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Modeling the Probability of the Detection Process of Tax Evasion Taking into Account Quality and Quantity Indicators

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Authors' contributions

This work was carried out in collaboration among all authors equally. Author AM designed the study, present the idea of this research. Authors AM and Author MG developed the model of this study. Author MG managed the statistical and other analysis, as well as literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Aims: In contrast to the classical approaches of the standard model of tax evasion based on game theory, our manuscript has considered the detection of tax evasion as one of the main function of tax administration and has proposed a model for assessing the probability of tax evasion taking into consideration qualitative and quantitative indicators.
Study Design: This investigation has been carried out on the basis of research methods such as scientific abstraction and systematic analysis, expert evaluation, logical generalization, statistical analysis.

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Methodology: For the evaluating of the probability of tax evasion's detection firstly, efficiency indicators of tax administration were selected including 3 groups such as internal environmental, external micro, and external macro-environmental factors. These indicators consist of both quantitative as well as qualitative indicators. Quantitative indicators were assessed on the base on statistics information base. Quantitative indicators were assessed on the base of expert skills, knowledge, and experiences in accordance with under investigation countries. The objectiveness of obtained data that characterize qualitative indicators was checked and used both these as well as quantitative indicators for formulating the tax efficiency index. The next step is consists of using these formulations for evaluating the probability of detection of tax evasion under uncertainty. The impact degrees (membership functions) of the parameters that characterize the influence of 3 groups-environmental factors, in the detection of tax evasion were defined, and taking them into account in the fuzzy inference system probability of detection of tax evasion was assessed.
Limitations: Lack or uncertainties of the information base cause difficulties in applying our model.
Results: The probability of detection of tax evasion in the Republic of Azerbaijan was assessed with the proposed model and depends on the results recommendations have been consulted for improving appropriate tax system. As a result of model the probability of detection of tax evasion was defined 29%. The result shows that tax administration mechanism in Azerbaijan Republic need to be improved.
Conclusion: Proposed model drives practical significance as a providing effective activity of tax institutions by defining the level of tax administration, as well as, as an impacting remarkably the revenue of state budget by determining the probability of tax evasion's detection.

Keywords: Probability of detection of tax evasion; tax administration; efficiency index; qualitative and quantitative indicators; expert evaluation; Mamdani inference system.

1. INTRODUCTION

Tax evasion is an illegal activity in which an economic entity deliberately evades paying a real tax liability, and by its nature is an extremely difficult process to observe. Generally, in literature are differentiated two forms of tax fraud: tax evasion and tax avoidance. Tax avoidance happens due to loopholes in tax legislation however, tax evasion occurs as a result of a violation of tax legislation. Tax avoidance is a different declaration of economic activity to the tax authority in order to reduce the real tax liability, however tax evasion characterizes all illegal activities involving the hidden or shadow economy, unmeasured economic activity (online trade and etc.). Therefore, they cannot be confused to each other. Since this global problem is widespread all around the world and could not eliminate yet, its theoretical and practical research has been one of the main interests of economists and politicians for many years. Scientists try to find new effective methods and ways to solve this problem. Recently (especially during the last decade) the use of technological science and tools such as Big Data, Neural Network, Fuzzy Inference system, and others have dominated the detection of tax evasion fraud. The reason for this, soft computing technologies provide much more effective consequences that traditional methods. This can be obvious from the recent researches that characterize the applying of soft computing technologies to reveal tax evasion. Let's look through some of them.

1.1 Related Literature

The study of P.C. Abrantes and F. Ferraz claims that application of Big Data technologies is one of the best way for improving of tax evasion through the systematic literature review that investigate the researches related with the detection of tax evasion. As a result of this review the importance of using of pattern recognition methodologies, natural language processing and data analytics to reveal tax evasion fraud were confirmed [1]. Other study related with this problem present utilization of machine learning classification approach to detect tax avoidance of Malaysian government-linked companies (GLCs) [2]. In Spain, some researchers also used machine learning and Multilayer Perceptron neural network (MLP) models for detecting tax fraud taking into consideration personal income tax returns filed.

The result proved that this model will provide to tax administrators to reveal tax fraud with 84.3 efficiency percent [3]. Sometimes applying supervised machine learning on auditing tax declaration or other processes that characterize taxpayers' liabilities requires a long period and great financial support. Therefore, instead of using this method, some researchers prefer to apply unsupervised learning techniques. One of these studies detected tax fraud through tax declaration by using these techniques. The results showed that the applied model didn't miss on marking declarations as suspicious and previously undetected tax declarations as suspicious, increasing the operational efficiency in the tax supervision process without needing historic data [4]. The effectiveness of utilizing a hybrid intelligent system that merges multilayer perceptron (MLP) neural network, support vector machine (SVM), and logistic regression (LR) classification models with harmony search (HS) optimization algorithm for detecting corporate tax evasion was assessed in a sample of two fields of economics such as food and textile sector in Iran. The results demonstrated that MLP performed best in the food sector and SVM performed best in the textile sector. [5]. An empirical analysis of income tax discrepancy was conducted in Switzerland based on a standard model of tax evasion. Modification of that model revealed that the incompability was positively correlated with inflation. As a result, the discrepancy is significantly lower when there is direct control over citizens or taxpayers, and in contrast when there is no control [6].

As numerous theoretical and empirical analyses that use soft computing technologies, as well as optimization methods, exist related to the detecting of tax evasion, it is feasible to expand further the review of the literature. Although they were proposed during the last century, the analysis of some famous researches and models has played a crucial role in detecting tax evasion, up to date. One of these studies was proposed by Allingham M., Sandmo A, that first and most widely used model for assessing tax compliance. The classic model of rational choice of the taxpayer was based on the assumption that the taxpayer's decision to evade tax depends on the tax rate, the probability of detection of tax evasion, and the rate of penalties. At the same time, this model assumed that in the circumstances of uncertainty the compliance of taxpayer's behaviors with the axioms of the Von Neumann-Morgenstern utility function and determined the expected utility of the income according to the reporting decision. The general expression of this model is as follows:

$$E[U] = (1-p)U(W-\theta X) + pU(W-\theta X - \pi(W-X)) \quad (1)$$

Where, $W-$ is the real income of the taxpayer that unknown to the tax authority; $X-$ declared income; $\theta-$ tax rate; $p-$ the probability of detection of tax evasion and was assumed to be exogenous for the individual taxpayer in the model under consideration; $\pi-$ penalty imposed when hidden income $(W-X)$ is discovered; $E[U]-$ indicates the maximum utility of the taxpayer [7].

This model has been accepted by many scholars as a standard model of tax evasion and various modifications have been developed to take into account the changing tax system, socio-economic situation, taxpayers and other factors. As an example, let us consider a few of them:

In Lectures on Public Finance book chapter, the taxpayer's max utility function was defined by equation (1) and the probability of tax evasion was determined due to the penalty rate to be applied [8]. Other research, related to revealing tax evasion that base on the game theory was implemented by Diego Escobari. That article consisted of modelling the imperfect detection of tax evasion motivated by the existence of a corrupt tax administration. [9]. Modifications with the addition of labor force to the generalization of the simple Allingham-Sandmo model include studies by Sandmo [10], Pencavel [11], Cowell [12], Weiss [13], and others. Detecting of tax evasion was realized based on the classical Allingham and Sandmo model by investigating the role of legal rules pertaining to implement for tax evasion in shaping the party's choices [14]. Another study that uses game-theoretic tools belongs to Sokolovskyi D. He developed a model based on well-known Alligham–Sandmo classics by introducing parameters of transparency of detected violations, transparency of the expenditure of control, transparency of tax evasion, and transparency of conscientious tax payment. The result showed that the model may help to estimate the tax burden appropriate to the real economy [15].

2. MATERIALS AND METHODS

2.1 Detection of Tax Evasion as a Main Function of Tax Administration

Generally, most investigations related to tax frauds, its detection and etc. have been

conducted on income taxes or fines. In the existing analysis, the probability of the detection of tax evasion is accepted as either an exogenous variable or the edges of it are identified by related to the penalty that occurs in case of detection. Actually, no specific assessment of the probability of detection of tax evasion has been made by considering tax administration. However, the detecting process requires professional tax administrators and an effective administrative mechanism. So, depending on the level of tax administration in the country, it is possible to assess the probability of detection of tax evasion and tax evasion, which is a major part of the shadow economy.

Since tax administration being a managing system of tax relationship between taxpayers and tax authorities, the effectiveness of it depends on the level of factors that characterize it. In literature defining these efficiency factors is based solely on the assumption of internal system factors of tax administration. However, international experience and our observations show that the importance of external micro and external macro-environmental factors is not less but more essential. Therefore, our previous study was devoted to defining the efficiency indicators of tax administration in 3 groups such as internal environmental, external micro, and external macro-environmental factors, and evaluating the efficiency index of tax administration by depending on these factors [16].

This paper focuses on the assessment of detecting the probability of tax evasion by utilizing tax administration efficiency indicators considering their qualitative and quantitative characters. For this purpose, we propose a special methodology for defining tax administration efficiency and measuring detecting probability (p) of tax evasion, avoidance, or other similar frauds as below:

2.2 Methodology of the Modeling the Assessing Process of the Probability of Detection of Tax Evasion Considering Qualitative and Quantitative Efficiency Indicators

The main purposes of our paper are to demonstrate the impact of both qualitative as well as quantitative indicators that characterize tax administration efficiency in terms of 3 environments, and how the fuzzy inference system gives us the opportunity to realize this process by considering the distinctive impact levels of these indicators. As we mentioned above, this paper considers the detecting of tax evasion as the main function of tax administration. Therefore, by evaluating the tax administration efficiency index we can measure the detection probability of tax evasion. The methodology of evaluating the tax administration efficiency index as well as the detecting probability of tax evasion is expressed as below:

Firstly, mathematical expressions of these indicators depend on their quantitative and qualitative characters, are defined as below:

i –the groups of factors;
q – whether the indicators are quantitative ($\dot{q}$) or qualitative ($\ddot{q}$);
j – factors that included in groups, by taking into consideration of being quantitative and qualititative then : $j = j^{'} + j^{''}$;
m –the number of groups;
n_i – the number of factors that in group i, by taking into consideration of being quantitative and qualititative then: $n_i = (\dot{q} + \ddot{q}) n_i = n_i^{'} + n_i^{''}$;
x_{ij}^{q} – represents the j^{th} factor with q character of i^{th} group, $x_{ij^{'}}^{\dot{q}}$ – the j^{th} quantitative indicators ($\dot{q}$) of of i^{th} group, $x_{ij^{''}}^{\ddot{q}}$ – the j^{th} qualitative indicators ($\ddot{q}$) of i^{th} group, respectively.

In this case, the matrix of factors (X) that affecting the efficiency of tax administration is as follows:

$$X = \left(x_{ij}^{q}\right) = (x_{ij^{'}}^{\dot{q}} + x_{ij^{''}}^{\ddot{q}}) \qquad i = \overline{1,m},\ j = \overline{1,n_i},$$
$$q = (\dot{q}, \ddot{q}),$$
$$j^{'} = \overline{1, n_{\dot{q}3}} = \overline{1, n_3^{'}} \quad , \qquad j^{''} = \overline{1, n_{\ddot{q}3}} = \overline{1 n_3^{''}}, \tag{2}$$

After defining these indicators in terms of qualitative and quantitative they must be evaluated.

Quantitative indicators $\dot{q}n_i, i = \overline{1,3}$ defined in 3 groups characterizing the activity of tax administration are intended to be assessed using the available statistical database in the country under study.

The statistics for each quantitative indicator by classification can be expressed as follows:

$$s_{ij^{'}}^{\dot{q}y}, \quad i=\overline{1,3},\ j^{'}=\overline{1,n_{\dot{q}3}}=\overline{1,n_{3}^{'}},\ y=[y_{min},y_{max}] \quad (3)$$

Herein, $s_{ij^{'}}^{\dot{q}y}$ – reprezent exist statistical information of each $x_{ij^{'}}^{\dot{q}}$, $i=\overline{1,3},\ j^{'}=\overline{1,n_{\dot{q}3}},\ q=\dot{q}$ quantitative indicators during $[y_{min},y_{max}]$ period, $\dot{q}$ – indicates that the indicators are quantitative. If we look at the quantitative indicators of tax administration, we see that most of them are expressed in different units of measurement. Therefore, it is more appropriate to use them by transforming to the same measurement unit in evaluation. For this reason, each of the quantitative indicators can be expressed as the average value of their normalization of statistical data.

$$\overline{(s_{ij^{'}}^{\dot{q}y})^{*}}=\frac{\Sigma_{y=min}^{max}(s_{ij^{'}}^{\dot{q}y})^{*}}{years} \quad (4)$$

Next stage is consists of estimating qualitatitive indicators. İn general, qualitatitve indicators define depends on the special investigation or study fields. Therefore, since any special database about these selected qualitative efficiency indicators are not avaliable, this information is obtained expert query method (based on the knowledge and observation of experts). The answers of the experts can be summarized as follows:

$$v_{ij^{''}}^{\ddot{q}k} \quad i=\overline{1,3},\ j^{''}=\overline{1,n_{\ddot{q}3}},\ k=\overline{1,f} \quad (5)$$

Herein, $v_{ij^{''}}^{\ddot{q}k}$ – express the value of experts to each of $x_{ij^{''}}^{\ddot{q}}$, $i=\overline{1,3},\ j^{''}=\overline{1,n_{\ddot{q}3}},\ q=\ddot{q}$ qualitative indicators, $\ddot{q}$ – indicates that the indicators are qualitative, k – is the experts who participating in the survey. After getting necessity data the Kendall coefficient is used to analyze and verify the objectivity of information obtained on quality indicators based on the experience, knowledge, and skills of individual experts. Fuzzy inference system can assess taking into consideration the distinctive influence of indicators on tax administration effectiveness. So, verified information is estimated by using fuzzy inference system.

Let us express the process with the following equation for each quantitative indicator:

If Input 1 is $v_{ij^{''}}^{\ddot{q}1}$ and Input 2 is $v_{ij^{''}}^{\ddot{q}2}$ and … and input j is $v_{ij^{''}}^{\ddot{q}f}$, then Output is $v_{ij^{''}}^{\ddot{q}f^{'}}$ (6)

Therefore, assessment of both quantitative and qualitative indicators that are obtained expression (4) and (6), use for measuring tax administration efficiency as below:

$$\begin{cases} I_1=\sqrt[n_1^{'}]{\prod_{j^{'}=1}^{n_1^{'}}\overline{(s_{1j^{'}}^{\dot{q}y})^{*}}}+\sqrt[n_1^{''}]{\prod_{j^{''}=1}^{n_1^{''}}\left(v_{1j^{''}}^{\ddot{q}f^{'}}\right)} \\ I_2=\sqrt[n_2^{'}]{\prod_{j^{'}=1}^{n_2^{'}}\overline{(s_{2j^{'}}^{\dot{q}y})^{*}}}+\sqrt[n_2^{''}]{\prod_{j^{''}=1}^{n_2^{''}}\left(v_{2j^{''}}^{\ddot{q}f^{'}}\right)}, \\ I_3=\sqrt[n_3^{'}]{\prod_{j^{'}=1}^{n_3^{'}}\overline{(s_{3j^{'}}^{\dot{q}y})^{*}}}+\sqrt[n_3^{''}]{\prod_{j^{''}=1}^{n_3^{''}}\left(v_{3j^{''}}^{\ddot{q}f^{'}}\right)} \end{cases} \quad (7)$$

$I_i, (i=\overline{1,3})$ – is a parameter that characterizes the impact of all 3 groups of factors on tax administration, determined by the internal environment, external microenvironment and external macroenvironment, using expert assessments for the country under study.

The next stage consists of the evaluation of the tax administration efficiency index and detecting the probability of tax evasion by using the quantities I_1, I_2 and I_3, with which we determine the level of administration depending on the internal environment, external micro, and external macro-environmental factors bu using the system (3), and the influence degree on their detection. To implement this, let's accept the following notations:

I – tax administration efficiency index;
p –probability of detection of tax evasion;
$\mu(I_1)$ – the impact degree of the quantity I_1 characterizing the influence of internal environmental factors in the detection of tax evasion;
$\mu(I_2)$ – the impact degree of the quantity I_2 characterizing the influence of external micro-environmental factors in the detection of tax evasion;
$\mu(I_3)$ – the impact degree of the quantity I_3 characterizing the influence of external macro-environmental factors in the detection of tax evasion.

Since there is no research on the dependence of the tax administration on these three factors, there is no database that characterizes their level and impacts degree. For this reason, the impact rates of $\mu_1, \mu_2\ and\ \mu_3$ will be assessed using methods and techniques that allow decision-making under uncertainty.

Assume that there is a fuzzy set M that consisting of I_i and $\mu_M(I_i)$, which characterize the impact of the internal environment, external

micro-environment, and external macro-environmental factors on tax administration and their impact degree on the detection of tax evasion. And this is defined as follows:

$$M = \{(I_i, \mu_M(I_i))|I_i \in (0,1), \mu_M(I_i) \in [0,1]\}$$
$$i = \overline{1,3} \quad (8)$$

If we take into consideration that the I_i indicator of tax administration can be expressed at different levels, then its degree of impact $\mu_M(I_i)$ can be determined such as "very weak", "weak", "medium", "high", "very high".

Using fuzzy inference system, we can assess effectiveness index of tax administration (I) as well as the probability of detection of tax evasion (p) by defining the parameters of the I_i və $\mu_M(I_i)$ $(i = \overline{1,3})$. In general, evaluation process can be expressed as follows:

If Input 1 is $(I_1\ \mu(I_1))$ and Input 2 is $(I_2\ \mu(I_2))$ and input 3 is $(I_3\ \mu(I_3))$, then Output is I (9)

Or

If Input 1 is $(I_1\ \mu(I_1))$ and Input 2 is $(I_2\ \mu(I_2))$ and input 3 is $(I_3\ \mu(I_3))$, then Output is p (10)

Herein, $(I_1\ \mu(I_1))$, $(I_2\ \mu(I_2))$ and $(I_3\ \mu(I_3))$ are the inputs of system and $I = p -$ the effectiveness index of tax administration or the probability of detection of tax evasion are outputs of a fuzzy inference system.

3. RESULTS AND DISCUSSION

In order to check the adequacy of the proposed model to the process under investigation, the assessment of the detecting probability of tax evasion through tax administration effectiveness in the Republic of Azerbaijan has been carried out. Selected efficiency indicators for tax administration are follows:

1. Internal environmental factors:

1.1. Quantitative indicators:

- Forecasting of tax potential and level of collection;
- Level of mandatory tax collection;
- Level of additional calculations;
- Level of digitalization of the tax authority;
- Provision of financial and technological resources;

1.2. Qualitative indicators:

- Level of professionalism of tax authority employees;
- Tax collection per employee of a tax authority;
- Level of awareness of the tax authority (about the taxpayer);
- Tax appeal, tax ambush, etc. quantitative indicators of work;
- Level of service;
- The level of clarity and reliability of the legal framework.

2. External micro environmental factors:

2.1. Quantitative indicators:

- Number of taxpayers;
- Number of taxpayers' complaints;
- The level of digitalization of business;
- The level of digitalization of the banking and credit system.

2.2. Qualitative indicators:

- Tax literacy of the population;
- Business awareness level;
- The level of compliance with the tax liability of the business;
- The tendency of business to evade taxes;
- The level of dependence of business on tax legislation;
- The level of application of special benefits for the payment of tax arrears.

3. External macro environmental factors:

3.1. Quantitative indicators:

- Tax burden;
- Income level of the population;
- Level of liberalism and conduction of state institutions;
- The level of digitalization of technological development and economy;
- The level of the shadow economy.

3.2. Qualitative indicators:

- Level of propensity of the population to business (share of state business, share of business, share of population).

In the first stage of implementing research, the quantitative and qualitative indicators were assessed by using (4) and (6) equations, respectively. Then these estimations values were utilized for measuring I_1, I_2 and I_3. The level of tax administration on the internal environment, external micro, and external macro-environment was determined by using (7) formulations:

$I_1 = 0.72$, $I_2 = 0.64$, $I_3 = 0.67$;

The next step, as mentioned above, consists of the finding of the $\mu_1, \mu_2\ and\ \mu_3$ impact degrees of I_1, I_2 and I_3 quantities which affect to the detection of tax evasion. Using the fuzzy program package of Mathwork Matlab R2018b, $\mu_1, \mu_2\ and\ \mu_3$ were found as follows:

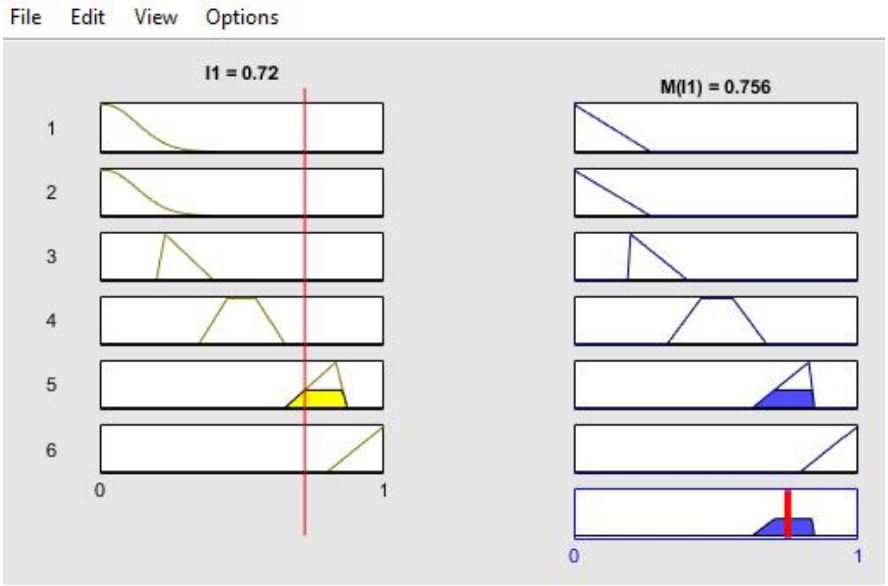

Fig. 1. $\mu(I_1)$

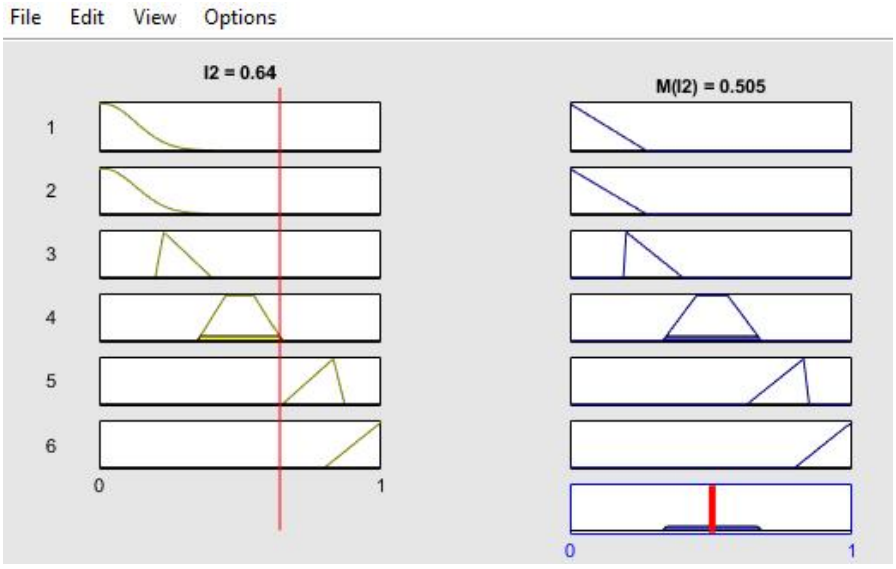

Fig. 2. $\mu(I_2)$

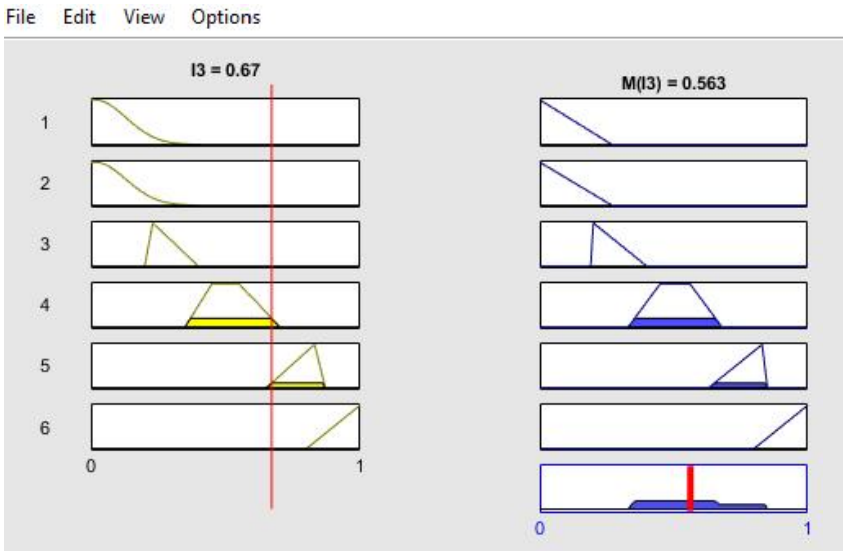

Fig. 3. $\mu(I_3)$

$\mu(I_1) = 0.76, \mu(I_2) = 0.51, \mu(I_3) = 0.56$

By evaluating I_1, I_2, I_3 that characterize the impacts of the internal environment, external micro, and macro-environmental factors to the tax administration and $\mu(I_1), \mu(I_2), \mu(I_3)$ which express the impact degrees of these factors to the detection of tax evasion, the probability of detection of tax evasion can be estimated by using fuzzy inference method as follows:

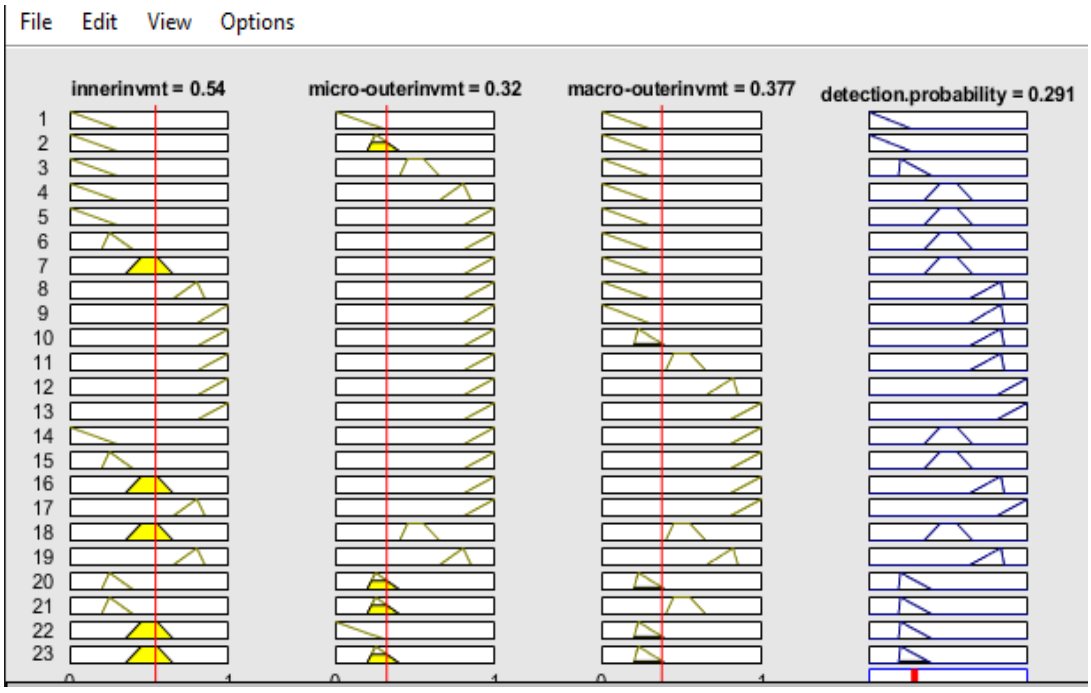

Fig. 4. The efficiency level of tax administration or the probability of detection of tax evasion

As can be seen from Fig. 4, the effectiveness of tax administration or the probability of detecting tax evasion by the applicating of a fuzzy decision-making system is 29 percent.

4. CONCLUSION

The proposed approach to assessing the effectiveness of tax administration and the probability of detection of tax evasion, taking into account quantitative and qualitative indicators allows us to mention the following.

1. The necessity of tax administration effectiveness was justified to detect and prevent tax evasion;
2. An index was proposed to assess the effectiveness of tax administration;
3. It was substantiated that this index can be considered as a probability of detection of tax evasion;
4. The importance of not only quantitative but also qualitative indicators for their evaluation was taken into account.
5. A fuzzy inference method was used to assess the tax administration efficiency and the probability of detection of tax evasion, taking into account quantitative and qualitative indicators.
6. In our opinion, the proposed approach will expand the opportunities to struggle with the phenomenon of the shadow economy.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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