REPUBLIC OF AZERBAIJAN

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MODELS FOR EVALUATION OF QUALITY OF LIFE ON LIFE DOMAINS OF SOCİAL GROUPS IN AZERBAIJAN

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ABSTRACT

of the dissertation for the degree of Doctor of Philosophy

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The research work was carried out at the Research and Training Center under Ministry of Labour and Social Protection of People and Azerbaijan National Academy of Sciences, Institute of Control Systems, “Laboratory of fuzzy models of economics”.

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GENERAL CHARACTERISTICS OF WORK

Actuality of the topic. Improving the quality of life in modern world is one of the key areas of economic policy of any country. Deterioration of living standards increases poverty, which ultimately leads to increased social tensions in society, reduced consumption decreases the efficiency of the economy and depreciates the investment attractiveness of the state.

In most studies, economic growth has been identified as one of the key factors in reducing poverty and improving living standards. There are several growth concepts in the economic literature to reduce poverty. According to UN guidelines, economic growth is not in itself a guarantee of poverty reduction, but if it creates an opportunity for the poorest people to engage in productive and well-paid work, then it is in favor of reducing poverty and raising living standards. The policy of redistribution of income also affects the improvement of living standards. In addition, the problem of raising living standards is associated with the dynamics of the labor market, social policy and macroeconomic stability.

For more accurate and objective measurement of uncertainty (lack or absence of accurate and reliable data, availability of data (information) in the form of expert opinions, randomness of the processes under consideration) in measurement factors affecting quality of life and living standards the use of fuzzy and intuitionistic fuzzy models to obtain forecasts is extremely relevant in the context of the country's sustainable development.

Factors for improving living standards and quality of life were analyzed and studied by a number of scientists and researchers, as well as given a global character by various international organizations. Researchs carried out by foreign scholars such as Easterlin, R.Veenhoven, B.M.S. Prague, A. Captain, E. Diener, A. Sen J. Stiglitz and others in this field. Among the international organizations that analyze and study various aspects of living standards and quality of life are the World Bank, the United Nations, the International Labor Organization, et.c.

In Azerbaijan, the scientific works of G.J. İmanov, Y.G. Hasanli, T.A. Alirzayev, A.G. Alirzayeva, B.J. Quliyev, R.K. Isgandarov, A.T. Naghıyev, V.A. Mutallimova and others can be cited.

Since the late 1970s, fuzzy methods have been actively used in the economy. In 1986, K.T. Atanassov generalized the theory of fuzzy sets and introduced the theory of intuitive fuzzy sets to science. This theory has opened up new horizons for economic research, including the possibility to address multi-criteria decision-making problems.

In the field of application of fuzzy logic in modeling of economic problems in Azerbaijan, a great contribution has been made by R.A. Aliyev and G.J. Imanov.

Currently, the works of researchers such as F.E. Boran, S. Genç, Z.S. Xu, L. Huchang are of great importance in solution of weighted linear combination problems.

Subject and object of the study. The subject of the dissertation is a study of living standards and quality of life at the macroeconomic level on the basis of econometric and intuitionistic fuzzy methods, and the object are the indicators such as monthly income of the population and households, GDP per capita, health, gender equality, etc.

The aim and objectives of the work. The main goal of the work is to analyze and study the standard and quality of life and modelling using econometric and fuzzy mathematical methods. To achieve this goal, the following objectives were established and realized: analysis and assessment of the relation of the population's income with labor productivity by classical and fuzzy models, calculation and fuzzy linguistic forecasting of social mobility for social groups, construction of an intuitive fuzzy model for measuring quality of life, the model for preference of expert opinions on social capital.

Research methodology. The theoretical and methodological basis of the dissertation are the scientific research and practical works of Azerbaijani and foreign scientists in the field of econometric and fuzzy logic based models. Methods of the research included econometrics and statistics, as well as classical and fuzzy regression models, fuzzy Markov chain, fuzzy sets and linguistic variables, intuitionistic fuzzy sets and Z-number theories and multicriteria decision making.

The main provisions for the defense. The following provisions in the dissertation are submitted for the defense:

- Analysis of living standards in Azerbaijan on the basis of objective indicators;
- Comparative analysis of agriculture in Azerbaijan and the Netherlands;
- Proposal of an econometric model for wage incomes of social groups stratified on the basis of monthly income;
- Proposal of fuzzy models for wage incomes in agriculture;
- Calculation of social mobility indices for social groups and forecasting using fuzzy linguistic Markov chain;
- Proposal of a model using intuitionistic fuzzy aggregation methods to determine the quality of life index;
- Proposal of a model for preference of expert opinions on social capital based on fuzzy z-numbers.

Scientific novelties of the research work.

- Quantitative and qualitative indicators determining the standard and quality of life are analyzed;
- The dependence of the population's wage incomes on labor productivity and unemployment rate is investigated through classical and fuzzy regression;
- For the first time, social mobility indices are measured for social groups and forecasted through a fuzzy linguistic Markov chain;
- Fuzzy and intuitionistic fuzzy set theory is used to model and substantiate the quality of life;
- For the first time, the quality of life index is calculated using intuitionistic fuzzy tools as a multicriteria decision-making problem, taking into account both argument weights and criteria weights;
- For the first time model for the preference of expert opinions on social capital is built based on fuzzy Z-numbers.

Teoretical and practical significance of the research. The theoretical and practical significance of the research is that the proposed quality of life assessment models can be used in the development and implementation and increase the efficiency of social programs as part of the country's sustainable economic development programs. In addition, high mobility indices are an indication that there is no need for income redistribution in society, so research in this area can be useful in the formation of social policy programs.

Publications. The main provisions and results of the dissertation work are reflected in 9 scientific papers and have been published in the Collection of Scientific Works of the Scientific Research and Training Center for Labor and Social Problems under the Ministry of Labor and Social Protection of Population of the Republic of Azerbaijan, in the journals of the Azerbaijan State University of Economics, namely, Scientific News and Economic Sciences: Theory and Practice, Advances in Intelligent Systems and Computing, Lecture Notes in Networks and Systems (Spinger indexed) and other conference proceedings.

Structure and volume of work. The dissertation consists of an introduction (9555 characters), 3 chapters (Chapter I – 43386 characters, Chapter II – 36179 characters, Chapter III – 115816 characters), conclusion (3387 characters), 171 references, and 165 pages. The dissertation contains 7 pictures, 52 tables and 2 diagrams. The volume of the work is 208,323 characters, excluding the bibliography and appendices.

MAİN CONTENT OF THE DISSERTATION

The introduction highlights the actuality of the topic, the aim and objectives of the research, the main provisions for the defense, research methods, the theoretical and practical significance of the research.

The first chapter of the dissertation is "**Wellbeing, life standards and quality of life**". This chapter provides the theoretical and methodological foundations of the concepts of welfare, living standards and quality of life. Approaches to the concepts of wellbeing and quality of life in the available literature in this direction are presented and analyzed.

These days, the concept of quality of life is widely used in various fields of science, including economics, sociology, statistics and politics. However, it is impossible to interpret exactly, completely, unambiguous and general meaning of this concept. There are many concepts that generally characterize the quality of life and have different approaches to life domens. Quality of life is a socio-economic concept that reflects the various living conditions for the existence of society at a certain moment in time in a general form.

Until recently, the amount of GDP per capita was considered as a general indicator that determines the standard of living. However, after analysis at other statistical indicators in different countries, it was observed that the state of well-being has not changed in many countries. As a result, we conclude that the standard of living should be determined through a complex system of indicators[1].

The second paragraph of the first chapter analysis of the local and foreign literature on living standards, welfare and quality of life are given. In the article "Fuzzy models in measuring the quality of social systems", fuzzy models for determination of the level of quality of social systems was proposed by G.J.Imanov[2]. Through them, the factors that determine the quality of life, such as multicriteria decision-

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[1] Stiglitz, E., Joseph, E., Sen, A., and Fitoussi J.P. Mismeasuring Our Lives: Why GDP Doesn't Add Up: The Report // -New York: New, -2010.

[2] Иманов, К., Акперов, Р. Нечеткие модели оценки качества социальных систем // / LAPLAMBERT AcademicPublishing, Saarbrüken, -2013, -60 p.

making, are summarized by fuzzy numbers and linguistic variables.

The second chapter is "**Possibilities and features of application of econometric and fuzzy methods in modeling of the quality of life**". This chapter provides basic terms and main statistical tests for estimation of parameters in construction of econometric models. According to the problem under consideration the exponent model is employed:

$$Y_i = \beta_1 X_i^{\beta_2} e^{u_2} \quad (1)$$

Which can be alternatively expressed (after transformation) as:

$$\ln Y_i = \alpha + \beta_2 \ln X_i + u_i \quad (2)$$

Subsequently, we get a model linear in parameters: α and β_2 that can be estimated using ordinary least squares method[3].

Next, the possible methods of applying fuzzy regression to the problem to be analyzed are given. The fuzzy regression model takes the following general form:

$$\tilde{Y} = \tilde{A}_0 + \tilde{A}_1 y_1 + \cdots + \tilde{A}_n y_n \quad (3)$$

The main purpose in the Tanaka approach called possibility regression, is to minimize the fuzziness generated by the input data of the model by minimizing the overall boundaries of the fuzzy coefficients[4].

This problem is brought to the following linear programming problem, provided that $[Y_i]_h \cap [\hat{Y}_i]_h$, and by minimizing the spread of $\sum \hat{Y}_i$:

$$\operatorname*{Min}_{\hat{\alpha},\hat{c}} \sum \hat{c}\,|x_i| = \hat{J}(\hat{c}) \quad (4)$$

$$y_i + |L^{-1}(h)|e_i \geq \hat{\alpha}x_i - |L^{-1}(h)|\hat{c}|x_i| \quad (5)$$

$$y_i - |L^{-1}(h)|e_i \leq \hat{\alpha}x_i + |L^{-1}(h)|\hat{c}|x_i| \quad (6)$$

$$\hat{c} \geq 0, i = 1, \ldots, N \quad (7)$$

İn this paragraph the Poulsen method of fuzzification and Chen method for forecasting of time series data are also provided. Applying

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[3] *Gujarati, D.N. Basic Econometrics / D.N.Gujarati -NY: The McGraw-Hill Companies, -2004, -1003 p.*

[4] *Tanaka, H. Fuzzy data analysis by possibilistic linear models // Fuzzy Sets and Systems, -1987, 24, -p.363-375.*

these methods, the input variables of the fuzzy model and the forecast values are found.

It is also necessary to provide the theory of forecasting by fuzzy Markov chain in the research work. The basic rules of fuzzy Markov chain theory are given below[5].

Definition 1. Let $S = \{x_1, x_2, \dots, x_n\}$ be a finite set with cardinality *t*, and F is a fuzzy set on S. Then we represent F as a vector:

$$F = (F(x_1), F(x_2), \dots, F(x_t)) \quad (8)$$

When represented this way, we say that F is a fuzzy distribution. In the case of probabilities, we require that the sum of the values in the distribution be equal to 1. This is not true for a fuzzy distribution, but in practice we will often find that this is the case anyway.

Definition 2. A fuzzy relation on a finite set S is a fuzzy distribution on the Cartesian product $S \times S$. We can represent a fuzzy relation P as a matrix

$$P = \{P(x_i, x_j)\}_{i,j=1}^{t} \quad (9)$$

*Definition 3***.** Let $X = \{x_1, x_2, \dots, x_t\}$ be a finite state space with cardinality *n*. A fuzzy Markov chain on *X* is a sequence zənciri $x^{(0)} = x, x^{(1)}, x^{(2)}, \dots$ of fuzzy distributions that satisfy the following property:

$$x_j^{(t+1)} = \max_{1 \le i \le t} \left\{ \min\left\{ x_i^{(t)}, p(x_i, x_j) \right\} \right\} \quad (10)$$

$\forall\, j \in \{1, \dots, n\}$, where P is a fuzzy relation on $S \times S$.

The relationship between Markov chains and fuzzy Markov chains is clear. Indeed, any matrix representation of a Markov chain can also be thought of as a fuzzy Markov chain.

Aperiodic and a non–diminishing sequence of powers of Markov chain is convergent.

İn the last paragraph of the second chapter intuitionistic fuzzy sets (IFSs), their main characteristics, and operations on IFSs are provided.

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[5] *Avrachenkov, K.E. Fuzzy Markov Chains and decision-making / K.E. Avrachenkov, E.Sanchez // Fuzzy Optimization and Decision Making, -2002, 1(2), -p.143-159.*

Let's denote the universal set by X. The concept of fuzzy set defined by Lotfizade is expressed as follows:

$$F = \{(x, \mu_F(x)|x \in X)\} \qquad (11)$$

The membership function that determines this set is $\mu_F(x)$, and the degree of non-membership is assumed to be $1 - \mu_F(x)$. However, it is also important to determine the degree of hesitation when studying the opinion of experts in real life events. However, this characteristic was not taken into account in the fuzzy set. To address these drawbacks, Atanassov generalized the theory of fuzzy sets, including the degree of hesitation, and laid the foundations for the theory of intuitiionistic fuzzy sets (IFSs)[6].

An intuitionistic fuzzy set A in a finite set X is defined [4] as following:

$$A = \{(x, \mu_A(x), \nu_A(x)|x \in X)\} \qquad (12)$$

Where, $\mu_A(x): X \to [0,1]$ and $\nu_A(x): X \to [0,1]$ represent the membership and non-membership functions respectively, such that

$$0 \leq \mu_A(x) + \nu_A(x) \leq 1 \qquad (13)$$

For all x ∈ X.

The third parameter of the IFSs A is:

$$\pi_A(x) = 1 - \mu_A(x) - \nu_A(x) \qquad (14)$$

Then, $\pi_{A(x)}$ is called the indeterminacy degree or hesitation margin of whether x belongs to A or not.

Then, the following condition must hold

$$0 \leq \pi_A(x) \leq 1 \qquad (15)$$

If $\pi_A(x)$ is small, then knowledge about x is more certain; if $\pi_A(x)$ is great, then knowledge about x is more uncertain. Obviously, when $\mu_A(x) = 1 - \nu_A(x)$ for all elements of the universe, the traditional fuzzy set concept is recovered.

Let $\alpha_1, \alpha_2, \alpha_3$ be three IFVs, where $\mu_\alpha \in [0,1]$, $\mu_\alpha \in [0,1]$, $\nu_\alpha \in [0,1]$, $\mu_\alpha + \nu_\alpha \leq 1$. The following operations are hold[7]:

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[6] *Atanassov, K.T. Intuitionistic fuzzy sets // Fuzzy Sets Syst., -1986, 20, -p.87-96.*

[7] *Huchang, L. Intuitionistic Fuzzy Hybrid Weighted Aggregation Operators / L.Huchang, Z.S.Xu // International Journal of Intelligent Systems, -2014, 29, -p. 971- 993.*

$$\lambda\alpha = \left(1-(1-\mu_\alpha)^\lambda, \nu_\alpha^\lambda\right),\ \lambda>0 \quad (16)$$
$$\alpha^\lambda = \left(\mu_\alpha^\lambda, 1-(1-\nu_\alpha)\right),\ \lambda>0 \quad (17)$$
$$\sum_{j=1}^{n} \alpha_j = \left(1-\prod_{j=1}^{n}(1-\mu_{\alpha j}), \prod_{j=1}^{n} \nu_{\alpha j}\right) \quad (18)$$
$$\prod_{j=1}^{n} \alpha_j = \left(\prod_{j=1}^{n} \mu_{\alpha j}, 1-\prod_{j=1}^{n}(1-\nu_{\alpha j}),\right) \quad (19)$$

The third paragraph is **“Quality of life models and solution of relevant problems”**, İn this chapter the living standards in Azerbaijan is analyzed on the basis of statistical data, then on the basis of the share of food expenditures in income and the share of labor income in total income some provisions have been put forward[8].

Based on the Cobb-Douglas production function, it is theoretically determined that there is relationship between wages and labor productivity[9]:

ΔReal wages = ΔShare of labour + Δ Labor productivity

Logarithmic negative relationship between wages and unemployment is defined as following:

$$\ln w = -0.1 \ln U + \text{other variables}$$

It turns out that labor productivity is a factor that increases wages and reduces unemployment. It is evident from macroeconomics that the growth rate of labor productivity exceeds the growth rate of wages, and let to assume that the combined effect of these two factors will accurately determine the growth rate of wages. Then, we can functionally express the dependence of wages on labor productivity and unemployment as follows:

AH= f(AM, İS , u)

Here *AH* - wages, *IS* - unemployment rate variables. Based on the above given functional rationale, we can express the relationship as follows:

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[8] Aliyev, A.Z. Quality of life and wellbeing in Azerbaijan // “Labor, recruitment and agendas of social protection” Scientific conference dedicated to 20-th anniversary of the Research and Training Center for Labour and Social Problems under the Ministry of Labor and Social protection of People, -Baku: -20 october -2017, -p.169-172.

[9] Aliyev, A.Z. Life satisfaction models of social groups // -Baku: Sientific News of ASEU, -2018, № 6(6), -p.92,-107.

$$\ln AH = \beta_1 \ln AM + \beta_2 \ln \dot{I}S$$

The results obtained by the application of Eviews 7 software package (Table 1) show that, for social groups stratified on income, the models coefficients, especially the labor productivity coefficient, are highly statistically significant. As an example, the agricultural model is as follows:

$$Ln(AH) = 0.976505 * Ln(AM) - 1.529864 * Ln(IS)$$

Analysis of the model suggests that the labor productivity is a key factor in increasing wage income, which is a key domain in improving living standards. The increase in the unemployment rate has a negative effect.

Table 1. Wage model

Dependent Variable: LOG(EH)
Method: Least Squares
Date: 03/09/22 Time: 21:40
Sample: 1 16
Included observations: 16
LOG(EH)=C(1)*LOG(EM)+C(2)*LOG(IS)

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.976505	0.055936	17.45742	0.0000
C(2)	-1.529864	0.258579	-5.916420	0.0000

R-squared	0.899192	Mean dependent var	5.158052
Adjusted R-squared	0.891991	S.D. dependent var	0.657856
S.E. of regression	0.216203	Akaike info criterion	-0.108732
Sum squared resid	0.654410	Schwarz criterion	-0.012159
Log likelihood	2.869859	Hannan-Quinn criter.	-0.103787
Durbin-Watson stat	0.869736		

Analogically, the functional relationship of wages on labor productivity and unemployment is analyzed with possibilistic fuzzy regression[10]. The solution to the possibilistic fuzzy regression problem is to find intercept and coefficients, as in classical regression:

[10] *Aliyev, A.Z. Fuzzy models for forecasting wages in agriculture // -Baku: BEU Scientific News, -2020, № 1(4), -p.32-42.*

$$\widetilde{AH} = \widetilde{A_1} \cdot AM + \widetilde{A_2} \cdot IS$$

In this expression, regressand $\widetilde{AH}$ – is wage, and the coefficients A_1, A_2 - are fuzzy numbers. The results obtained with the application of possibility regression called Tanaka approach, were close to those obtained with classical models.

With the application of MATLAB 2018 software package, and using the *linprog* operator (f, A, b, Aeq, beq, lb, ub) designed for linear programming problems we solve possibilistic fuzzy regression problem at each α level in the model built for the agricultural sector. As a result we find the coefficients A_1, A_2 , which are also shown in the table 2:

Table 2. Coefficient values according to α - cuts

Coefficients		α- cuts			
		0.0	0.3	0.5	0.7
A_1	a_{1c}	0.0864	0.0864	0.0864	0.0864
	a_{1w}	0.0108	0.0154	0.0215	0.0358
A_2	a_{2c}	-10.3309	-10.3309	-10.3309	-10.3309
	a_{2w}	0.0318	0.0455	0.0636	0.1061

The fuzzy results obtained in the next stage can be expressed in crisp values, which is called defuzzification:

$$A^* = \frac{\sum_{r=1}^{R} A_r \alpha_r}{\sum_{r=1}^{R} \alpha_r} \qquad (20)$$

As a result, we find α levels values of wages and the real forecast values for 2021, which are illustrated in the following table:

Table 3. Forecasted wage values in agriculture.

Variantlar	Wages according to α- cts				Deffuzzified results in crisp values
	0	0.3	0.5	0.7	
Pessimistic	329.66	304.91	272.08	195.13	242.74
Average	387.78	387.78	387.78	387.78	387.78
Optimistic	445.90	470.66	503.48	580.44	532.83

In classical regression expressing the coefficients with average values reduces the accuracy of the forecast results. In fuzzy regression, however, these differences are regulated by confidence intervals found at α-levels. Another advantage of the results obtained by the fuzzy regression equation, which is more reasonable solution, is that the obtained number can be accurately expressed along with the lower and upper bounds. Based on the above, it can be considered that the results of solving the fuzzy regression problem are more acceptable and expedient than the results of the classical regression method for forecasting purposes.

One of the main issues addressed in this study is the fuzzy linguistic forecasting of social mobility. The researchers studying welfare, social inequality, and poverty concluded that these indicators are not always sufficient to comprehend. In order to gain a complete picture of wellbeing and its movement, it is necessary to study income mobility or change of population income over time. In this section Theil and Fields indices are calculated from many available methods for calculation of social mobility[11]. Using the Fields approach, the logarithmic mobility of gross per capita income can be calculated. The abovementioned method has been applied to social groups:

$$M\ (Y_{\omega}^{e}, X_{\omega}^{e}) = \sum_{i=1}^{n} (|\ln(y_i^e) - \ln(x_i^e)|)\omega_i \qquad (21)$$

Where, $i = 1, \dots, n$ is the number of income intervals within a social group (n is conditional and changes for each social group), x_i^e– is equivalent household income for income groups in the initial period, y_i^e- is equivalent household income for income groups in the final period.

The initial state vector S_{2020} = (0, 0.07, 0.47, 0.18, 0.04) of social mobility indices in the economic strata for the last period (2020) is in line with the linguistic social mobility vector (VL, L,VM, L, L). Where, added VL – very low, VM – very medium, VH – very high are concentrated forms of the above given terms. According to the analysis of transition graph, the matrix of transition from one economic stratum to another expressed in linguistic terms can be represented as follows:

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[11] *Imanov, G. J. Fuzzy Linguistic Forecasting of Social Mobility / G.J.Imanov, A.Z.Aliyev // The Journal of Economic Sciences: Theory and Practice, -2019, 2(76), -p. 4-28.*

$$T_{2020} = \begin{matrix} & S_1 & S_2 & S_3 & S_4 & S_5 \\ \begin{matrix} S_1 \\ S_2 \\ S_3 \\ S_4 \\ S_5 \end{matrix} & \multicolumn{5}{c}{\begin{pmatrix} VL & VL & VL & VL & VL \\ VL & VH & VL & VL & VL \\ VL & L & VH & L & VL \\ VL & VL & VL & VH & VL \\ VL & VL & VL & M & H \end{pmatrix}} \end{matrix}$$

The elements of the vector obtained through estimation of Fields index -S_i for the next year is defined as following:

$$S_i = \underset{n}{\cup}(S_i \wedge T_i) \qquad (22)$$

By estimation of elements S_i, the forecasted fuzzy linguistic vector is obtained:

$$S_{2021} = \text{(VL, L, VM, L, L)}$$
$$S_{2022} = \text{(VL, L, VM, L, L)}$$
$$S_{2023} = \text{(VL, L, VM, L, L)}$$

The elements of the vector S_{2021} are determined in the following order:

$S_1 = \cup[(VL \wedge VL), (VL \wedge VL), (VL \wedge VL), (VL \wedge VL), (VL \wedge VL)] = VL$
$S_2 = \cup[(L \wedge VL), (L \wedge VH), (L \wedge L), (L \wedge VL), (L \wedge VL)] = L$
$S_3 = \cup[(VM \wedge VL), (VM \wedge VL), (VM \wedge VH), (VM \wedge VL), (VM \wedge VL)] = VM$
$S_4 = \cup[(L \wedge VL), (L \wedge VL), (L \wedge L), (L \wedge VH), (L \wedge M)] = L$
$S_5 = \cup[(L \wedge VL), (L \wedge VL), (L \wedge VL), (L \wedge VL), (L \wedge H)] = L$

The results show that there has been any changes in the mobility indices of social strata. The inexistence of change in other social strata mobility indices is due to the fact that the transition matrix covers only recent data. If the transition matrix is ideal, that is, if the transition from the very poor to the poor, from the middle to the upper class and staying in the upper class is high (H), the other transitions are medium (M), then the mobility indices for social classes will converge at the medium (M) level. This means a sustainable and ideal state of social mobility.

The forecast for next year carried out by fuzzy linguistic Markov chain suggest that there will be no significant change. As high mobility indexes indicate that there is no need for redistribution of income in society, research in this area can be useful in the development of social policy programs.

One of the main issues addressed in this chapter is the intuitionistic fuzzy assessment of quality of life (QOL). İn the evaluation of QOL multiple criteria decision making (MCDM) and intuitionistic fuzzy aggregation instruments were employed. In this research, the novatory intention is to incorporate criteria weights along with data weights in the assessment QOL with the application of intuitionistic fuzzy hybrid weighted operator (IFHWA)[12]. In the course of decision making with IFSs, aggregation operators play a very important role since they can be used to synthesize multidimensional evaluation values represented as intuitionistic fuzzy values into collective values. All intuitionistic fuzzy weighted averaging (IFWA) operators can be used to fuse intuitionistic fuzzy values (IFVs) into an overall IFV, and different operators have different properties and applicable scopes. Note that the IFWA operators can be used to weight the intuitionistic fuzzy arguments but ignore the importance degrees of the ordered positions of the arguments. The IFHWA operators overcome this drawback and weight both the given arguments and their ordered positions simultaneously.

The Economist Intelligence Unit identified the following nine factors that best predict QOL:

- ❖ Material Wellbeing (MW) - Measured by GDP per capita.
- ❖ Health (H) - Measured by life expectancy at birth.
- ❖ Political Stability and Security (PS) - Measured by political and security ratings developed by the EIU.

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[12] *Imanov, G. J. Intuitionistic Fuzzy Assessment of Quality of Life / G.J.Imanov, A.Z.Aliyev // Advances in Intelligent Systems and Computing, -2020, 14(1306), -p. 174-182.*

- ❖ Political Freedom (PF) - Measured by the Freedom of the World Index.
- ❖ Family Life (FL) - Measured by the divorce rate.
- ❖ Community Life (CL) - Measured through church attendance or union membership.
- ❖ Climate and Geography (CG) - Measured by latitude to distinguish between warm and cold climates.
- ❖ Job Security (JS) - Measured by the unemployment rate.
- ❖ Gender Equality (GE) - Measured by the ratio between female to male average earnings.

As the data collected on these factors are measured in different units, their aggregation is not possible, so these indicators should be initially normalized. Normalized data are converted into intuitionistic fuzzy numbers (IFNs) by the following intuitionistic fuzzy triangular function - *iftrif*:

$$\mu_A(x) = \begin{cases} 0 & ; \\ \left(\frac{x-a}{b-a}\right) - \epsilon; & \\ \left(\frac{c-x}{c-b}\right) - \epsilon; & \\ 0 & ; \end{cases} \quad \nu_A(x) = \begin{cases} 1-\epsilon & ; \quad x \le a \\ 1-\left(\frac{x-a}{b-a}\right); & a < x \le b \\ 1-\left(\frac{c-x}{c-b}\right); & b \le x < c \\ 1-\epsilon & ; \quad x \ge c \end{cases} \qquad (23)$$

Normalization of positiv and negative indicators constituting QOL are coded in C# as following:

```
   namespace Data_Normal_
{
   internal class Program
{
   static void Main(string[] args)
{
   // n - göstəricilər(sütunlar üzrə)
   // m - illər üzrə göstəricilərin qiymətləri
(sətirlər üzrə)
   int n = int.Parse(Console.ReadLine());
   int m = int.Parse(Console.ReadLine());
   string[] göstəricilər = { "Maddi təminat",
"Səhiyyə", "Siyasi stabillik və təhlükəsizlik",
"Siyasi azadlıq", "Ailə həyatı", "ictimai həyat",
```

```
"İqlim və coğrafi şərait","Əməyin təhlükəsizliyi",
"Gender bərabərliyi"};
   int[] göstəricitəsiri = {1,1,1,0,0,1,1,0,0};
   float[,] a = new float[n, m];
   float[,] b = new float[n, m];
   float[,] min = new float[n, m];
   float[,] max = new float[n, m];
   Console.WriteLine("göstəricilərin    qiymətlərini
illər üzrə daxil edin:");
   for (int i = 0; i < n; i++)
{
   Console.WriteLine(göstəricilər[i]);
   for (int j = 0; j < m; j++)
{
   a[i, j] = float.Parse(Console.ReadLine());
}
}
   Console.WriteLine("göstəricilərin          minimum
qiymətlərini illər üzrə daxil edin:");
   for (int i = 0; i < n; i++)
{
   Console.WriteLine(göstəricilər[i]);
   for (int j = 0; j < m; j++)
{
   min[i, j] = float.Parse(Console.ReadLine());
                }

 }
    Console.WriteLine("göstəricilərin        maksimum
qiymətlərini illər üzrə daxil edin:");
    for (int i = 0; i < n; i++)
{
    Console.WriteLine(göstəricilər[i]);
    for (int j = 0; j < m; j++)
{
    max[i, j] = float.Parse(Console.ReadLine());
}

}

    for (int i = 0; i < n; i++)
{
```

```
    for (int j = 0; j < m; j++)
{
    if (göstəricitəsiri[i]==1)
    b[i, j] = (a[i, j] - min[i, j]) / (max[i,j] -
min[i,j]);
    else
    b[i, j] = (max[i, j]- a[i, j]) / (max[i, j] -
min[i, j]);
                }
}
    for (int i = 0; i < n; i++)
{
    for (int j = 0; j < m; j++)
{
    Console.Write(b[i, j] + " ");
}
    Console.WriteLine();
}
```

Let to assume that, $D_k = [\mu_k, \nu_k, \pi_k]$ k-th decision makers (DM) opinion as intuitionistic fuzzy number. Then, k-th decision makers weight is estimated as following :

$$\lambda_k = \frac{(\mu_k + \pi_k(\frac{\mu_k}{\nu_k}))}{\sum_{i=1}^{l}(\mu_i + \pi_i(\frac{\mu_i}{\nu_i}))} \qquad (24)$$

Where, $\sum_{k=1}^{l} \lambda_k = 1.$

In the next step, considering weights of QOL data converted into IFVs, and aggregation associated weights of criteria, data on life objects (domains) converted into IFVs are aggregated, and as a result IFNs, having linguistic analogue defining QOL level for each year is obtained.

For a collection of IFVs $\alpha_j = (\mu_{\alpha_j}, \nu_{\alpha_j})$ (j= 1,2,…,n), the aggregated value by using the IFHWA operator is also an IFN, and

$$IFHWA_{\lambda,\omega} = \left[1 - \prod_{j=1}^{n}\left(1-\mu_{\alpha_j}\right)^{\frac{\omega_{\varepsilon(j)}\lambda_j}{\sum_{j=1}^{n}\omega_{\varepsilon(j)}\lambda_j}}, \prod_{j=1}^{n}\left(\nu_{\alpha_j}\right)^{\frac{\omega_{\varepsilon(j)}\lambda_j}{\sum_{j=1}^{n}\omega_{\varepsilon(j)}\lambda_j}}\right] \quad (25)$$

Where, $IFHWA_{\boldsymbol{\lambda},\boldsymbol{\omega}} = (\mu_{A_i}(x_j), \nu_{A_i}(x_j), i = 1,2,\dots,m; j = 1,2\dots,n.)$ and $\omega = (\omega_1, \omega_2, \dots, \omega_n)^T$ is an associated weighting vector with $\omega_j \in [0,1]$ and $\sum_{j=1}^{n}\omega_j = 1$, $\varepsilon : \{1,2,\dots,n\} \to \{1,2,\dots,n\}$ is the permutation such that α_j is the $\varepsilon(j)$th largest element of the collection of IFVs $\alpha_j(j = 1,2\dots,n)$, and $\lambda = (\lambda_1, \lambda_2, \dots, \lambda_n)^T$ is the weighting vector of the IFVs $\alpha_j(j = 1,2\dots,n)$, with $\lambda_j \in [0,1]$ and $\sum_{j=1}^{n}\lambda_j = 1$.

The results of the calculations are given in the following table:

Table 4. Intuitionistic fuzzy hybrid weighted average results

№		2014	2016	2018	2020
1	$IFHWA_{\lambda,\omega}$	(0.56,0.34)	(0.54,0.36)	(0.53,0.36)	(0.48,0.41)

The results as aggregated intuitionistic values are not quite enough to comprehend and deduce reasonable conclusions. To this end, interval value intuitionistic fuzzy scale (IVIFS) that could reflect humanistic perception for rating the QOL was used.

Table 5. Linguistic scale and Its corresponding IVIFS

Linguistic terms	**Membership and non-membership values**
Absolutely high (AH)	([0.85, 0.90], [0.00, 0.10])
Very high (VH)	([0.75, 0.85], [0.10, 0.15])
High (H)	([0.65, 0.75], [0.15, 0.25])
Medium high (MH)	([0.55, 0.65], [0.25, 0.35])
Medium (M)	([0.45, 0.55], [0.35, 0.45])
Medium low (ML)	([0.35, 0.45], [0.45, 0.55])
Low (L)	([0.25, 0.35], [0.55, 0.65])
Very low (VL)	([0.15, 0.25], [0.65, 0.75])
Absolutely low (AL)	([0.10, 0.15], [0.75, 0.85])

Referring to table 5, IFVs obtained by the application of $IFHWA_{\lambda,\omega}$ matched with their corresponding linguistic terms. Obtained results reflect Aggregated Quality of Life Index over years:

AQLI(2014) = Medium High (MH)
AQLI(2016) = Medium (M)
AQLI(2018) = Medium (M)
AQLI(2020) = Medium (M)

In this research, we have estimated QOL as a problem of MCDM with the application of IFS. The notion of IFS can handle both vagueness and ambiguity (non-specifity) type of uncertainties. Concept of IFS is suitable to convert crisp data into intuitive fuzzy data, then aggregate and deduce a result. For this purpose, we used IFHWA operator, which fuses IFVs into an overall IFV considering argument weights and aggregation – association weights of criteria. The obtained data are compatible with intuitionistic linguistic values that replicate real human decisions. This approach can be useful in elaborating sustainable macroeconomic development policies by improving the QOL across life objects (domains) and reducing poverty.

In the last paragraph of the third chapter, preference of expert opinions (PEO) on social capital using Z-number theory and methods was considered[13]. The application of Z-numbers is more efficient in solving PEO - type problems. With this purpose, Kang's modified method of generation Z-number based on ordered weighted average and maximum entropy method was applied[14]. The proposed method can be useful in solving relevant socio-economic problems.

In this paper we evaluate Azerbaijan SC indicators proposed by two experts. In an effort to develop social capital indicators (SISC) presented by UN Basel Institute of Commons and Economics, the Healthcare and Corruption indicators were also added to the list:

1. Social climate – **SC**
2. The interpersonal trust among the people – **TR**
3. Interest of the people to take individual strict measures with a

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[13] Imanov, G. Z - numbers Based Preference of Expert Opinions on Social Capital / G. Imanov, M. Murtuzaeva, and A. Aliyev // Switzerland, Lecture Notes in Networks and Systems 362, -2021, p.59-66.

[14] Tian, Y. A modified method of generating Z-number based on OWA weights and maximum entropy / Y.Tian, B. Kang, B // Soft Comput., -2020, 24, 15841-15852.

view to fund public goods – **PG**
4. Interest of the people to be involved in paying more taxes and making contributions to fund public goods – **PT**
5. Willingness of the people for adding up to national and regional level investments – **IE**
6. Helpfulness of the people – **HE**
7. Friendliness of the people – **FR**
8. Hospitality of the people – **HO**
9. Healthcare – **HL**
10. Corruption – **CO**

The expert opinions are expressed in zero to ten scale [0-10] respectively, where 0 – very bad and 10 – very high, which are represented in table 6.

Table 6. Expert opinions in crisp values

	SC	TR	PG	PT	IE	HE	FR	HO	HL	CO
Expert. Opinion 1	6	6	5	5	7	9	8	9	6	7.5
Expert. Opinion 2	9	9	5	6	6	10	10	10	7	9

For every version, experts were proposed three scenarios of weight distributions:

normative - W^1[0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1],
intuitionistic- W^2[0.04,0.04,0.15,0.15,0.19,0.07,0.17,0.07,0.04,0.08]
optimistic - W^3[1,0,0,0,0,0,0,0,0,0].

The ORNESS measure that evaluates each expert's attitude (W) is expressed by the following formula:

$$ORNESS(W) = \alpha = \frac{\sum_{i=1}^{n}(n-i) * w_i}{n-1} \qquad (26)$$

where w_i (i=1,2,..,10) are components of the vector W^i (i=1,2,3).
For normative distribution ORNESS α_1 is calculated as:

$$\alpha_1 = \frac{1}{9}\sum_{i=1}^{10}(n-i) * w_i = \frac{1}{9} * \frac{1}{10}\sum_{i=1}^{10}(10-i) = \frac{45}{90} = 0.5$$

Following the same rule α_2, α_3 are calculated:

$$\alpha_2 = 0.505, \qquad \alpha_3 = 1$$

Using the maximum entropy formula, the vector of the probability distribution of the options accepted by the expert can be calculated, that is, using α_i $(i = 1,2,3)$ the following optimization problem is solved:

$$\max H(W) = -\sum_{i=1}^{n} w_i * \ln(w_i)$$
$$\text{s.t} \quad \begin{cases} \alpha = \frac{\sum_{i=1}^{n}(n-i)*w_i}{n-1} \\ \sum_{i=1}^{n} w_i = 1 \\ 0 \le w_i \le 1 \end{cases} \qquad (17)$$

Afterwards, the probability for the constraint part A is denoted as:

$$p_X(x_i) = w_{n-i+1}$$

As a result, referring to papers the following outcomes are obtained:

P_N= [0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1],

P_i= [0.04,0.04,0.15,0.15,0.19,0.07,0.17,0.07,0.04,0.08],

P_O = [0,0,0,0,0,0,0,0,0,1]

Expert opinions on SC indicators which proposed by expert I and II given in crisp values are fuzzified, using fuzzy triangle membership function, which is given in table 2.

Table 2. Membership function values of expert opinions on SC indicators

	SC	TR	PG	PT	IE	HE	FR	HO	HL	CO
I Expert Opinion	0.89	0.89	0.89	0.89	0.67	0.22	0.44	0.22	0.89	0.55
II Expert Opinion	0.67	0.67	0.89	0.89	0.89	0.00	0.00	0.00	0.67	0.67

By utilizing indicators from table 2, the constraint part (A_i) of Z-number for normative attitude is calculated as below:

$$A_1 = \frac{\mu_{A_1}}{x} = \frac{0.89}{6} + \frac{0.89}{6} + \frac{0.89}{5} + \frac{0.89}{5} + \frac{0.67}{7} + \frac{0.22}{9} + \frac{0.44}{8} + \frac{0.22}{9} + \frac{0.89}{6} + \frac{0.55}{7.5}$$

$$A_2 = \frac{\mu_{A_2}}{x} = \frac{0.67}{9} + \frac{0.67}{9} + \frac{0.89}{5} + \frac{0.89}{5} + \frac{0.89}{5} + \frac{0.00}{10} + \frac{0.00}{10} + \frac{0.00}{10} + \frac{0.67}{7} + \frac{0.67}{9}$$

Fuzzy probability of the argument X for the constraint part A_1, A_2, are calculated:

$$\frac{P_x(x_i)*\mu_{A_1}(x_i)}{x_i} = \frac{0.89*0.1}{6} + \frac{0.89*0.1}{6} + \frac{0.89*0.1}{5} + \frac{0.89*0.1}{5} + \frac{0.67*0.1}{7} + \frac{0.22*0.1}{9} + \frac{0.44*0.1}{8} + \frac{0.22*0.1}{9} + \frac{0.89*0.1}{6} + \frac{0.55*0.1}{7.5}$$

$$\frac{P_x(x_i)*\mu_{A_2}(x_i)}{x_i} = \frac{0.67*01}{9} + \frac{0.67*0.1}{9} + \frac{0.89*0.1}{5} + \frac{0.89*0.1}{5} + \frac{0.89*0.1}{5} + \frac{0.00*0.1}{10} + \frac{0.00*0.1}{10} + \frac{0.00*0.1}{10} + \frac{0.67*0.1}{7} + \frac{0.67*0.1}{9}$$

On the base of calculation $P(A)$, the quantity of b of the reliability part (B) is obtained by formula:

$$b = p(A) = \int_R \ \mu_A(x)p_X(x)dx, b \in B \qquad (28)$$

Herein, R is the domain of real numbers.
The quantity of reliability part of B for expert I and II are:

$$b_1^1 = P(A_1^1) = 0.655$$
$$b_2^1 = P(A_2^1) = 0.651$$
$$b_3^1 = P(A_3^1) = 0.55$$
$$b_1^2 = P(A_1^2) = 0.535$$
$$b_2^2 = P(A_2^2) = 0.565$$
$$b_3^2 = P(A_3^2) = 0.67$$

Here, $i = 1,2,3$ (subscripts) denote weight distribution versions, $j = 1,2$ (superscripts) denote experts.

As evidenced from calculations the degrees of fuzzy membership functions equal to the value of *ORNESS*:

$$\mu_B(x) = \mu_{p_A}(p_A) = k\alpha_1$$
$$\mu_{B_1 =} \mu_{PA_1(P_{A_1})} = \alpha_1 = 0.5;$$
$$\mu_{B_2 =} \mu_{PA_2(P_{A_2})} = \alpha_2 = 0.505$$
$$\mu_{B_3 =} \mu_{PA_3(P_{A_3})} = \alpha_3 = 1$$

To establish the most reliable version of expert opinions, the distance measures between the obtained probability distributions, the degrees of similarity and credibility have to be calculated. The Hellinger distance for discrete probability distributions is calculated by the following formula:

$$D_H(P,Q) = \frac{1}{\sqrt{2}} \sqrt{\sum_{i=1}^{n}(\sqrt{p_i} - \sqrt{q_i})^2} \qquad (29)$$

All possible distances between distributions are also calculated and the following values are obtained:
$D_H(P_1, P_2) = 0.185, \quad D_H(P_1, P_3) = 0.805, \quad D_H(P_2, P_3) = 0.843$
Constructed elements of similarly matrix between three probability distribution (5) defined as:

$$Sim(p_i, p_j) = 1 - D_H(p_i, p_j) \tag{30}$$

The obtained values are:
$Sim\ P_{12} = 0.815, \quad Sim\ P_{13} = 0.195, \quad Sim\ P_{23} = 0.157$
On the base of results obtained above the similarity measure matrix (SMM) is constructed as follows:

$$\text{SMM}=\begin{pmatrix} 1.00 & 0.815 & 0.195 \\ 0.815 & 1.00 & 0.157 \\ 0.195 & 0.157 & 1.00 \end{pmatrix}$$

The support degree $Sup\ (P_j)$, is defined by the following formula:

$$Sup(P_j) = \sum_{\substack{i=1 \\ i \neq j}}^{n} Sim(P_i, P_j) \tag{31}$$

As a result:

$$Sup(P_1) = 0.815 + 0.195 = 1.01$$
$$Sup(P_2) = 0.815 + 0.157 = 0.972$$
$$Sup(P_3) = 0.195 + 0.157 = 0.352$$
$$\sum_{i=1}^{3} Sup(P_i) = 2.334$$

Creditability degree of probability distributions is defined by formula:

$$crd_j = \frac{Sup(P_j)}{\sum_{j=1}^{n} Sup(P_j)} \ , \ (i = 1,2,3) \tag{32}$$

That can be employed as weight and transformed into discount coefficient to get the membership degree of the reliability part B. The outcomes appear as follows:

$$crd_1 = \frac{1{,}01}{2{,}334} = 0{,}433$$
$$crd_2 = \frac{0{,}972}{2{,}334} = 0{,}416$$

$$crd_3 = \frac{0,352}{2,334} = 0,151$$

The membership degree for reliability part (B) of Z-number is defined as :

$$\mu_B^j(x) = \frac{k*\alpha_j*crd_j}{max(k*\alpha_j*crd_j)} \qquad j = (\overline{1,,n}) \qquad (33)$$

In this research, for the sake of simplicity, the relation coefficient k between orness measure and membership function of B is set: $k = 1$

$$\alpha_1 = 0.5, \quad \alpha_2 = 0.505, \quad \alpha_3 = 1$$

$$k*\alpha_1*crd_1 = 0.439*0.5 = 0.2165$$

$$k*\alpha_2*crd_2 = 0.505*0.416 = 0.2101$$

$$k*\alpha_3*crd_3 = 1*0.151 = 0.151$$

$$\mu_{B_1}(x) = \frac{0.5*0.433}{0.2165} = 1$$

$$\mu_{B_2}(x) = \frac{0.505*0.416}{0.2165} = 0.9703$$

$$\mu_{B_3}(x) = \frac{0.151*1}{0.2165} = 0.692$$

In the end, the generated Z-numbers have been developed all-inclusive. This allows one to choose the most reliable option with the maximum value of the B part of the Z-number, which corresponds to the normative option. For the normative attitude, the obtained values of the Z-numbers for both experts are as followings:

$$B_1^1 = 0.5/0.655 \qquad B_1^2 = 0.5/0.535$$

It is obvious that both expert opinions have equal membership degree for the normative option. But, the opinion of the I expert is preferred due to the greatest reliability.

CONCLUSION

The main scientific results obtained in the dissertation are the followings:

1. The standard of living and quality of life in Azerbaijan were analyzed using panel indicators and the Engel curve for the years 2005-2020. As a result, it was revealed which areas are developing and

which areas need attention.

2. Factors on which wage incomes depend in agricultural sector of Azerbaijan, especially labor productivity, were analyzed. To get a clear picture, a comparison was made with the agricultural sector of the Netherlands. As can be seen, despite the fact that the area is almost as half, the population is twofold, the number of people working in this field is 8.77 times less, the volume of agricultural production is 6.74 times larger, the amount of output per employee is many times higher. This shows how important labor productivity is and has a significant impact on incomes, including wages.

3. The stratification of the workers in Azerbaijan into social classes was carried out. As can be seen, 71.21% of the working people belong to the poor class, 22.3% belong to the low-income class.The relationship of the wages and with the factors that make them up in the mining, processing, education, and healthcare sectors, and especially in agricultural sector which have a higher weight regarding the number of employees, was investigated by building econometric models. An analysis was carried out to determine the factors that can increase wages, such as the possibility of providing social groups with life objects. It was determined that the main factor that can increase wage income is labor productivity, which requires scientific and technical innovation, diversified investments and the introduction of skilled labor.

4. Similar results were obtained with the solution of the above-mentioned problem as a fuzzy linear regression problem. In any case, we conclude that labor productivity is an important factor in improving the quality of life, and in a broader sense, in building a productive society.

5. In the dissertation, the mobility index and indicators of social groups for 2009, 2013, 2017 were calculated separately based on the methods proposed by Theil, Fields and Ok. Mobility indices were found to be very low for the poor, medium for the middle class, and low for the rest. The forecast for the next year through the fuzzy linguistic Markov chain shows that there will be no significant change.

6. In the dissertation, the quality of life in Azerbaijan for the years 2014-2020 was calculated based on an intuitionistic fuzzy model. The

concept of IFSs is suitable do deal with both uncertain and ambiguous types of information. From this point of view, the concept of IFSs is suitable in convertion of real numbers into intuitionistic fuzzy numbers and aggregation.

7. In this study, we proposed a solution to the problem of QOL as a problem of MCDM with the application of IFSs. For this purpose, the IFHWA operator is used, which converts the IFNs to the total IFVs, taking into account the weights of the data and the weights of the factors that determine the QOL. By converting the obtained results - IFNs into linguistic intuitionistic fuzzy terms are suitable for human perception.This approach can be useful in developing sustainable macroeconomic development policies and poverty reduction programs by raising QOL based on the factors that determine it.

8. At the end of the research work, the problem of preference of expert opinions (PEO) in the assessment of social capital was solved. For this purpose, a model of the PEO problem was developed using fuzzy Z-number theory and methods.

The main results of the dissertation were published in the following scientific works:

1. Aliyev, A.Z. Comparative analysis of labor productivity in the agricultural sector of Azerbaijan // By the support of Ministry of Education of the Republic of Azerbaijan, Azerbaijan Technical University, Union of Economists of Azerbaijan, Republican scientific conference on "Expansion of innovation activities in non-oil sector of Azerbaijan" dedicated to the 80th anniversary of prominent economist, state award winner, dr., prof., Shamil Aliabbas oglu Samadzade, Baku: March 10, 2016;

2. Aliyev, A.Z. Regression analysis of social groups based on income stratification in Azerbaijan // Scientific Research and Training Center for Labor and Social Problems under the Ministry of Labor and Social Protection of Population of the Republic of Azerbaijan, -2017, № 1(19), -p.160-165.

3. Aliyev, A.Z. Life standards and quality of life in Azerbaijan // International scientific-practical conference on "Current problems of labor, employment and social protection" dedicated to the 20th

anniversary of the Scientific Research and Training Center for Labor and Social Problems under the Ministry of Labor and Social Protection of Population of the Republic of Azerbaijan, Baku: October 20, 2017;

4. Aliyev, A.Z. Basic terms and statistical tests in the construction of econometric models // International scientific-practical conference on "Development of the social protection system in Azerbaijan: yesterday, today and tomorrow", dedicated to the 100th anniversary of the Ministry of Labor and Social Protection of Population of the Republic of Azerbaijan, Baku: December 26, 2018;

5. Aliyev, A.Z. Life satisfaction models of social groups // Scientific News of Azerbaijan State University of Economics, Vol. 6, -2018, -p.92-107.

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7. Imanov G. J. Fuzzy linguistic forecasting of social mobility / G.J. Imanov, A.Z. Aliyev // The Journal of Economic Sciences: Theory and Practice, v.76, № 2, 2019, pp. 4-28

8. Imanov, G. J., Aliyev A.Z. Intuitionistic Fuzzy Assessment of Quality of Life // 14th International Conference on Theory and Application of Fuzzy Systems and Soft Computing – ICAFS-2020, Antalya, Türkiye, -p. 174-182.

9. Imanov, G. Z - numbers Based Preference of Expert Opinions on Social Capital / G. Imanov, M. Murtuzaeva, and A. Aliyev // Switzerland, Lecture Notes in Networks and Systems 362, -2021, -p.59-66.

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