J. Appl. Res. Ind. Eng. Vol. 6, No. 3 (2019) 200–218

Journal of Applied Research on Industrial Engineering
www.journal-aprie.com

A Multi-Input, Multi-Output Model on Fuzzy Rule-Based Systems to Predict Macroeconomic Variables in Iran

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PAPER INFO

Chronicle:
Received: 23 November 2019
Revised: 27 September 2019
Accepted: 22 September 2019

Keywords:
Fuzzy Rule-Based Systems.
Fuzzy Logic.
Crude Oil.
Predicting.
Macroeconomic Variables in Iran.

ABSTRACT

The prediction of economic variables is one of the main issues in a country's macro decisions. Since in many cases there is no historical data for this purpose and it is necessary to have more than one output, it is necessary to use expert opinions and consequently, model expert opinions in the form of mathematical functions, adds to the complexity of the task and the importance of the problem. To solve such problems, this paper presents a ten-step process using fuzzy rule-based systems. At the first step, the three inputs that include: the price of OPEC oil, the level of Iran and Saudi relations and the level of political tension in OPEC member countries and also the three output variables that include: the amount of employment, the economic growth, and the oil price forecast, have been modeled in the form of trapezoidal and triangular functions. Then, these variables have been converted to linear functions. In the next steps, the three-dimensional decision tables were designed and then by using the fuzzy rule-based systems (if, ... Then...), the preconditions and sequences (results) of the decision rules were written and coded in the Matlab software. The results indicate that the outputs are in line with the existing economic realities of Iran and that three input variables to a certain extent can cause changes in the three output variables. Less technical so far with problems with this complexity of problems are capable of results with this obvious.

1. Introduction

Iran's economy is a single-product economy based on oil revenues and a major part of the country's revenue is from oil revenues. Considering that the change in oil prices causes oil revenues to change, identifying the impact of these fluctuations on economic growth is essential since economic growth is one of the main pillars of development in each country [1].

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DOI: 10.22105/jarie.2019.195436.1098

Reducing oil prices sharply reduce government revenues and will affect developmental projects. Naturally, part of government revenues is spent on investing in the petroleum industry. When the state budget is reduced, investment in the oil industry and, consequently, investment in other industries is decreasing, which causes a lot of problems for the country's economy [2].

Studies show that Iran, along with Venezuela and Nigeria, had the highest error rate in predicting oil prices in annual budgets between 1999 and 2011. Today, the use of new methods such as fuzzy logic to predict the quality of financial decisions has improved dramatically [3].

Many techniques have been presented to predict macroeconomic variables and in numerous articles. Techniques such as statistical techniques: multivariate regression, EGARCH, ARIMA [4, 5], economic techniques: time series ([6], artificial intelligence: neural networks [4, 6], convolutional neural network techniques [7], or a combination of techniques the above: ARFIMA [3, 4].

But in all of the techniques mentioned, historical data is almost an essential component of the technique. Therefore, our goal in this article is to present a different approach that can be based on historical data or expert judgment or a combination of them. There is also only one output variable in almost all of the techniques mentioned, although in many cases we need multiple output variables at the same time with their interactions.

The purpose of this paper is to provide a structured method based on fuzzy rule-based systems (if, ... Then,) in order to predict the behavior of macro variables in Iranian economy with multi-output (oil price, growth economic and level of employment) by using of multi- inputs (current oil prices, Iran-Saudi relations and tension levels in OPEC exporting countries).

2. Theoretical Foundations and Research Literature

2.1. Oil Effects on Economic Growth

The results of the co-integration test on the long-term relationship between oil price variables, exchange rate, housing price index and gold price in the period of 1995-2012, using a structural vector error correction approach, suggest a long-term relationship between variables is significant at the level of 99%. The general results of the variance analysis of forecast error show that the largest share in the variance of the exchange rate is related to the oil price shock, which affects the currency exchange rate variance in the long run [8].

In the study of the asymmetric hypothesis, the relationship between oil price changes and demand for consumption in selected OPEC countries by using of panel data method from 2003 to 2013, suggests that the effects of change in the price of crude oil in selected oil countries (Iran, Saudi Arabia, Iraq, and Kuwait) are asymmetric [9].

In examining the relationship between oil prices and oil price volatility, also oil prices with economic growth in oil-exporting countries, the countries divided into two groups of OPEC-member oil-producing countries and major non-OPEC oil-producing countries, and the research period has lasted of the year 1980 to 2014. In this study, the oil price stability index was first extracted in the framework of the GARCH model, and then the relationship of this variable with the inflation, real exchange rate, and oil price variables on the growth of production was investigated. The results of the immediate

correlation function analysis showed that the reaction of oil-free production growth to oil price shocks and oil price stability in the OPEC countries was more severe, while the economies of non-member countries do not show it [10].

The impact of the oil price shock on voluntary financial policies in OPEC countries during the years 1980-2015 was studied using the Autoregressive (PSVAR) technique. Based on the findings, the impact of oil price shock on fiscal policy is voluntary in the short term, but it is ineffective in the long run. In addition, the shock of oil prices has increased government inflation and government spending and reduced OPEC's growth [11].

Many kinds of research have argued that oil price changes are inherently unpredictable, and efforts to predict crude oil prices are in vain. These deniers view current oil prices as the best predictor of future oil prices [12].

In other studies, in the member countries of the European Economic and Financial Society that are importing crude oil, the impact of oil price volatility on GDP growth in the years 2000-2015 has shown a negative impact on these countries [16].

In a study aimed at investigating the effect of oil price volatility on economic growth using the Vector Auto-Regressive test technique for the years 2000-2015, the results showed that in the long run, between the price of crude oil and the growth of the relationship and data suggest that rising oil prices have had a significant positive impact on Libya's economic growth [17].

Other researchers studied the extent of the interdependence of oil prices and economic growth in the UAE, Kuwait, Saudi Arabia and Venezuela in OPEC during the period 2000-2010. They used the Co-Integration test for this purpose. The results showed that the shock of the short and medium oil prices during the fluctuation period in the financial crisis and the global business cycle affects economic growth in the organization of oil-exporting countries, while the effect of medium-time is greater than the short-time effects [18].

In recent years, there have been some patterns of new econometric prediction in the literature that is more accurate, at least to a less than real-predicted level [13, 14, 15].

2.2. Review the Methods of Forecasting

Major well-known techniques for better prediction and studying can be categorized into statistical methods, econometric and statistical methods, and artificial neural networks.

2.2.1. Statistical methods

Nicholas and Sumpter [19], investigated various statistical models for monitoring and forecasting. These models belonged to random models, including Arch, Garch, and the model of statistical fluctuations. GARCH stands for the generalization of the heterogeneous variance of conditional regression itself. The term "self-regression" refers to the feedback construction that incorporates the past observations in the present time. The term "conditional" indicates that the variance is immediately dependent on the past. The term "heterogeneous variance" refers to the variance (oscillation) of the variable with time. The Garch model, introduced by Butterfly, generalized the previous version of Arch-Ingle that includes the regression itself and the moving average.

To forecast 2018 domestic air passenger demand in Nigeria between 2010 and 2017, two mean square deviation (MSD) forecasting methods were examined and compared to determine which method has the least deviation. It was found that MSD with two yearly moving average gave a better forecast rather than simple exponential smoothing because it has a lower MSD [20].

However, the shortcomings in the GARCH class models are as follows:

First, most GARCH models can only capture short-horizontally attributes rather than long-term dependencies, even though long-term dependencies in volatility are commonly recorded in the writings. In particular, Lee and et al [21] show that some sudden events (for example, the Iraqi invasion of Kuwait and the Persian Gulf war) lead to an increase in the constant component conditional variance that results in structural failures.

Second, GARCH class models cannot be adapted to a multi-scale feature, which is a well-known design reality in economics [22].

2.2.2. Econometric and statistical methods

The US Energy Information Administration (EIA) has represented a technique for forecasting oil prices, which creates quarterly forecasts for crude oil prices for the next two years.

Techniques such as empirical mode decomposition (EMD), sparse Bayesian learning (SBL) are used to predict crude oil prices as well as decomposition and ensemble used in time series.

Experimental results show that EMD and SBL are better than many predictions in terms of several evaluation criteria such as absolute mean absolute percentage error (MAPE) and root mean square error (RMSE) [23].

In another study with the aim of predicting the number of hospitalized patients in Mashhad hospitals over a period of 12 years ending to 2016 year in Iran, using time series and techniques group such as: Holt-Winters, SARIMA, MLP and GRNN shows that time series techniques are a good tool for predicting the number of patients with one output variable [24].

2.2.3. Artificial intelligence methods

Neural Networks is one of the most attractive methods of artificial intelligence in dealing with nonlinear predictions due to the ability to learn and adapt to dynamic environments. Many studies have shown the success of the implementation of neural networks in the field of oil exploration and development, such as the pattern of test analysis and prediction of natural gas production in the United States [25].

In order to predict the price of Brent crude oil during the period of 1998-2011, it has been used the three methods of fuzzy, EGARCH and ARFIMA as a comparison. The results have shown a significant fuzzy logic superiority compared to the methods of EGARCH and ARFIMA [3].

Apart from the statistical models used to identify and predicting, a lot of attention has recently been paid to the use of various AI techniques. Preeti and Santi [26] have presented a variety of techniques in the field of artificial intelligence to better understand and predict. The most popular techniques include neural network, data mining and fuzzy neural systems.

It has also been reported that neural network models are better than any other conventional statistical model, such as ARIMA, moving average, widespread self-regression and moving average [27].

Artificial Intelligence (AI) deep learning approaches make more accurate predictions of short-term oil prices than the Naive Prediction (NF) model. It also provides strong evidence that CNN models with matrix inputs are better in the short run than neural network (NN) models with single vector inputs [7].

2.2.4. Machine learning algorithms

In a case study, machine learning algorithms to predict oil prices using linear regression techniques known as super-vector regression, polynomial models, linear models, and Arbf models have been investigated. They have shown that they have considerable capability for predicting the variables with one output [28].

2.3. Summarizing Theoretical Foundations and Research Literature

The results of research that argued by Dourra [29], has represented that fuzzy logic is a more valid method with the following reasons:

- A neural network system lacks conceivable reliability in its judgments. There is no way to determine if the training kit is sufficient or no.
- In most cases, the response to the technical indicators, yes or no, is not definitive, therefore the fuzzy argument is very effective in these environments.
- The rules are structurally similar to those of English that is more in line with human thinking.
- Fuzzy logic is more flexible than the specialized system because it uses fewer rules and their composition needs more likely coverage of results.
- Fuzzy inference can address or overcome the overlap or ambiguity between the rules.
- The fuzzy system is considered as a comprehensive system because it is more coherent compared with artificial intelligence techniques, such as neural network-based trading systems, and has more freedom to repair it.
- The fuzzy inference system can be used to score points in an organization, giving a good understanding of the importance of each indicator in relation to others for evaluating the past, present, and future of the organization [30].

As with all techniques used for forecasting, whether statistical techniques or artificial neural network-based techniques, historical data is essential, but for the technique proposed in this article, even if historical data is not available, comments experts can be modeled using fuzzy rule-based systems. In addition, in almost all of the techniques mentioned in the research literature, the output of the predictive model is not one higher variable, but in the proposed technique in this paper, there is no limit (although for more than three output variables, the computational complexity increases).

3. Methodology of Research

According to what is mentioned in the literature, oil sales and, therefore, an estimate of the real price of oil plays an important role in the actual cost of oil exports projected by countries like Iran. The rate of oil exports and its prices over the past years has shown that oil price is not only related to the oil price in the past, but also political factors and political relations between OPEC members and political tensions are heavy affects the oil price.

According to Fig. 1, taken from Washington. D.C newspaper [31] from 1970 to 2017, the main factors influencing the price of oil have been as follows:

- 1970 to 1975 US Oil Surplus Capacity.
- In 1973, the sanctions of oil from Arab countries to western countries.
- In 1979, the occurrence of the revolution in Iran.
- In 1981 the Iran-Iraq war.
- In 1985, Saudi Arabia acted as a decisive step in oil prices.
- In 1990 Iraq invaded Kuwait.
- In the year 2000, the Asian financial crisis has been formed.
- In 2001, OPEC reduced its production by 7.1 million barrels.
- The 2003 Second Gulf War (US invasion of Iraq and the overthrow of Saddam Hussein's government).
- In 2008, global financial markets collapse.
- In 2009, OPEC cut its production by 4.2 million barrels.
- During 2013-2015, OPEC retained its production margin and did not cut it.

Regarding the 12 factors mentioned in this chart (Fig. 1) that affect oil prices, 9 factors have directly related to political issues or decisions made by OPEC exporting countries. Therefore, due to the effective role of political decisions and tensions in OPEC countries, two variables (Iran-Saudi relations and tension levels in OPEC exporting countries) as two of three variables that effect on oil prices in this article has been considered (the variable of current oil price is also considered as the main variable).

According to the description given, the output variables of research are oil price, economic growth, and employment rate. Although the role of oil in economic growth is different and sometimes contradictory. For example, in some studies, the existence of oil and the rise in prices have led to economic growth [10]. Some other studies have concluded that oil revenues and rising oil prices have had a negative impact on economic growth and development [6, 32, 33].

But given Iran's reliance on oil revenues, it is natural that part of economic growth and employment and employment levels depend on oil revenues.

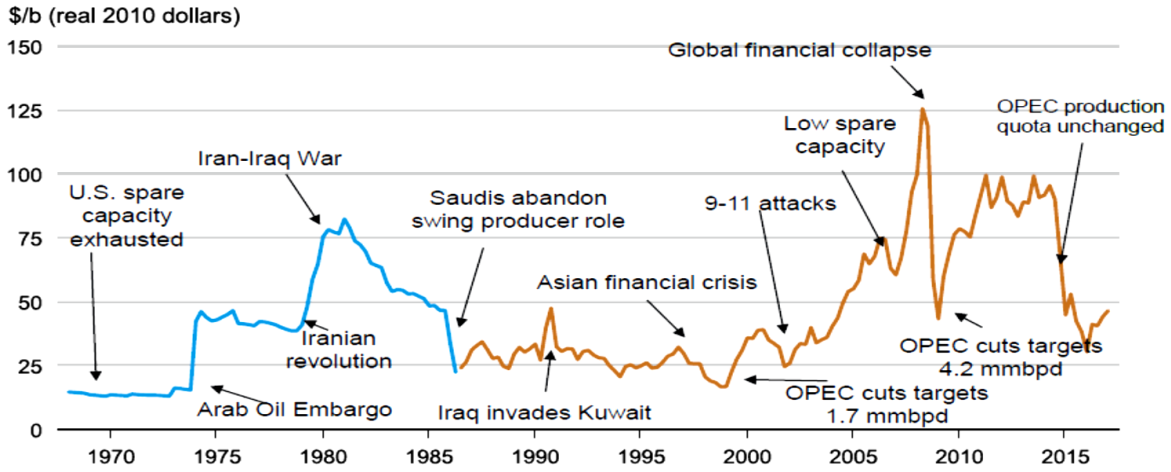

Fig. 1. *Political and geographic factors that have been affecting oil prices from 1970 to 2015 (Source: Washington DC Newspaper, 2017).*

In order to extract the rules of decision making and plotting and extracting functions for the oil price, it has used the past behavior of the oil variable over the past 45 years (from 1970 to 2015).

For example, when the current oil price is low (under $ 55), and the relationship between Iran and Saudi Arabia is weak (for example, they still lack official diplomatic relations, but they have not yet entered a military conflict, because then there is a very different issue. Because with the closure of the Strait of Hormuz and the regional conflict, Iranian and Saudi oil exports are sharply reduced, and oil prices are rising sharply) and if the regional tensions in the OPEC exporting countries will be low, the reasonable result is that the price oil will not increase in the near future (Providing that other conditions, such as the export volumes of Russian and American oil, are not changing, as well as the using of alternative energy does not change) and Iran's economic growth, which is highly dependent on oil prices, will be around the same current economic growth and the amount of employment that depends to a certain extent on oil prices will also be around the current level.

In another mode, if the current oil price is low, but the relationship between Iran and Saudi Arabia increasing to a high diplomatic level, and the tensions in the OPEC oil exporting countries being low, in this case, the price of oil can increase, which will also increase the country's economic growth and employment will slightly improve.

4. Presenting the Proposed Model and Proposed Procedures for Research

A block diagram for solving a real problem by using fuzzy logic control has a general framework as described in the figure below (Fig. 2).

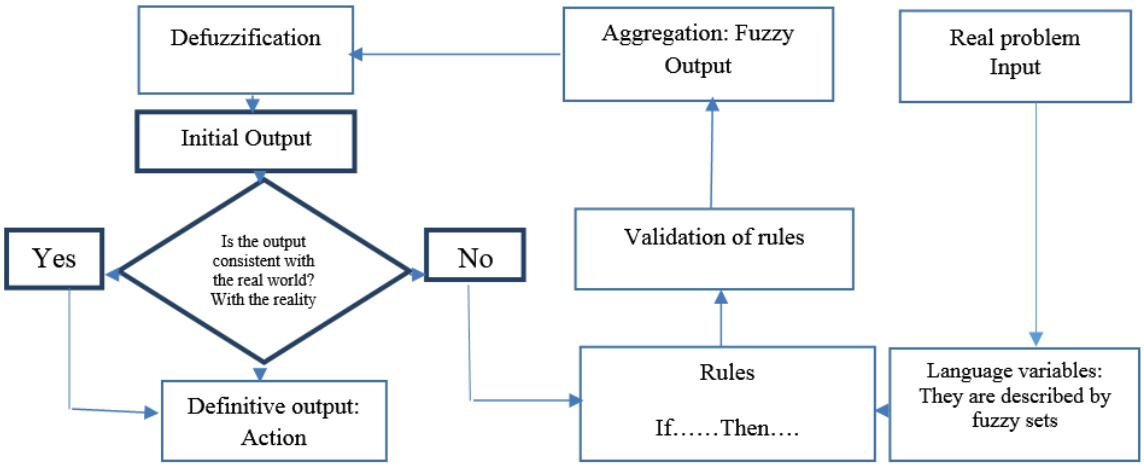

***Fig. 2**. The block diagram presented in fuzzy logic control.*

A fuzzy logic control model has a block diagram as described above (Fig. 2). As shown in the figure, working with a problem in the real world starts as input. In the next step, transforming the real problem into fuzzy sets. The next step is to design the inference rules (if .,.,. then .,.,.,.). Other steps are:

Step 1. Defining the structure of the fuzzy rule bases (the number of input and output variables).

Control issues have inputs and outputs that are considered as linguistic variables. Linguistic variables are including sets of A, B, C, etc.

$$A = \{A_1,...,A_i\ ,A_{i+1},...,A_n\}$$
$$B = \{B_1,...,B_j\ ,B_{j+1},...,B_m\}$$
$$C = \{C_1,...,C_k\ ,C_{k+1},...,C_l\} \quad (1)$$

linguistic variables

Step 2. Specify the type of input and output membership functions (triangular, trapezoidal, etc.). In this paper, triangular and trapezoidal membership functions have been used because they are better able to express the goals of the paper. These functions are:

$$trm(x:a,b,c) = \begin{cases} 0 & x \le a \\ \dfrac{(x-a)}{(b-a)} & a \le x \le b \\ \dfrac{(c-x)}{(c-b)} & b \le x \le c \\ 0 & x \ge c \end{cases} \quad (2)$$

triangular membership function

The letters, a, b, and c are the parameters

$$trm(x:a,b,c,d) = \begin{cases} 0 & x \le a \\ \dfrac{(x-a)}{(b-a)} & a \le x \le b \\ 1 & b \le x \le c \\ \dfrac{(d-x)}{(d-c)} & c \le x \le d \\ 0 & x \ge d \end{cases} \quad (3)$$

trapezoidal membership function

The letters, a, b and c, are parameters

Step 3. Linguistic terminology (low, medium, high) and the range of these linguistic semantics have been defined as follows:

$$A_i = \{(x, \mu_{Ai}(x)) \mid x \in A_i \subset U_1\},\ i = 1,...,n.$$
$$B_j = \{y, \mu_{Bj}(y) \mid y \in B_j \subset U_2\},\ j = 1,...,m,$$
$$C_k = \{z, \mu z_{ck}(z) \mid z \in C_k \subset U_3\},\ k = 1,...,l \quad (4)$$

linguistic terminology

Step 4. Specify the type of operators (Max, Min, and Product). Many fuzzy relations have been proposed and applied by researchers, and much research has been done on the behavior of fuzzy relations in different contexts. [34, 35, 36].

The relationship of Mamdani's requirement: $R_c : R(u,v) = \min([A(u), B(v)]$.

The relationship of Larsen's requirement: $R_p : R(u,v) = A(u), B(v)$.

The relationship in Lukashevich's requirement: $R_l : R(u,v) = \min[1, 1 - A(u) + B(v)]$.

The relationship of probability requirement: $R_k : R(u,v) = 1 - A(u) + A(u), B(v)$.

In practice, the use of the Mamdani or Larsen's requirement, which is based on the Min and multiplication, respectively, is used.

In a relation x equal to A_i , and y equal to β_j , i.e. p_i , and q_j this relation is defined as a turning. The point, which is a fuzzy relationship with $A \times \beta \subseteq U_1, U_2$ the following membership function:

$$p_i \wedge q_j = \min(\mu_{Ai}(x), \mu_{\beta j}(x)), (x, y) \in A \times B \subseteq U_1, U_2 .$$

The rule, if.... then,.,.,., in the inference relation is a conditional combination that indicates the correctness of the precondition. There are a few definitions for this rule. Here, according to Mamdani, we define the inference principle as a turning point, which is represented by the operator (minima) and is called the result of the resultant (the result) which can also be displayed as follows:

$$p_i \wedge q_j \wedge r_k = \min\ (\mu_{Ai}(x), \mu_{\beta j}(x), \mu_{cij}(\mathrm{x})), r_k = r_{ij} \quad . \tag{5}$$

$$i = 1,...,n; J = 1,...m; k = 1,...,l; and\ (x, y, z) \in A \times \beta \times C \subseteq U_1 \times U_2 \times U_3 .$$

type of operators

The above equation provides a regular value that is the result of the minimal operation of the membership functions of fuzzy sets.

Step 5. Designing the multidimensional tables of the intensity of the rules of knowledge. Setting rules if..... and..... when referring to the logic of inference, the rules of control or the rules of extraction are also called. The number of rules is equal to nm.

The rules are designed to create L or obtain $(L < nm)$ a different output number as a result or result (L the number of terms in the output C variable). The rules with fuzzy outputs (C_{ij}) are represented symbolically on a rectangular table nm (n number of rows and m number of columns), which is called the decision table.

Step 6. Writing the rules of inference and the decision of the knowledge base and programmed in a suitable software (such as Matlab).

Step 7. Doing aggregation Operations (Elimination of Contradiction). The application of the control rule, which is also called firing, is used to decide which of the rules must be used. In each rule, the degree of firing or firing can be achieved through the following relationships.

$$\begin{aligned}
&\wp_{ij} = \mu_{Ai}(x_0) \wedge \mu_{\beta j}(y_0) = \min((\mu_{Ai}(x_0), \mu_{\beta j}(y_0)) , \\
&\wp_{i,j+1} = \mu_{Ai}(x_0) \wedge \mu_{\beta j+1}(y_0) = \min((\mu_{Ai}(x_0), \mu_{\beta j+1}(y_0)) , \\
&\wp_{i+1j} = \mu_{Ai+1}(x_0) \wedge \mu_{\beta j}(y_0) = \min((\mu_{Ai+1}(x_0), \mu_{\beta j}(y_0)) , \\
&\wp_{i+1,j+1} = \mu_{Ai+1}(x_0) \wedge \mu_{\beta j+1}(y_0) = \min((\mu_{Ai+1}(x_0), \mu_{\beta j+1}(y_0)) .
\end{aligned} \tag{6}$$

aggregation operations

Step 8. Defuzzification operation. In order to be able to assign a classical (ordinary) number that is displayed with Z^* to the output, several methods have been proposed; the maximum membership principle, The center level method, the weighted average method, center method, maximum center method, first (or Last) maximum method. In this paper, the center level method has been used, which is used $\tilde{Z}$ to calculate the following equation.

$$Z^* = \frac{\int_z Z \sum_{k=1}^{n} \mu_{C_k}(z)\,dz}{\int_z Z \sum_{k=1}^{n} \mu_{C_k}(z)\,dz}. \quad (7)$$

the center level method

The sign of "∫" is the integral sign and the applied state when the $|z_1, z_q|$ problem interval is divided to q by the number of equal intervals (or approximately equal) in points $z_1, z_2, ..., z_{q-1}$, the definite amount Z^* according to this method is Z_k the averaging of the numbers.

Step 9. Designing the program and write the program code in one of the software. Due to the nature of the programs, which are large variables and also require a lot of repetitions, it is necessary to run programs in one of the most powerful programming software. Matlab software, especially in its new releases, has very good capabilities for fuzzy logic and artificial intelligence. In this article, Matlab software is also used for this purpose.

Step 10. Run the program and analyze the sensitivity of the desired domains. At this stage, the program is executed. The program outputs are tested with a variety of inputs and compared to the actual facts, and, if necessary, the required modifications in the knowledge base structure (the type of functions, language terms, operators, inference rules) to express the reality that the knowledge base has been designed for. The modified model is used to decide and predict the values of the output variables.

5. Findings of the Research and Implementation of the Proposed Technique in Practice

According to the steps described in the previous section, the practical steps of implementing the technique and its results are now presented below. It should be noted that software sections have been designed and implemented in the Matlab software.

Step 1. Determine the number of input and output variables of the research. In this paper, the three variables, prices, and current trends of OPEC oil, IRAN, and Saudi political relations, and the level of political tension in OPEC exporting countries have been used as input variables. Also, variables, prediction of future OPEC oil price, the economic growth rate in Iran, and employment level in Iran have been used as output variables.

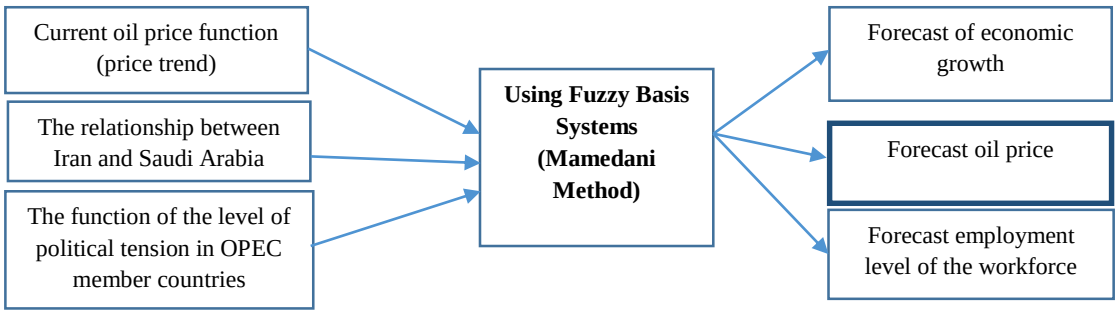

Fig. 3. *Conceptual model of research with a structure of three input variables and three output variables (source: researcher).*

Steps 2 and 3. Designing the linguistic variables of the research and their membership functions in the relevant tables.

In the presented paper, given the limitations of the pages of the article, only one table and a graph (Table 1 and Fig. 4) are presented in the text of the article. And the rest of the tables (5 tables and 5 other charts) only give their results in the final output of the paper. According to the table below (Table 1), the linguistic variables in the current oil price research are mainly presented in three groups: low, medium and high.

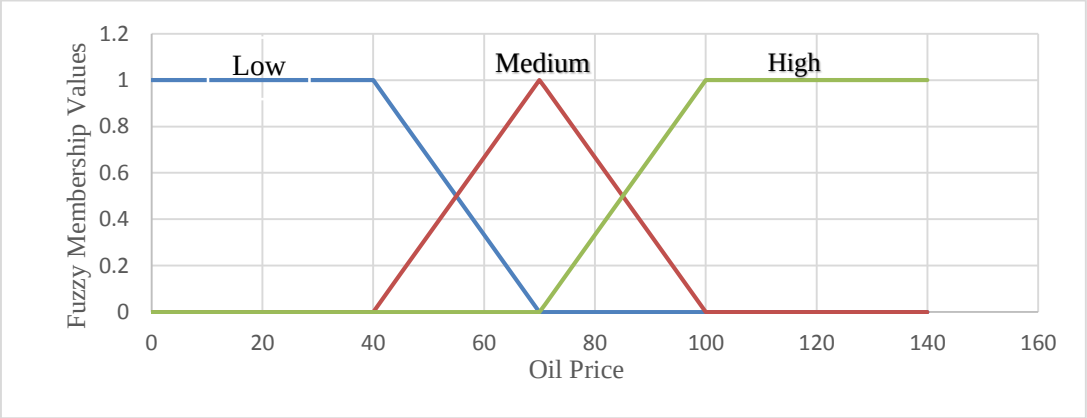

Fig. 4. *Linguistic variables for the oil price in dimensions of low, medium and high.*

Table 1. *Designing oil price variables in regard to oil price trends over the past 45 years.*

Type of function	Linguistic range	Description of the language variable Oil price
Trapezoidal	*[0 0 40 70]*	*(Low Oil Prices) Low*
Triangular	*[40 70 100]*	*(Average Oil Prices) Medium*
Trapezoidal	*[70 100 140 140]*	*(High of Oil prices) High*

In addition to drawing the tables and charts for the input and output variables of the research, all of their respective functions in formulas 8 to 25 are given below.

$$\begin{cases} y = 1 & 0 \le x \le 40 \\ y = \dfrac{-1}{30}x + \dfrac{7}{3} & 40 \le x \le 70 \\ 0 & others \end{cases} \quad (8)$$

linear trapezoidal functions for low oil prices

$$\begin{cases} y = \dfrac{1}{30}x - \dfrac{4}{3} & 40 \le x \le 70 \\ y = \dfrac{-1}{30}x + \dfrac{10}{3} & 70 \le x \le 100 \\ 0 & others \end{cases} \quad (9)$$

linear triangular function for

the average price of oil

(10)

$$\begin{Bmatrix} y=0 & x\le 70 \\ y=\frac{1}{30}x-\frac{7}{3} & 70\le x\le 100 \\ y=1 & others \end{Bmatrix}$$

linear trapezoidal function for high oil prices

(11)

$$\begin{Bmatrix} y=1 & 0\le x\le 25 \\ y=\frac{-1}{25}x+2 & 25\le x\le 50 \\ 0 & others \end{Bmatrix}$$

linear trapezoidal function for the low relationship between Iran and Saudi Arabia

(12)

$$\begin{Bmatrix} y=\frac{1}{20}x-\frac{3}{2} & 30\le x\le 50 \\ y=\frac{-1}{20}x+\frac{7}{2} & 50\le x\le 70 \\ 0 & others \end{Bmatrix}$$

linear triangular function for the normal relationship between Iran and Saudi Arabia

(13)

$$\begin{Bmatrix} y=0 & x\le 50 \\ y=\frac{1}{25}x-2 & 50\le x\le 75 \\ y=1 & x\ge 75 \end{Bmatrix}$$

linear trapezoidal function for the sincere relationship between Iran and Saudi Arabia

(14)

$$\begin{Bmatrix} y=1 & x\le 25 \\ y=\frac{-1}{25}x+2 & 25\le x\le 50 \\ 0 & others \end{Bmatrix}$$

linear trapezoidal function for very low tension

(15)

$$\begin{Bmatrix} y=\frac{-1}{25}x-1 & 25\le x\le 50 \\ y=\frac{-1}{25}x+3 & 50\le x\le 75 \\ 0 & others \end{Bmatrix}$$

linear triangular function for tension case in the usual style

(16)

$$\begin{Bmatrix} y=0 & x\le 50 \\ y=\frac{1}{25}x-2 & 50\le x\le 75 \\ y=1 & x\ge 75 \end{Bmatrix}$$

linear trapezoidal function for very high tension

(17)

$$\begin{Bmatrix} y=1 & 0\le x\le 25 \\ y=\frac{-1}{50}x+\frac{3}{2} & 25\le x\le 70 \\ 0 & others \end{Bmatrix}$$

linear trapezoidal function predicted for low oil prices

(18)

$$\begin{Bmatrix} y=\frac{1}{30}x-\frac{4}{3} & 40\le x\le 70 \\ y=\frac{-1}{30}x+\frac{10}{3} & 70\le x\le 100 \\ 0 & others \end{Bmatrix}$$

linear triangular function for average oil price prediction

(19)

$$\begin{Bmatrix} y=0 & x\le 70 \\ y=\frac{1}{30}x-\frac{7}{3} & 70\le x\le 100 \\ y=1 & others \end{Bmatrix}$$

linear trapezoidal functions representing the prediction of high oil prices

(20)

$$\begin{Bmatrix} y=0 & x\le -5 \\ y=1 & -5\le x\le 4 \\ \frac{-1}{4}x+3 & 4\le x\le 8 \end{Bmatrix}$$

linear trapezoidal function to predict low economic growth

(21)

$$\begin{Bmatrix} y=0 & x\le 4 \\ y=\frac{1}{5}x-\frac{3}{5} & 4\le x\le 8 \\ y=\frac{-1}{5}x+\frac{13}{5} & 8\le x\le 13 \end{Bmatrix}$$

linear triangular function to express the prediction of moderate economic growth

(22)

$$\begin{Bmatrix} y=0 & x\le 8 \\ y=\frac{1}{5}x-\frac{8}{5} & 8\le x\le 13 \\ y=1 & x\ge 13 \end{Bmatrix}$$

linear trapezoidal function to

express the prediction of high economic growth

$$\begin{Bmatrix} y=0 & x\le 0 \\ y=1 & 0\le x\le 1000 \\ \frac{-1}{1000}x+2 & 1000\le x\le 2000 \end{Bmatrix} \quad (23)$$

linear trapezoidal function to predicting low-level of employment

$$\begin{Bmatrix} y=0 & x\le 1000 \\ y=\frac{1}{1000}x-1 & 1000\le x\le 2000 \\ y=\frac{-1}{1000}x+3 & 2000\le x\le 3000 \end{Bmatrix} \quad (24)$$

Linear triangular function to predicting medium-level of employment

$$\begin{Bmatrix} y=0 & x\le 2000 \\ y=\frac{1}{1000}x-2 & 2000\le x\le 3000 \\ y=1 & x\ge 3000 \end{Bmatrix} \quad (25)$$

Linear trapezoidal function to predicting high-level of employment

Step 4. In this study, it has been used as the "Max" operator for the union, the "Min" operator to intersection, the "Prod" operator for product, the "Sum" operator to aggregate, and "Centroid" to defuzzification.

Step 5. The fifth step is the three-dimensional tables of the intensity of the rules of knowledge. On one side of the table, the current trend of the oil price (right side of the table) in the second dimension, the relationship between Iran and Saudi Arabia (the middle of the top of the table), and in the third dimension, the regional tensions in the member states OPEC (on the left side of the table) has been shown. In this research, we need 9 tables for this purpose, but with regard to the limited the pages of paper, only three tables (Tables 2, 3, and 4) are presented in the article. For example, if the current oil price below, the level of relations between Iran and Saudi Arabia be at a low level and the tensions in the OPEC exporting countries be high, then the common sense and past experience of the experts indicate that the predicted price for crude oil, it will be moderate (first from the right and at the bottom of the table).

Table 2. *Decision rules for predicting the intensity of three variables (oil prices, economic growth, and employment rates) for the linguistic variable of low level.*

Regional tensions in OPEC member countries	**Relations between Iran and Saudi Arabia**				
	Language terms	**High**	**Medium**	**Low**	**Language terms**	**The status of the current trend of oil price**
	Low	*M (Oil Price)* *M (Economic Rate)* *L (occupation)*	*L (Oil Price)* *L (Economic Rate)* *L (occupation)*	*L (Oil Price)* *L (Economic Rate)* *L (occupation)*	*Low*	
	Medium	*H (Oil Price)* *M (Economic Rate)* *L (occupation)*	*M (Oil Price)* *L (Economic Rate)* *L (occupation)*	*L (Oil Price)* *L (Economic Rate)* *L (occupation)*	*Low*	
	High	*H (Oil Price)* *M (Economic Rate)* *L (occupation)*	*H (Oil Price)* *L (Economic Rate)* *L (occupation)*	*M (Oil Price)* *L (Economic Rate)* *L (occupation)*	*Low*	

Source: computing researcher

According to Table 3, for example, if the current trend of the oil price situation be on the average, the relations between Iran and Saudi Arabia be in moderation and regional tension also be on average, in this case, the predictions that the price of oil would be moderate, Iran's economic growth would be average and level of employment would be Low (the middle house of Table 3).

Table 3. *The decision rules for predicting the intensity of knowledge for three variables (oil prices, economic growth, and employment rates) in the medium linguistic variable.*

	Relations between Iran and Saudi Arabia					
Regional tensions in OPEC member countries	**Language Terms**	**High**	**Medium**	**Low**	**Language Terms**	**The status of the current trend of oil price**
	Low	*H (Oil Price)* *H (Economic Rate)* *M (occupation)*	*M (Oil Price)* *M (Economic Rate)* *L (occupation)*	*M (Oil Price)* *M (Economic Rate)* *L (occupation)*	*Medium*	
	Medium	*H (Oil Price)* *H (Economic Rate)* *M (occupation)*	*M (Oil Price)* *M (Economic Rate)* *L (occupation)*	*M (Oil Price)* *M (Economic Rate)* *L (occupation)*	*Medium*	
	High	*H (Oil Price)* *H (Economic Rate)* *M (occupation)*	*H (Oil Price)* *M (Economic Rate)* *L (occupation)*	*H (Oil Price)* *M (Economic Rate)* *L (occupation)*	*Medium*	

Source: computing researcher

According to Table 4, for example, if the current trend of oil price is high, relations between Iran and Saudi Arabia be moderate and regional tension be on average, in this case, it predicts that the price of

oil would be high, economic growth and employment levels in Iran would be average (middle house of Table 4).

Table 4. *The decision rules for predicting the intensity of three variables (oil prices, economic growth, and employment rates) in the high linguistic variable.*

Regional tensions in OPEC member countries	**Relations between Iran and Saudi Arabia**				
Language Terms	**High**	**Medium**	**Low**	**Language Terms**	**The status of the current trend of oil price**
Low	*H (Oil Price) H (Economic Rate) H(Occupation)*	*M (Oil Price) H (Economic Rate) M (Occupation)*	*M (Oil Price) H (Economic Rate) M (Occupation)*	*High*	
Medium	*H (Oil Price) H(Economic Rate) H(Occupation)*	*H (Oil Price) H (Economic Rate) M(Occupation)*	*M (Oil Price) H (Economic Rate) M(Occupation)*	*High*	
High	*H (Oil Price) H (Economic Rate) H (Occupation)*	*H (Oil Price) M (Occupation)*	*H (Oil Price) M (Occupation)*	*High*	

Source: computing from researcher

The 6 and 7 Steps. Inference rules and decision bases of knowledge in the Matlab software are programmed. These rules include 27 rules, which, however, given the nature of the problem and the explanations mentioned in the discussion of the aggregation of the rules, can be reduced to 9 rules (these 9 rules have been shown in Fig. 5).

Step 8. In this paper, the central technique has been used for defuzzification. This technique is known in the Matlab software called "Centroid". For example, for three inputs of the model, that includes, oil price, Iran and Saudi Arabia's relations and tension levels in OPEC countries with amounts of "50, 50, 50", the output prediction values for these three variables are: "70, 2.32 and 834" for oil price, economic growth and employment level.

Step 9. Coding and executing the program. In this paper, coding and executing the program has been done in the Matlab software. You can also use the fuzzy toolbox to do this. Also, it can be done using programming power (using the M file). Some of the features the program which has been designed to solve the research problem by using the fuzzy rule system includes:

The main fuzzy relation is Mamdani. A number of input variables: three variables. The number of output variables: three variables. The number of fuzzy rules: 27 rules. The " Min" has been used for "and". "OR" has been used for Max. "Max" has been used for aggregate. The method used to "defuzzification" is "Centroid". The function that has been used for the low domain (MF1) is "Trapmf". The function for Medium level(MF2) is a triangular function with the name of "Trimf". The function for a high level (MF3) is a trapezoidal function with the name of "Trapmf". The Software that has been used is Matlab.

Also, in the figure below (Fig. 5), the results of the program's implementation in 50 (current oil price), 50 percent (Iran and Saudi-Arabian- relations) and 50 percent (the level of political tension in the OPEC countries) are visible.

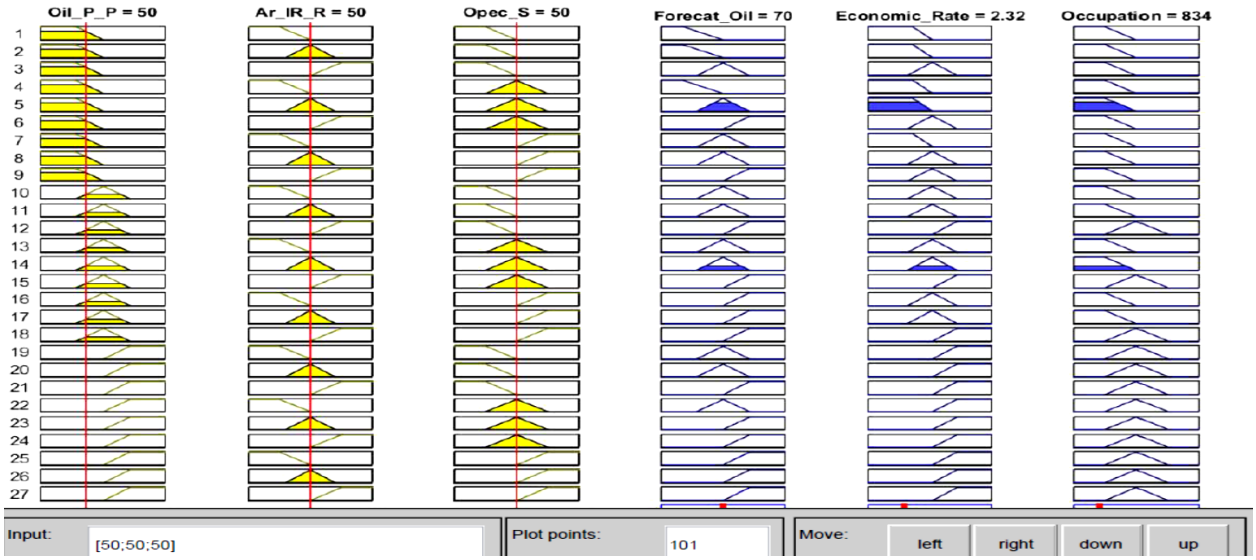

Fig. 5. *Inputs and outputs from the fuzzy rule-based system in Matlab software.*

Step 10. The results of the sensitivity analysis for the proposed model of research with three inputs and three outputs in different quantities in the table below (Table 5) can be seen for 12 different modes.

As you can see in Table 5, the model is sensitive in the low values for the three variables, and any change in input values causes visible changes in the output values, but for high values (for example, for oil above $ 80, and for the level of Iran's relations, Saudi Arabia, above 70%) the results of the table are estimated at $ 112 (for oil price forecasts), 14.9% (Iran's economic growth forecast), and 2,000,000 people (projected employment growth during the forecast period)the model has reached a steady state.

Table 5. *Sensitivity analysis of the designed model in different input values.*

Row	**Input values to the model**			**Output values of the model**		
	The current price of oil (in dollars)	*The Relationship between Iran and Saudi Arabia (In the range 0 to 100)*	*The variable of tension in OPEC member countries (In the range 0 to 100)*	*The variable employment rate (per thousand)*	*Economic growth variable*	*Oil price forecast variable (in dollars)*
1	*35*	*25*	*25*	*767*	*0.497*	*25.1*
2	*38*	*30*	*30*	*806*	*0.674*	*26.7*
3	*40*	*35*	*35*	*849*	*0.856*	*38.2*
4	*43*	*40*	*40*	*871*	*1.66*	*48.6*
5	*45*	*45*	*45*	*817*	*1.53*	*58.4*
6	*50*	*50*	*50*	*834*	*2.32*	*70*
7	*55*	*55*	*55*	*1150*	*5.31*	*83.7*
8	*65*	*60*	*60*	*1320*	*9.61*	*91.4*
9	*75*	*65*	*65*	*1630*	*13.4*	*101*
10	*80*	*70*	*70*	*2000*	*14.9*	*110*
11	*90*	*75*	*75*	*2000*	*14.9*	*110*
12	*100*	*100*	*100*	*2000*	*14.9*	*110*

6. Conclusion and Discussion

According to the results of the sensitivity analysis presented in Table 5, it can be seen that with the three input influential variables (current OPEC oil price, the relationship between Iran and Saudi Arabia and the level of political tension in OPEC member countries) the maximum expected oil price will reach to $ 110, the maximum economic growth of $ 14.9 and the maximum employment of two million people in Iran's current economy (it is rarely or perhaps impossible to relate the relationship between Iran and Saudi Arabia is 100% or the tension in oil-exporting countries is 100%). Therefore, if we are looking for better conditions, for example, to create employment, we need to introduce more variables (such as increased private sector investment, increased foreign investment, tourism development, etc.). Also, in current conditions, the current price of oil is about $ 50, while Iran-Saudi relations are lower at moderate levels and the tension level in OPEC countries is also close to moderate (50, 50 and 50, respectively), output quantities are respectively oil price forecasts, economic growth and employment are equal to $ 70, $ 2.32, and $ 834,000, which, in particular, does not meet the expectations of government-designated programs. According to the theoretical foundations of the research [10, 6, 32, 33], the oil variable can somehow cause Improving economic growth or increasing employment levels, and in the current state, not expecting more than 2.5 percent of economic growth or employment of 800,000. Therefore, economic planners should either think about improving other variables such as increasing private sector investment, increasing foreign investment, improving tourism conditions, etc.

In historical data-based methods (such as regression, economic techniques, and time series), the first condition of their use is the availability of historical data, for days, months or years and many. In the classical techniques mentioned, the opinion of the experts, and the expert person has little or no role. If historical data is unavailable or the process of future events varies with the past, what should be done in predicting the future status of the variables? In the technique presented in this paper, historical data

can be designed in the form of both linear and nonlinear equations in the model (for example, oil prices in this paper), and where there is no historical data, using the ten-step technique presented in this paper, experts' opinions can be modeled to predict future issues. It is also faster and easier to model variables because of fuzzy logic in modeling and because of the proximity of this logic to human interactive language. In addition, the model presented with multi-variable inputs and multivariate outputs is a great advantage that other models have less of this feature. The technique presented in this article will be of great use to design scenarios and be easily developed for more economical and marketing issues that are more complex.

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