 0.52 & 1 & 0.248 & 1 \\ 0.287 & 0.248 & 1 & 0.248 \\ 0.52 & 1 & 0.248 & 1 \end{pmatrix}$$

$$\Psi^{column} = \begin{pmatrix} 1 & 0.248 & 0.287 & 0.248 \\ 0.248 & 1 & 0.52 & 1 \\ 0.287 & 0.52 & 1 & 0.52 \\ 0.248 & 1 & 0.52 & 1 \end{pmatrix} \quad (4)$$

$$\Psi^{total} = \frac{\Psi^{line} + \Psi^{column}}{2} = \begin{pmatrix} 1 & 0.384 & 0.287 & 0.384 \\ 0.384 & 1 & 0.384 & 1 \\ 0.287 & 0.384 & 1 & 0.384 \\ 0.384 & 1 & 0.384 & 1 \end{pmatrix} \quad (5)$$

Let us receive angle cosines matrixes on the basis of Ψ^{line}, Ψ^{column}, Ψ^{total}, the relevantly corrected PCM is A^{line}, A^{column}, A^{total}:

$$A^{line} = \begin{pmatrix} 1 & 2 & 1/3 & 1 \\ 1/2 & 1 & 1/9 & 1 \\ 3 & 9 & 1 & 5 \\ 1 & 1 & 1/5 & 1 \end{pmatrix}$$

$$A^{column} = \begin{pmatrix} 1 & 1/5 & 1/3 & 1/9 \\ 5 & 1 & 1 & 1 \\ 3 & 1 & 1 & 1/2 \\ 9 & 1 & 2 & 1 \end{pmatrix} \quad (6)$$

$$A^{total} = \begin{pmatrix} 1 & 4 & 9 & 2 \\ 1/4 & 1 & 2 & 1/2 \\ 1/9 & 1/2 & 1 & 1/4 \\ 1/2 & 2 & 4 & 1 \end{pmatrix}$$

Having compared the received PCM A^{line}, A^{column}, A^{total}, it is possible to draw a conclusion that assessment approach of coherence on the basis of vectors from elements of PCM lines and vectors from elements of columns works more effectively, since the matrix A^{total} corrects wrong pair comparison of a matrix A_1.

CONCLUSION

Thus, this approach will allow experts to control process of assessment and to raise the received result trust degree. The developed DSS will allow to carry out the multicriteria analysis of social risks that will give an opportunity to receive more exact results in comparison with the known declarative methods applied in this sphere. Operability of DSS on the Internet will allow to increase considerably the number of the social risks analysis participants as well as to conduct distal surveys. The offered information means will allow to automate processes of obtaining entrance information (expert, statistical and empirical), assessment of the entered data discrepancy and logical reliability of the received result.

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