

FUZZY APPROACH TO SOCIOECONOMIC SYSTEM MODELING

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Socioeconomic system (SES) is an open, dynamic and ill-structured system [1] functioning in conditions of complete uncertainty and, secondly, there are no effective methods to overcome this uncertainty. Moreover they have uncertain or fuzzy nature. Therefore, it is quite justified that the further researches of SES are in the area of studying the nature of the present uncertainty. Uncertainty concept is a concept reflecting absence of unambiguity. There are two types of uncertainty: true uncertainty – stipulated by internal properties of researched objects, and uncertainty related to incompleteness of information about these objects. As many researches have shown, there are both types of uncertainty in SES.

The first researcher of a phenomenon of uncertainty in SES was the American economist F.Knight [2], who particularly noted that for definition of a reasonable way of behaviour the economic subject should define causal relations between the decisions and their consequences. However by virtue of increased uncertainty of economic environment he can resort only to defining probabilities of event occurrence. However, the more we approach to innovative field, the more we face unique events, the mathematical calculation of probabilities of such is simply impossible. In this respect, F.Knight has proposed to name uncertainty of the first type (when there is some information about processes) as a risk, while for the second type he has kept the definition *an uncertainty* itself. Problem of uncertainty investigated also by J.Gil-Aluja [3,4] very wide, with fuzzy nature.

It is known that the basic sources of uncertainty in economy, as well as in other areas, are incompleteness or inadequacy of human knowledge about processes that take place and about the environment, and also contingency, which in similar conditions occurs unequally and which beforehand cannot be foreseen. In this case the research of uncertainty in its all appearances on SES scale is being conducted through application of the alternative approaches.

Each SES is the complex self-organizing object developing under influence of many changing certain and uncertain factors – both internal and external. From the factors forming a principle of uncertainty in the SES, it is possible to distinguish *economical, political, socio-psychological, technological* and *natural* components of uncertainty.

Research made existing factors of uncertainty in SES and proceeding from these alternative fuzzy models for solution of the level problems of economic system is presented below.

1. FUZZY MODELS OF THE LEVELS OF SES

At micro level of SES we investigated models of market, production and financial stability. At this level we use mainly fuzzy logic inference, fuzzy linear programming and fuzzy regression [5,6].

For mezzo (regional development) level of SES the fuzzy productive model for definition of level of regional development *RD* can be presented as follows:

$$\text{If } P_1 = \tilde{p}_1^{k_1} \text{ and } P_2 = \tilde{p}_2^{k_2} \text{ and } \dots \text{ and } P_{13} = \tilde{p}_{13}^{k_{13}}, \text{ then } RD = \tilde{l}_j \quad (1)$$

where $P_i (i = \overline{1,13})$ are linguistic variables describing the basic social and economic indicators of regions; $\tilde{p}_i^{k_i}$ is the fuzzy term-set corresponding to k_i -th value of linguistic variable P_i ; $\tilde{l}_j (j = 1, 2, \dots)$ is the fuzzy j -th level of regional development. Number of rules and amount of term-sets for each linguistic variable P_i is chosen on the basis of accessible heuristic knowledge. On the basis of this model and Fuzzy C-means clustering on eleven regions of

Azerbaijan the ranging of the appropriate regional levels of development is carried out.

On macro level we propose the fuzzy analogue for econometric model of definition of gross domestic product (GDP) whose level in the generalized form depends on investments volume, inflation rate and the oil price in the world market. In classical interpretation the parameter of GDP and the designated factors influencing its value are averaged. Actually these values vary in the certain limits which establish corresponding levels to them. Therefore, to increase degree of adequacy of model for definition of GDP it is proposed to use the mathematical tool of fuzzy sets trough fuzzification of elements and parameters of the model. In this case the fuzzy analogue model of definition of GDP can be presented as the following linear dependence:

$$G\tilde{D}P = \tilde{A}_0 + \tilde{A}_1 \cdot I\tilde{N}V + \tilde{A}_2 \cdot I\tilde{N}F + \tilde{A}_3 \cdot \tilde{P}_{oil} \quad (2)$$

where $G\tilde{D}P$ is a required fuzzy parameter of GDP; $I\tilde{N}V$ is a fuzzy volume of investment contributions; $I\tilde{N}F$ is a fuzzy inflation rate; \tilde{P}_{oil} is a fuzzy price level of one barrel of crude oil in the world market; $\tilde{A}_k (k = \overline{0,3})$ are fuzzy parameters.

For definition of fuzzy level of investment contributions $I\tilde{N}V$ it is possible to take advantage of a fuzzy recurrent parity:

$$I\tilde{N}V = \tilde{B}_0 + \tilde{B}_1 \cdot \tilde{S}(t-1) + \tilde{B}_2 \cdot \tilde{S}(t-2) + \tilde{B}_3 \cdot \tilde{S}(t-3) \quad (3)$$

where $\tilde{S}(t-1), \tilde{S}(t-2), \tilde{S}(t-3)$ are fuzzy volumes of savings relative to the t -th year relative to years $(t-1), (t-2)$ and $(t-3)$; $\tilde{B}_k (k = \overline{0,3})$ are fuzzy parameters.

To determine fuzzy analogue of inflation rate it is possible to apply the following fuzzy linear model:

$$I\tilde{N}F = \tilde{C}_0 + \tilde{C}_1 \cdot \tilde{M} \quad (4)$$

where \tilde{M} is a fuzzy volume of money available in circulation; \tilde{C}_0 and \tilde{C}_1 are unknown fuzzy parameters.

Finally, for definition of the current fuzzy price level of one barrel of oil in the world market it is possible to use a fuzzy recurrent parity:

$$\tilde{P}_{oil}(t) = F(\tilde{P}_{oil}(t-1), \tilde{P}_{oil}(t-2), \tilde{P}_{oil}(t-3)) \quad (5)$$

where $\tilde{P}_{oil}(t-1), \tilde{P}_{oil}(t-2), \tilde{P}_{oil}(t-3)$ are the fuzzy price levels of one barrel of oil relative to the current t -th year in years $(t-1), (t-2)$ and $(t-3)$ accordingly.

The next important problem of macro level of SES is development of the balance reflecting interbranch proportions. The exact formulation of the purpose of the problem of input-output balance (IOB) and criteria of its achievement (of criterion function) generally represents a most complex problem of measurement and comparison of many diverse (incommensurable) variables. By virtue of these circumstances it is possible to replace classical model of IOB by fuzzy analogue, i.e. system of the algebraic equations with fuzzy variable and fuzzy parameters:

$$\tilde{X} = \tilde{A} \cdot \tilde{X} + \tilde{Y} \quad (6)$$

where $\tilde{Y} = (\tilde{y}_1, \tilde{y}_1, \dots, \tilde{y}_n)$ is a vector of the final products expressed as fuzzy levels of volumes; $\tilde{X} = (\tilde{x}_1, \tilde{x}_1, \dots, \tilde{x}_n)$ is a set of fuzzy levels of volumes of production possible at the present resources; $\tilde{A} = (\tilde{a}_{ij})_{n \times n}$ is a matrix of fuzzy factors of direct expenses \tilde{a}_{ij} , which show fuzzy levels of production volumes of i -th branch necessary for production of one unit of production of j -th branch. Fuzzy problem of IOB (6) can be simulated and solved by means of a fuzzy neural network [7].

For meta level of SES the alternative approach for estimation of the global level of state

development based on fuzzy logic inferences is considered. On the basis of the proposed fuzzy model and on the basis of researches which have been done within the framework of the United Nations Development Program, the estimation of global level of development of Azerbaijan is carried out. Endogenous value of the given model is the quality indicator "global level of development" (*GD*) of SES and exogenous values are linguistic variables: "index of human development" (*HDI*) and "index of technological achievements" (*TAI*), accepting values in the fuzzy term-sets determined by gradational scales. On their basis and based on the chosen dominant judgments fuzzy linguistic rules for the estimation of *GD* are formed:

$$\text{If HDI} = \tilde{A}_i \text{ and TAI} = \tilde{B}_j, \text{ then GD} = \tilde{C}_k \quad (7)$$

where $\tilde{A}_i (i = 1, 2, \dots)$ is the fuzzy term-set corresponding to *i*-th value of linguistic variable HDI; $\tilde{B}_j (j = 1, 2, \dots)$ is the fuzzy term-set corresponding to *j*-th value of linguistic variable TAI; $\tilde{C}_k (k = 1, 2, \dots)$ is the fuzzy term-set corresponding to *k*-th value of linguistic variable GD.

Fuzzy model of ecological-economic subsystem, with input parameters being investments to man-made capital, investments to human capital, investments to natural capital; and output parameter being GDP per capita was also studied at present level. Two methods were used for solution of this problem: fuzzy logic inference and the fuzzy regression equations.

2. THE INDEX OF POPULATION LIFE QUALITY

The basis of each society is its socioeconomic system (SES). Under the socioeconomic system we understand a set of economic system and the social environment. Usually in the literature an output parameter of socioeconomic system is the gross domestic product (GDP) per capita. As this parameter is an economic parameter it does not completely reflect the social condition of the population of republic. In human life along with the economic level the important role is played by social, moral and psychological levels of the person. Therefore GDP can not describe results of functioning of social and economic system completely.

In other words, in development of the model it is necessary to take into account the factors influencing the level of development of life quality. Present part of the paper considers the model of quality of life of the population of the state.

Using various methods of an estimation of an index of life quality [8,9] and using technology of fuzzy logic inferences it is necessary to estimate LQI on the basis of fuzzy model [10]. It is necessary to note, that LQI parameter as well as many economic parameters, has uncertain character.

Target parameter of the model is the integrated parameter of activity of social and economic systems *an index of quality of life of the population* (LQI), and input parameters are the following linguistic variables:

- index of quality of the population (PQI);
- index of well-being of the population (WPI);
- index of quality of social sphere (SSI);
- index of quality of ecological niche (EQI);
- index of natural - climatic conditions of the country (NCI).

In present model all parameters of each block shall be presented by means of linguistic variables and using methods of fuzzy logic inferences.

Estimations carried out by means of MATLAB 7.0/Fuzzy Toolbox/Fuzzy Inference System for each block for 2004 for Azerbaijan resulted in the following precise values:

- | | |
|---------------------------------------|-------|
| 1. Quality of the population (PQI) | 0.852 |
| 2. Well-being of the population (WPI) | 0.500 |

3. Quality of social sphere (SSI)	0.330
4. Quality of an ecological niche (EQI)	0.500
5. Natural - climatic conditions (NCI)	0.330

20 rules defined on the basis of results of exogenous variables were used for estimation of quality of life of the population in Azerbaijan. Calculations carried out defined LQI parameter for Azerbaijan equal to 0.5, i.e. "Average".

CONCLUSION

On the basis of the performed research of uncertainty factors under whose influence the socioeconomic system functions, we propose the fuzzy models for solution of some problems of economic system on micro, mezo, macro and meta levels and of socioeconomic behavior. The method of fuzzy inferences calculates the integrated index of quality of life of the population which covers not only quantitative, but also qualitative parameters which are not measurable. The research carried out is not complete. For completeness of research it is necessary to develop the integrated system of models of economic system and the social environment.

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