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## Evaluation of the impact of the tax legislation reforms on the tax potential by fuzzy inference method

Akif Musayev<sup>a</sup>, Shahzada Madatova<sup>b</sup>, Samir Rustamov<sup>c\*</sup>

<sup>a</sup> Institute of Control Systems, Baku AZ1000, Azerbaijan

<sup>b</sup> Azerbaijan State University of Oil and Industry, Baku AZ1000, Azerbaijan,

<sup>c</sup> ADA University, Baku AZ1008, Azerbaijan, Institute of Control Systems, Baku, AZ1000, Azerbaijan

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### Abstract

In the paper the Mamdani-Type Fuzzy inference method is applied for the expert evaluation of the impact of the tax legislation reforms on the tax potential. The model being investigated includes 4 inputs, 8 IF-THEN rules and a single-output. Triangle, trapezoid, Gaussian and Bell-shaped membership functions are used for the fuzzification of input data and output of the system is evaluated by Gaussian curve membership function. For the investigated year the laws made reforms in the Azerbaijan tax legislation are classified and evaluated on the base of fuzzy inference system.

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*Keywords:* tax legislation; Mamdani-type fuzzy approach; membership functions; defuzzification methods; IF-THEN rules.

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### 1. Introduction

Tax policy means a set of economic, financial and legal measures carried out by the country in order to ensure financial statements of different social groups of the state and public as well as to develop country's economy normally due to the redistribution of financial resources. Implementation of tax policy by the state is based on the functions pertaining to taxes and it uses these functions to carry out active fiscal policy. Different methods are used for the implementation of fiscal policy depending on the country's economic situation and the objectives considered

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\* Corresponding author, Tel.: +994505242700

E-mail address: [samir.rustamov@gmail.com](mailto:samir.rustamov@gmail.com)

priority on a certain stage of economic development. Being an integral part of the government's economic policy tax policy considerably depends on the forms and methods of its implementation.

Basic principles of the state's tax policy, especially the principle for general, equal and fair implementation of taxation have been reflected in Tax Code of the Republic of Azerbaijan remaining in the force since January 1, 2001. New Tax legislation significantly reduced tax rates and reduced the tax benefits of different categories. It should be noted that tendencies for the reduction of tax incentives have increased recently by lowering tax rates internationally. One other advanced features of the new tax legislation is accurate provision of the date, amount and rules of taxes in Tax Code.

It is known that perfect tax legislation does not exist and therefore as a result of its tax obligations minimization the state loses a certain amount without prejudice to legislation taking advantage of loopholes in the tax laws by taxpayers. These funds form a part of the economy's tax potential used in the plural. Using loopholes in the legislation by taxpayers is called "tax planning" (VAB) in Economic literature.

Taxation problems are one of the most important problems paid special attention by experts as well as institutions at all stages of human history of formation of economic relations and the state human history.

This problem is even more urgent for the economy of any country in the current stage of economic development. Thus, the processes created by the globalization of economic relations are of extraordinary importance for assessment of the tax system impact and creation of competitive, innovative national economy. Being of special importance for optimization of taxation, economic development, economy of real and public sector, its advanced theoretical basis have been created in the nineteenth century and today they are being developed<sup>1-3</sup>.

Researches show that there is a direct link between sustainable economic development and tax potential i.e. the tax burden of economy and the perfect tax legislation and administration, knowledge level of the population about the economy and the taxes and the like factors have serious impact on this dependence. Therefore, the main purpose shouldn't be increasing the tax burden but it should be correct assessment of the tax potential formed by economic system and maximizing its collection rates in terms of optimization of taxation.

The collection level of tax potential formed by the economy depends on the tax system, the basics of taxation, tax identification, payment and collection rules, taxpayers and the tax authorities, as well as the tax legislation and tax administration covers complaint rules on the other participants of tax relations rights and obligations with regard to taxation, tax control forms and methods, responsibility for violation of tax laws and the tax authorities and their officials' activities (inactivity).

Fuzzy inference system is very powerful tool that applied in evaluation of different kind of complex systems and decision processes<sup>12-22</sup>. We applied fuzzy inference method to the evaluation of the impact of the tax legislation reforms on the tax potential. The main focus of the study has been aimed at assessing the state's legislative and administrative efforts and as a result a methodological approach has been proposed using medium-term forecast methodology, tax recovery and tax flexibility factors through time series to determine the current and forecast prices of these efforts.

In the paper Mamdani-Type fuzzy inference system with 4 input, 8 IF-THEN rule and a single output used in the evaluation of impact of Azerbaijan tax legislation reforms on Azerbaijan tax potential has been studied. In the problem being investigated the purpose of taking the data of 2012 is having more changes and amendments made to the Azerbaijan tax legislation compared to other years.

### *1.1. Tax potential*

Tax potential represents the maximum sum of taxes and fees to be paid by a state or a taxpayer under existing tax and other similar legislation during a certain time. The assessment object of tax potential may be country, territory, region, district, municipality, customs territory, organization, firm, separate legal entities and individuals. At the same time, evaluation of the total capacity can be conducted on taxes and fees proposed in the legislation in the mentioned objects separately and together with all tax payments<sup>5-7</sup>.

Tax potential of the state is determined by the situation of its economic system and tax legislation of foreign trade, tax administration and as a whole tax policy. Put another way, tax policy factor - one of an important element of the structure of tax relations that influences its capacity should be taken into account during the assessment of tax potential.

Implementation of tax policy in different ways causes significantly different outcomes during the evaluation of tax potential. Therefore, tax potential should be understood as the sum of financial resources that can be mobilized through the taxation system formed by tax policy determined by the legislation.

## 2. Application of the Fuzzy Inference method to the evaluation of the impact of the tax legislation reforms on tax potential

Fuzzy inference is the mapping process to the output element of the input data on the base of fuzzy logic. The decision is made on the base of the samples given at the end of this mapping. Fuzzy inference with 4 input, 8 IF-THEN rules and single output is looked through in the expert evaluation of the impact of the Azerbaijan tax legislation reforms made in 2012 in the problem being studied. In the problem being studied the purpose of taking the data of 2012 is having more reforms made to the tax legislation compared to other years (fig.1).

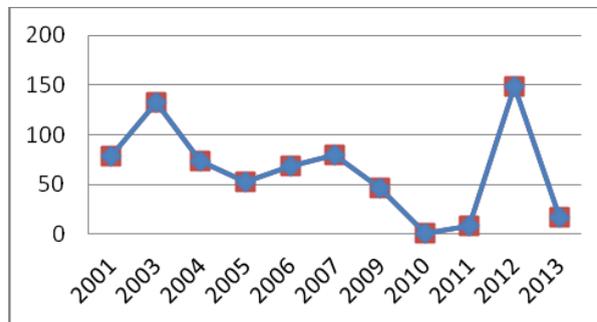


Fig. 1. The dynamics of the reforms of Azerbaijan tax legislation per years.

### 2.1. Pre-processing of the data

Taking into account the expert opinions the reforms made to tax legislation in 2012 conditionally are divided into four groups according to the potential impact: “much less important”, “less important”, “important”, “very important” laws. With the exception of “much less important” laws other classified laws are given in tables 1-3. In the constructed system the numbers evaluated between 0-100 intervals by 18 economic experts are taken as input data for the impact of the reforms made to the tax legislation on the tax potential. In its turn, being evaluated by other experts, the conducted evaluation has been included the accuracy weight coefficients. These weight coefficients are multiplied by input data price and at the end the average value for each input data has been found. Looking at average values, the values of some laws were found to have a large dispersion. The expert values with such variances have been reviewed, and the data that outlier to the average value have been removed from the Data Base. Note that, such kind of abnormality has been come across in the “less important laws” group.

Table 1. According to the expert opinion “less important” laws, average value of their expert evaluation and variance of expert value.

#	Tax legislation reforms	Average value	Variance	New average value	New variance
1	Article 65.2	19.2	23.9	20.4	0.99
2	Article 76	20	1.2	20	1.2
3	Article 124.4	28.7	41.9	30.2	0.8
4	Article 159.5	10.1	0.3	10.1	0.3
5	Article 159.10	27.2	65.1	29.9	0.9
6	Article 175.6.	18.8	22.4	19.9	0.3
7	Article 211.1.1.1	19.2	12.7	20.1	0.1
	The average value of the group	20.5		21.5	

Table 2. According to the expert opinion “less important” laws, average value of their expert evaluation and variance of expert values.

#	Laws	Average value	Variance
1.	Article 96.1	43.1	2.4
2.	Article 101.4	42.3	2.3
3.	Article 23.1.13	40.8	2.3
4.	Article 13.2.16.17-1	40.7	2.3
5.	Article 15.1.15-1	47.1	2.6
6.	Articles 16.1.11 -1 and 16.1.11 -2	45.7	2.5
7.	Article 16.3	45.8	2.5
8.	Article 23.1.2	42.4	2.4
9.	Article 195.3	38.6	2.1
	The average value of the group	42,9	

Table 3. According to the expert opinion “less important” laws, average value of their expert evaluation and variance of expert values.

#	Laws	Average value	Variance
1	Article 50-1;	81.9	4.5
2	Article 155.1	67.7	3.8
3	Article 157.3.1	64.9	3.6
4	Article 158.2.	58.6	3.3
5	Article 211.1.2.	58	3.2
	The average price of the group	66.2	

Let's denote the groups of “much less important”, “less important”, “important”, “very important” laws by  $X_1$ ,  $X_2$ ,  $X_3$  and  $X_4$  respectively. And let's denote the impact of the reforms made to the tax legislation on the tax potential by  $Y$ .

8 rules have been determined in the expert evaluation of the impact of the reforms made to the tax legislation on the tax potential (table 4). The rules have been composed and realized in Matlab “Fuzzy Inference System” program package.

Table 4. IF-THEN rules for the expert evaluation of the impact of the reforms made to the tax legislation on the tax potential

#	IF-THEN RULES
1.	If ( $x_1$ is excellent) and ( $x_2$ is very effective) and ( $x_3$ is excellent) and ( $x_4$ is very effective) then ( $Y$ is excellent)
2.	If ( $x_1$ is excellent) and ( $x_2$ is very effective) and ( $x_3$ is good) and ( $x_4$ is very effective) then ( $Y$ is very good)
3.	If ( $x_1$ is good) and ( $x_2$ is very effective) and ( $x_3$ is good) and ( $x_4$ is effective) then ( $Y$ is good)
4.	If ( $x_1$ is not excellent) and ( $x_2$ is not very effective) and ( $x_3$ is satisfactory) and ( $x_4$ is less effective) then ( $Y$ is unsatisfactory)
5.	If ( $x_1$ is not excellent) and ( $x_2$ is effective) and ( $x_3$ is good) and ( $x_4$ is less effective) then ( $Y$ is satisfactory)
6.	If ( $x_1$ is not excellent) and ( $x_2$ is not very effective) and ( $x_3$ is good) and ( $x_4$ is very effective) then ( $Y$ is good)
7.	If ( $x_1$ is good) and ( $x_2$ is effective) and ( $x_3$ is excellent) and ( $x_4$ is effective) then ( $Y$ is good)
8.	If ( $x_1$ is excellent) and ( $x_2$ is very effective) and ( $x_3$ is satisfactory) and ( $x_4$ is less effective) then ( $Y$ is satisfactory)

Fuzzy inference process consists of 5 main stages<sup>4</sup>.

• **Fuzzification of the input data**

In this step we determine the degree of inputs which they belong to each of the appropriate fuzzy sets via membership functions (MF). Before evaluating the rules, the input data should be fuzzified according to each

linguistic set. For example, how effective are the laws in  $X_2$  sets? If this indicator is estimated by 60 points in (0-100) scale, the membership degree of the “very effective” linguistic set is 0.4. All input data are fuzzified by this manner.

We use following membership functions for the input data.

1. The input data  $X_1$  (“much less important” laws) is fuzzified by a triangle-shaped membership function. There are three linguistic variables have been determined: “sufficient”, “good” and “excellent” (figure 2). The triangle-shaped membership function is defined by the following formula.

$$f(x; a, b, c) = \begin{cases} 0, & x \leq a \\ \frac{x-a}{b-a}, & a \leq x \leq b \\ \frac{c-x}{c-b}, & b \leq x \leq c \\ 0, & c \leq x \end{cases}$$

where  $a, b, c$  are parameters of the triangle membership function.

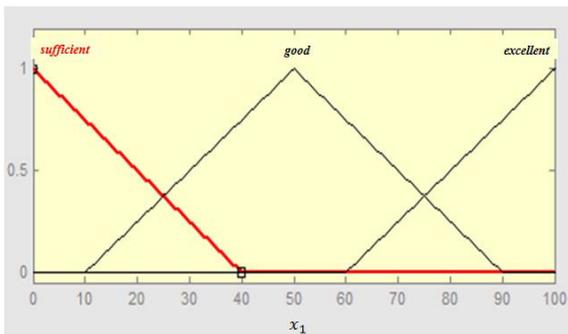


Fig.2.Graphical illustration of MF of  $X_1$

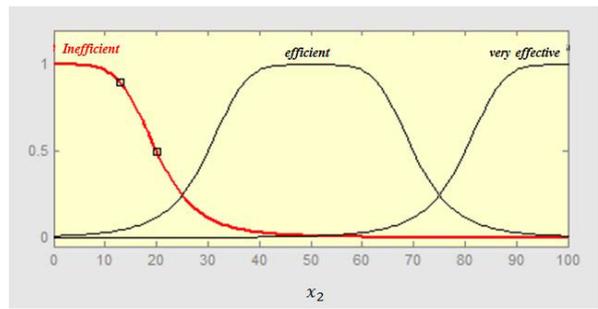


Fig.3.Graphical illustration of MF of  $X_2$  .

2. The input data  $X_2$  (“less important”) is fuzzified by the generalized Bell-shaped membership function. There are 3 linguistic variables have been determined: “inefficient”, “efficient” and “very effective” (figure 3). Bell membership function is expressed by the following formula.

$$f(x; a, b, c) = \frac{1}{1 + \left| \frac{x-c}{a} \right|^{2b}}$$

where  $a, b$  and  $c$  are the parameters of Bell-shaped membership function.

3. The input data  $X_3$  (“important laws”) is fuzzified by trapezoid-shaped membership function. There are 3 linguistic variables have been defined: “sufficient”, “good” and “excellent” (figure 4). Trapezoid-shaped membership function is defined by the following formula.

$$f(x; a, b, c, d) = \begin{cases} 0, & x \leq a \\ \frac{x-a}{b-a}, & a \leq x \leq b \\ 1, & b \leq x \leq c \\ \frac{d-x}{d-c}, & c \leq x \leq d \\ 0, & d \leq x \end{cases}$$

where  $a, b, c, d$  are the parameters of trapezoid membership function.

4. The input data  $X_4$  (“very important laws”) is fuzzified by Gaussian curve membership function. There are 3 linguistic variables have been defined: “Inefficient”, “efficient” and “very effective” (figure 5). The Gaussian curve membership function is defined by the following formula.

$$f(x; \sigma, c) = e^{-\frac{(x-c)^2}{2\sigma^2}}$$

where  $\sigma$  and  $c$  are the parameters of the Gaussian curve membership function.

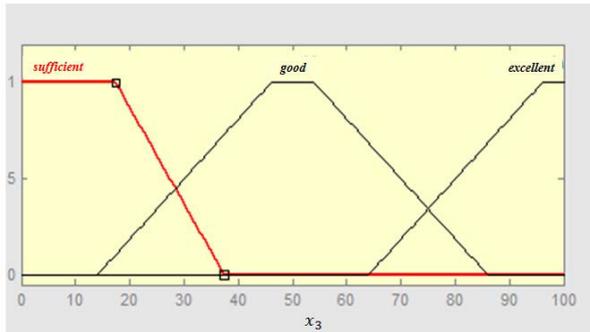


Fig.4.Graphical illustration of MF of  $X_3$  .



Fig.5.Graphical illustration of MF of  $X_4$  .

- **Application of fuzzy operators**

After the inputs are fuzzified, the degree which each part of the antecedent is satisfied for each rule. If the antecedent of a given rule has more than one part, the fuzzy operator is applied to obtain one number that represents the result of the antecedent for that rule<sup>4</sup>. This number is then applied to the output function. The input of the fuzzy operator is two or more membership values from fuzzified inputs and the output is a single value. In our system, we used “AND” and probabilistic “OR” operators.

- **Application of the implication method**

Before applying the implication method, the weights of the rules should be defined. Each rule has a weight (a number between 0 and 1). High-weight rule has more impact on the result in the implication process. The rules are equal in the studied matter. After recording a proper weight of each rule implication method is applied. The result of the process is fuzzy set that illustrated by the membership function. The shape of this set varies depending on the value of the membership functions of the input. The input of the implication process is a number and output is a fuzzy set. Implication is applied to each rule.

- **Aggregation of the outputs**

Because decision-making is based on the testing of all the rules in a Fuzzy Inference System (FIS), the result of the rules must be combined in some manner. The input of the aggregation process is the value of output functions returned by the implication process for each rule. The output of the aggregation process is fuzzy set for each output variable.

The membership function, their implication and aggregation of the rules are used in all estimation have been illustrated in the following diagram. As a result of the aggregation fuzzy set in the bottom right corner of the diagram illustrated in figure 6 has been obtained.

- **Defuzzification**

The input for the defuzzification process is a fuzzy set and the output is a single number. We use the Center Gravity Defuzzification (CGD) method for the defuzzification operation (figure 7). The CoGD method avoids the defuzzification ambiguities which may arise when an output degree of membership comes from more than one crisp output value.

### 3. Conclusion and Future Directions

Involvement of tax potential in maximum tax collection formed by economic system depends on its assessment seriously. Including macroeconomic, representative, regional and others, different approaches are available to the determination of tax potential in the international practice. At the same time, as tax potential changes depending on economic growth, its rate and dynamics, the approaches to its assessment also change and require a specific approach depending on each country's economic development model in which a well-known methodology is taken into account.

Formation features, economic and institutional components of all tax potential have been studied, using existing evaluation methods in the separate assessment of those components have been analyzed and certain generalizations and modifications have been developed in the presented investigation.

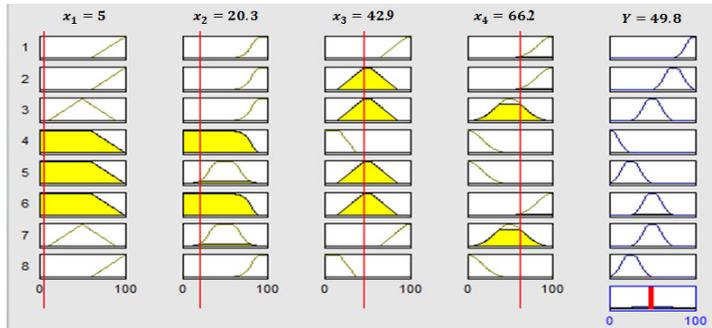


Fig.6.The Aggregation process of the FIS.

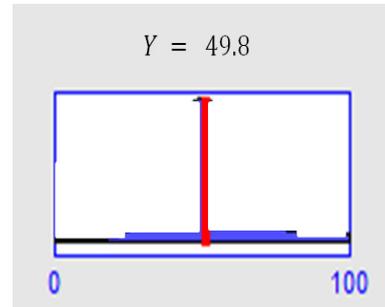


Fig.7.The defuzzification process of the FIS

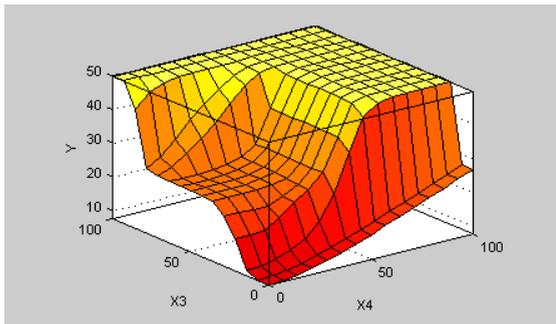


Fig.8.The surface of the evaluation of impact of tax legislation reforms on tax potential depends on elements of  $X_3$  and  $X_4$

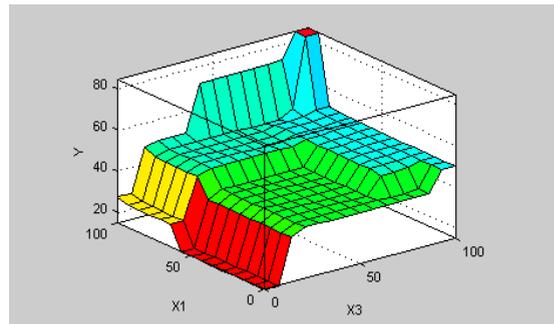


Fig.9.The surface of the evaluation of impact of tax legislation reforms on tax potential depends on elements of  $X_1$  and  $X_3$

The main focus of the study has been aimed at assessing the state's legislative and administrative efforts and as a result a methodological approach has been proposed using medium-term forecast methodology, tax recovery and tax flexibility factors through time series to determine the current and forecast prices of these efforts.

In the paper Mamdani-Type fuzzy inference system with 4 input, 8 IF-THEN rules and a single output used in the evaluation of impact of Azerbaijan tax legislation reforms on Azerbaijan tax potential has been studied. In the problem being investigated the purpose of taking the data of 2012 is having more changes and amendments made to the Azerbaijan tax legislation compared to other years. Taking into account the expert opinions the reforms made to tax legislation in 2012 conditionally are divided into four groups according to the potential impact: "much less important", "less important"; "important"; "very important" laws. In the constructed system the numbers evaluated between 0-100 intervals by 18 economic experts are taken as input data for the impact of the tax legislation reforms on the tax potential.

Triangle, trapezoid, Gaussian and Bell-shaped membership functions are used for the fuzzification of the input data. Being evaluated by Gaussian curve membership function, fuzzy set of the output system is defined by 5 linguistic variables: “unsatisfactory”, “satisfactory”, “good”, “very good” and “excellent”. The output value of the fuzzy inference system is 49.8. This value corresponds to the “good” linguistic set in 1-100 point scale that divided regularly.

As a result of the research, the impact of tax legislation reforms made in 2012 on tax potential can be evaluated by “good” linguistic variable. For the studied problem the Mamdani-type fuzzy inference system has been realized in the Matlab program package.

## References

1. Tax reforms in EU Member States. Tax policy challenges for economic growth and fiscal sustainability. *European Economy*, Institutional paper 2013; 5
2. Karatayev AS. The largest tax payer`s instrumentation of calculating taxable capacity`s values. *Vector Science of Togliatti State University* 2010; 4:226-9.
3. Slobodchikov DN, Petrenko VA. Methodological aspects of efficiency growth of municipal finance management. *Vector Science Togliatti State University* 2015; 1(31): 189-194.
4. Mathwork. Fuzzy Inference Process. <http://www.mathworks.com/>.
5. Musayev AF. Tax potential and its assessment methods. *Tax Magazine of Azerbaijan* 2014; 5(119)
6. Musayev AF. *Innovation economics and tax stimulation*. Baku: The University of Azerbaijan; 2014.
7. Musayev AF, Gahramanov AG. *Introduction to econometrics*. Baku: The University of Azerbaijan; 2011.
8. Mamdani EH, Assilian S. An experiment in linguistic synthesis with a fuzzy logic controller. *International Journal of Man-Machine Studies* 1974; 7(1):1-13.
9. Mamdani EH. Advances in the linguistic synthesis of fuzzy controllers. *International Journal of Man-Machine Studies* 1976; 8:669-678.
10. Sugeno M. *Industrial applications of fuzzy control*. New York: Elsevier Science Pub. Co;1985.
11. Zadeh LA. Outline of a new approach to the analysis of complex systems and decision processes. *IEEE Transactions on Systems, Man, and Cybernetics* 1973; 1(3):28-44.
12. Yen J, Langari R. *Fuzzy Logic: Intelligence Control and Information*. Pearson Education; 2004.
13. Ross TJ. *Fuzzy logic with engineering applications*. Singapore: Wiley; 2010.
14. Koop G. *Analysis of economic data*. Chichester: Wiley; 2000
15. Rustamov SS. An application of neuro-fuzzy model for text and speech understanding systems. In *Proc. the IV International Conference “Problems of Cybernetics and Informatics”, PCI’2012*, Baku, Azerbaijan, 2012, p. 213-217.
16. Rustamov SS, Mustafayev EE, Clements MA. Sentiment Analysis using Neuro-Fuzzy and Hidden Markov Models of Text. In *Proc. of IEEE Southeast Conference*, Jacksonville, USA, 2013, p. 1-6
17. Rustamov SS, Clements MA. Sentence-Level subjectivity detection using neuro-fuzzy and hidden markov models. In *Proc. of the 4th Workshop on Computational Approaches to Subjectivity, Sentiment and Social Media Analysis in NAACL-HLT*, Atlanta, USA, 2013, p. 108-114.
18. Rustamov SS. On an understanding system that supports human-computer dialogue. In *Proc. the IV International Conference “Problems of Cybernetics and Informatics”, PCI’2012*, Baku, Azerbaijan, 2012, p. 217-221.
19. Alan J. Auerbach. Measuring the impact of tax reform. *National Tax Journal* 1996; 4(49): 665-673.
20. Hammond PJ. Project evaluation by potential tax reform. *Journal of Public Economics* 1986; 1(30):1-36.
21. Eleftherios G. Study of discrete choice models and adaptive neuro-fuzzy inference system in the prediction of economic crisis periods in USA. *Economic Analysis and Policy* 2012; 42(1) :79-96.
22. Shekariana E, Gholizadeh AA. Application of adaptive network based fuzzy inference system method in economic welfare. *Knowledge-Based Systems* 2013; 39:151–8.