Research Paper

Modelling the Effect of Monetary Policies of Central Bank on Macroeconomic Indicators in Iran using System Dynamics and Fuzzy Multi-Criteria Decision-Making Techniques

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ABSTRACT

The most important policymaker entity in the bank-centered economy of Iran is central bank of Islamic Republic of Iran which has always been trying to manage and improve macroeconomic indicators by applying monetary policies. However, investigation of Iran's economy after four decades shows that this country has always suffered from double-digit inflation rates and 15000-fold liquidity throughout this period, while GDP of Iran has grown only by two times during this period. This paper tries to evaluate the effect of monetary policies of central bank on macroeconomic indicators by analytical-descriptive and library method via combining system dynamics and fuzzy multi-criteria decision-making using Vensim and Super Decision software. Monetary policy instruments in this research include foreign exchange rate, deposits interest rate, facilities interest rate, required reserve ratio, and open market operations. Further, the macroeconomic indicators include inflation, liquidity, national foreign exchange value, and economic growth. The results indicated that the most important macroeconomic indicators in the country according to economic experts are "national foreign exchange value" and "inflation". The most important tool for monetary policies of central bank is "foreign exchange rate". Indeed, in order to improve the economic misery index, this bank should take measures to improve the national foreign exchange value, then manage inflation and liquidity, and eventually adjust the banking interest rate.

1 Introduction

Increasing liquidity along with double-digit inflation (as two macroeconomic indicators) in the economic conditions of Iran has always led to a decrease in social welfare, an increase in misery and a decrease in economic growth. The main reason for the increase in inflation and liquidity in Iran's oil-

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based economy has always been discussed and disputed by experts and researchers. Some believe that the government has caused the situation with a budget deficit and an imbalance in rial-foreign exchange earnings, and some blame the central bank for creating liquidity in the economy. Accordingly, by prioritizing monetary policy instruments, macroeconomic indicators can be optimally managed and while creating a roadmap for the Iranian economy, provide the basis for improving and establishing an efficient economic system. System dynamics is an approach for studying and investigating systems. System dynamics functions as a soft tool for studying behavior based on cause-and-effect relations, and its aim is to design policies, whereby it could change the system behavior in a desirable way. Accordingly, by applying system dynamics, we show that over the long run the outcomes can occur in a different way and the dynamic relations between variables should also be considered, i.e. static solutions cannot be solely relied upon [1]. The aim of this paper is to apply two methods for investigating the effect of monetary policies of central bank on macroeconomic indicators including system dynamics and fuzzy multi-criteria decision-making. At the first glance, clearly system dynamics is a soft tool which deals with investigating dynamic and continuous systems. System dynamic methodologies help, instead of defining the problem component by component, investigate it holistically and from a systemic point of view. The main emphasis in system dynamics is on the design of policies and support decision-making as useful and competitive approach. On the other hand, some non-dynamic methods investigate mostly discrete and static systems in hard space and rarely enter continuous areas [1]. Another point that diverges non-dynamic methods from reality is consideration of immediate effect of factors on each other. Another major problem of non-dynamic methods is output visualization as one point and inability in representing the path for achieving this point as well as having few parameters in modeling. Thus, the output of the system in the long run cannot be relied upon and most decisions are made as short-term or midterm. With all these differences, system dynamics and non-dynamic methods have one essential similarity which is display of feedbacks. Accordingly, the most important features, advantages, and indicators that differentiate systemic dynamics against other non-dynamic methods are as follows [1]:

- In terms of type of system, it is dynamic and continuous.
- Considering feedback, it has return loops.
- Regarding display of delay, it has delay function.
- Considering display of output, it shows all changes on the system throughout the entire range.
- With regards to the time range of decision, it includes midterm and long-term decisions (not merely short-term)
- Considering the nature of outcomes, it captures both quantitative and qualitative results.

With this explanation, in order to explain system dynamics and fuzzy multi-criteria decision-making techniques in determining the effect of monetary policies of central bank on macroeconomic indicators, the most important terms of the research have been defined as follows:

1. Interest rate on banking deposits: deposit is the sum of money deposited to the bank or financial Institute by real or legal entities according to some rules. The bank deposit profits refer to the profit on the capital deposited by people in the bank. Typically, banks and major financial institutes provide risk-free and definite profit rate to their customers. This profit rate which is generally approved and modified by the central bank or reserve, is one of the factors that affect economy of the country [2].

2. Monetary policies: "monetary policy" refers to the policies through which the central bank intends to achieve specific economic goals through changing the level and structure of "interest rate", changing and controlling the money volume, or other conditions of granting credit as well as financial facilities. Indeed, the monetary policy is implemented through changing the money volume, altering the money

volume growth and interest rate as well as conditions of granting financial facilities. Thus, the initiative of changing the money volume is mostly in the hands of the central bank, and this bank changes the money volume by applying monetary policies such as changing the legal reserve rate of banks, altering the rediscount rate and open market operations. Accordingly, the most important tools of monetary policy by central banks are as Table 1 [3].

Table 1: The Most Important Monetary Policy Tools of Central Banks Worldwide [3]

1.	Open market operations (partnership bonds, bonds, etc.)
2.	Discount rate
3.	Inter bank market bid rate
4.	Required reserve ratio and required deposit reward
5.	Foreign exchange operations
6.	Open market operations (partnership bonds, bonds, etc.)

3. Legal reserve or deposit: legal deposit or reserve refers to part of the assets of banks in the central bank which can be effective in resolving problems of banks or authorized institutes during critical situations. This reserve exists in all banks of the world. The legal reserve ratio is an indirect tool for implementing monetary policy by central banks. Banks always need to deposit part of their debts (sums received from people under the title of deposit) into the central bank of the country. Indeed, this deposit is received by the central bank to ensure security of people's deposits, control liquidity and inflation, as well as to support banks at the time of possible confrontation with bankruptcy or need to blocked liquidity [4].

4. Legal deposit bonus: the legal sums banks deposit to the central bank receive a low interest rate by the central bank, which is known as the legal deposit bonus [5]. Since the deposit kept by the central bank should be based on debt and practically no investment is done by banks in this area, the interest rate paid to the required reserve is always controversial worldwide.

5. Central bank participation bonds: one of the major and central tools of central bank is open market operations granting banks the necessary flexibility for liquidity management and intervention in the money market. In order to develop and expand open market operations as well as implement monetary policies considering liquidity management and influence on the money and capital market, finding suitable examples as rules of Islam's holy law after implementing usury-free banking operation laws found great significance. Bonds are not accepted principally in Islam as they are based on interest rates. Nevertheless, participation bonds and getting investors involved in economic activities and paying real profits are not only faced with barriers but are also encouraged [6]. Publication and dissemination of bonds of central bank are among the tools of contractive policy and implementing open market operations; with distribution of these bonds, the liquidity volume decreases and the sums of these bonds are blocked by the central bank. Thus, overall, distribution of bonds provides grounds for reducing liquidity growth. Indeed, it enables the monetary policy maker to accomplish low inflation rate at necessary situations through controlling liquidity [7].

with this explanation, in this paper, after the introduction, the literature of the research has been reviewed on issues of the effect of monetary policies of central bank on macroeconomic indicators in relation to system dynamics. Then, the research methodology including system dynamics and fuzzy multi-criteria decision-making techniques with DEMATEL and ANP methods have been introduced. Next, the most important macroeconomic indicators and monetary policy tools according to economic experts are prioritized using fuzzy multi-criteria decision-making techniques. Thereafter, the cause-and-effect and flow diagrams are drawn, after which the trends of diagrams of macroeconomic indicators

are analyzed to investigate the effect of monetary policies on these indicators. At the end, the results are analyzed and the findings are discussed, and finally some suggestions are provided for improving the effectiveness of monetary policies.

2 Literature Review

The research literature has been presented regarding the effect of central bank monetary policies on economic indicators with focus on the system dynamics. This section first includes definitions and concepts related to monetary policy tools as well as macroeconomic indicators and then deals with research regarding the effects of monetary policies on economic indicators using system dynamics tools.

Central banks affect changes of money supply and liquidity volume across the society using monetary policy tools depending on the extent of money supply which plays a key role on macroeconomic variables. In this way, independence of central banks from governments is accomplished to a large extent so that they could perform their duties properly. Based on previous studies, the most important monetary policy tools of central banks are as follows:

2.1 Discount Rate

Central banks determine the discount rate as the most important influential factor on economic activities and supervise it. Determining the discount rate is one of the most important measures taken by central banks for establishing economic balance and controlling the general level of prices (inflation). Discount rate is the rate that the central bank applies on its sums and inventory of assets when offering loans to the eligible financial institutes. Indeed, discount rate is the same as interest rate that is assigned to the loans paid by the central bank. The discount rate is controlled by the central bank and it has no relationship with the trades of this bank. This rate is considered a basis for determining the interest rate. Commercial banks begin to offer loans based on the basic interest rate. This rate is according to the discount rate and is often higher than it. There is no correlation between the basic interest rate and discount rate. For example, if the discount rate increases, definitely the basic interest rate also grows. However, if the discount rate decreases, the basic interest rate may not follow it and banks obtain higher profits from this difference.

2.2 Banking Interest Rate

The banking interest rate is the interest rate with which the central bank gives loans to commercial banks or receives deposits. Central banks survey economic data and the factors affecting different sectors of the economy and then implement the final decisions. Although changes of the interest rate can affect the level of inflation and national income of country, central banks use this tool carefully since sudden change of the interest rate can encourage economic instability. By changing the banking interest rate, the central bank tries to achieve the economic goals of the country. If the central bank of country feels that reception of credits from people has increased excessively, it will raise the banking interest rate which causes diminished demand for credit from commercial banks and absorption of people's deposits to the central bank.

2.3 Legal Deposit Ratio

Legal reserve for deposit refers to part of the assets of banks in the central bank which can be effective during critical situations for resolving the problems of banks or authorized institutes. This reserve exists in all banks of the world. The legal deposit ratio is one of the indirect tools of monetary policy of the

central bank. Banks need to keep part of their debts (the sums they receive from people under the title of deposit) in the central bank of the country. Indeed, Tavasoli et.al [4] show that reception of this sum by the central bank is performed to ensure security of people's deposits, control liquidity and inflation, and as support banks at the time of possible bankruptcy or need to blocked liquidity. The legal deposit ratio of banks is determined by the central bank of Iran which may be different in terms of the composition and type of activity of banks. Nevertheless, according to the article 14 of the banking monetary law approved in 1972, at any circumstances this ratio will not be lower than 10% and more than 30%.

2.4 Open Market Operations

Another financial tool of the central bank is open market operations in which bonds are bought or sold. Here, by selling the bonds for collecting people's deposits, the central bank contributes to reduction of their credit power. By purchasing the bonds from banks, the central bank takes step for developing supply of money and supporting increased loan giving power of banks.

2.5 Foreign Exchange Operations

In goal setting for inflation based on the foreign exchange rate, implementation of monetary policy is focused on the foreign exchange rate. In this regime, in order to keep the inflation rate low, balanced foreign exchange rate (based on the weight of the major commercial partners) is managed within a target range by the monetary policymakers. These policymakers perform some interventions in order to maintain the exchange rate within the determined range. Unlike other regimes, in this framework, the interest rate is not used as an operational target and the exchange rate can be used instead of the interest rate as a monetary policy tool. Also, naturally transparency in inflation goalsetting based on the exchange rate is lower compared to other regimes. The economies that adopt for exchange rate-based inflation goalsetting are open economies and the exchange rate plays a key role in the mechanism of transfer of monetary policy. New Zealand and Singapore are the countries that have adopted inflation goalsetting system based on the exchange rate [8].

With this explanation, various studies show that banking crises incur staggering costs to the economy either directly through reduction of production and employment or indirectly via increased governmental expenditure and decreased tax incomes [9]. Meanwhile, various studies have been performed on the factors affecting banking crises. Evidence shows that adopting improper monetary policies by monetary policymakers has always been one of the reasons of incidence of banking crises. The mechanism of transfer and the important channels of influence of monetary policy in the economy include the interest rate channel, foreign exchange rate channel, credit channel through the bank balance sheet, and bank loaning channel. Accordingly, banks play the key role in the monetary transfer mechanism of the central bank, and function as the executor of monetary policies of the central bank. Askari and Krichene [10],[11] showed that the monetary policies of the central bank for changing the interest rate and increasing the credit as well as creating liquidity are among the causes of incidence of financial and banking crises worldwide. Accordingly, debt-based money or creation of money and credit through the banking system aggravate inflation, and the fact that inflation stimulates employment and growth is a kind of sophistry. Inflation is a kind of tax which transfers the wealth from one group to another needlessly, causing income inequalities. Meanwhile, reduction of the money value leads to decreased purchase power, thereby eliminating financial savings. In this situation, compulsory saving will replace voluntary saving, and it is imposed on creditors and brokers through inflationary tax.

Accordingly, some studies performed on the effect of monetary policies on economic indicators using system dynamics approach both in Iran and in foreign countries have been as follows:

Otzurk. et al. [12] conducted a study entitled "system dynamics approach for determining the optimal monetary policy during the COVID-19 economic crisis: case study Turkey". They performed that research with the aim of investigating the effects of expansionary monetary policies of the central bank of Turkey on economic growth, inflation, and financial stability in this country with the comprehensive approach using a dynamic model and two scenarios from the period of January 2010 to May 2020. In the first scenario, when the money development policy is implemented, it is assumed that the rate of monetary policy and the required reserves would not change, rather a development-oriented policy will continue. In the second model, strict monetary policy, entrance of foreign capital and if required foreign exchange was designed as confounding factors. In this state, the expansionary scenario of the monetary policy that is not based on foreign resources cannot fully fulfill the expected economic improvement. The findings obtained in the second scenario are more effective than those of the first scenario. In addition, the second scenario is more effective on economic development, inflation, and financial stability.

Ghafarifard et al., [13] conducted a study entitled "simulation of the influence of monetary policies on stimulating production in Iran's economy with system dynamics approach". The aim of that paper was to investigate the influence of monetary policies through the most important money transfer channels on macroeconomic variables especially production in Iran. They applied system dynamics method and 20 year time horizon in order to interpret this influence as precisely as possible. After interpreting the cause-and-effect relations of variables, the relations of the rate and flow were drawn and then the intended model was implemented and put in the scenario. The findings indicated that increased money volume in Iran has positive effect on consumption, savings, and level of prices, yet it will have an inverse effect on investment. The influence of changes of money value on production is such that with increase of money volume in the short-term, gross domestic production will flourish in the short run. However, in the long run, it results in decreased production. Thus, in order to fulfill economic goals and the Vision Document, the economic policymakers should set controlling the money volume as their agenda in the long run.

Bakhshi Dastjerdi et al[14] in their study entitled "system dynamics attitude to effect of creation of banking money on inflation in Iran's economy" believed that lack of optimal allocation of resources in the banking system and aggravation of inflation alongside recession, monetary imbalances and their spread to the real part of the economy as well as the resulting problems on account differences, plus lack of conducting banking credits towards production sectors are among the issues that can be seen in the bank-oriented economy of Iran. The results obtained from designing different scenarios in this research indicated that increase of the legal reserve rate against short-term deposits up to 100% and eliminating the loan giving power of banks from this type of deposits as well as increasing the legal deposits rate in exchange for long-term deposits and determining a balanced rate by the central bank would reduce the power of creation of money by banks, resulting in stability of money supply, stability of level of prices as well as production costs in the long run. Also, design of scenario of changing the interest rate in that research indicated that reduction of the banking interest rate would lead to improvements in the major variables such as inflation, money supply, power of credit creation, and production costs. Kheiralbahri [15] employed system dynamics method to investigate the trend of economic development of Indonesia. Their analysis unveils that the Indonesia economy has a chance to fulfill the vision document 2030, provided that investment in technological development increases. Pourakbar and Firoozan Sarnaghi [16] dealt with modeling increased liquidity in Iran using system dynamics approach.

In that research, part of the monetary sector of Iran's economy has been modeled using system dynamics and soft calculation tools. The soft computational methods of the research have been a combination of artificial neural networks and genetic algorithm. The study results indicated that under conditions when oil incomes follow a similar trend in recent years and the tax rate is about 0.06, and the nominal foreign exchange rate reaches below 30000 Rials, the liquidity would decrease up to 2000 billion Rials.

Ghazizadeh and Molaalipour [17] identified the effect of changing the foreign exchange rate on the macroeconomic variables of Iran's economy with system dynamics approach. In that research by employing this approach, a model was developed to identify the effect of changing the foreign exchange rate on other macroeconomic variables. That study deals with exploring the behavior of households, enterprises, government, and foreigners within the country's economic framework and by determining the effect of exogenous variables on other variables, their behavior was simulated in interaction with one another. In this way, it would be possible to predict the economic system feedback of the country to changes of foreign exchange rate as well as to perform sensitivity analysis for testing and understanding the best possible decision regarding foreign exchange rate. For designing the model, first system variables were identified and then the cause-and-effect relations between them were described and the circular cause-and-effect diagram was drawn. In the next stage, by developing the flow diagram model and incorporating the relations and the data extracted from Iran's economy, the system behavior was simulated. Thereafter, in order to explore the accuracy of outputs, the model was run based on real data for a specific period of time, whose accuracy was confirmed when comparing the outputs with the available information. Eventually, by implementing two different exchange-rate scenarios (dollar) in the model, the behaviors of system variables including the national income, household income, government income, enterprise assets, and national production were investigated. The outputs of the model indicated multiple time increase of incomes for all economic brokers in case of elevation of the foreign exchange rate especially within the first 30 months of the simulation period.

Yamaguchi [18] employed system dynamics modeling, and in eight steps he dealt with analyzing the behaviors of the current banking system. Within a 25-year period, they investigated the behavior of variables such as the money base, money supply, government debt, and current coin. In that research, the researcher found that in order to increase the reserve of capital, production, consumption, and reduction of economic fluctuations, the conventional banking system which is based on partial reserve should be modified. The Yamaguchi's proposal is "public monetary system". To interpret his proposed model, throughout six stages using system dynamics, he analyzes the behavior of his desired economic system variables.

Research Gap: as observed in the above studies, so far no special study has been performed regarding the effect of monetary policies of the central bank concurrently (including interest rate, legal deposit ratio, foreign exchange rate, and open market operations) on macroeconomic indicators including inflation, liquidity, unemployment, national foreign exchange value, and economic development based on system dynamics in Iran or overseas. Furthermore, in the present research, using multi-criteria decision-making techniques and in a fuzzy way, the most important macroeconomic indicators and the monetary policy tools affecting these indicators in the economy with high misery index of Iran have been investigated based on the opinions of experts and professors of economics.

3 Methodology

The method of this study has been analytical-descriptive, and data collection has been of library type. Accordingly, first macro variables and those related to monetary policies and the way they impact and are impacted in the macro economy are presented.

Interest rate on deposits: in case the interest rate on deposits (as a monetary policy tool) increases, more individuals begin to deposit their money in banks. Evidently, in this case the interest rate on facilities also increases and hence fewer individuals start to receive facilities from the banking system. Also, in case of reduction of the interest rate on deposits, individuals would withdraw their deposits from the banking system and would guide them to parallel markets.

Inflation rate: in case the inflation rate increases in the country, since individuals will find less purchase power, inevitably and for preventing loss of their money value, they mostly tend to invest their money and assets in bank and its other parallel markets so that they could use the profit obtained from the deposit or through rushing into parallel markets of banking deposit (including foreign exchange market, calling and gold, housing and real estate, vehicle, and stock market), they would maintain the value of their assets. Nevertheless, under inflationary conditions, some others begin to receive facilities from banks (albeit with high interest rate) with the belief that under these conditions debt has no meaning.

Liquidity volume: when the volume of the liquidity present in the economy rises, the central bank typically begins to increase the banking deposit interest rate in order to curb inflation resulting from increased liquidity volume. In this way, it could control the volume of the liquidity present in the economy and reduce it. Thus, individuals would find tendency to invest their money and liquidity in the bank.

Employment/unemployment rate: high employment rate in the country causes individuals to gain more income. Higher income itself leads to increased purchase power, though it can result in increased demand and hence inflation. Indeed, in this situation, individuals with higher purchase power begin to receive banking facilities, and those who worry about loss of their money value (resulting from inflation) tend to invest their assets and money in bank or parallel markets. Meanwhile, increased unemployment rate causes the unemployed population begins to invest their assets and money in the bank as they have no income.

Economic growth rate: higher economic growth rate leads to increased economic activities and flourishing businesses. As such, more individuals begin to receive facilities from banks, whereby the rate of granting facilities increases.

National foreign exchange value: in case of increase in the foreign exchange price (dollar), since the national monetary value drops, many individuals begin to withdraw their banking deposits and purchase foreign exchange foreign exchange (especially dollar) considering the loss of monetary value and their capital, so that they could keep the value of their money. Hence, the volume of investment in banks decreases. Meanwhile, the government or central bank through the increase in the foreign exchange price elevate their incomes.

General level of incomes: if the price of crude oil as the main source of government income increases, the government incomes also rise, which can potentially lead to increased economic development and flourishing businesses. Thus, the tendency of individuals towards development and enhancement of economic activities increase, whereby they begin to receive facilities from the banking system more. Accordingly, in case of elevation of the general income levels, the purchase power of people increases which can lead to encouraging the individuals to receive facilities. Also, considering the increased assets

and balance of individuals in these situations, they can begin to invest their money and assets in banks. Overall, in this scenario the events are similar to the employment/unemployment rate scenario.

Speculation in parallel markets of banking deposits: banking deposits are considered among the least risky markets of investment. However, one of the reasons behind encouraging people to invest in markets parallel to banking deposits is the mismatch between the interest rate on banking deposits and the predominant inflation rate in the society. Indeed, determination of banking interest rate lower than the inflation rate in the economy of the country results in withdrawal of banking deposits from the banking system and increased liquidity circulating across the society. The wandering liquidity withdrawn from the banks flows towards parallel markets including foreign-exchange, coin and gold, land, housing and real estate, as well as vehicle; due to their concerns over maintaining the value of their assets, the society begins to speculate and invest in parallel markets. While increasing the extent of demand in these markets, given the mismatch between supply and demand, this aggravates inflation in these markets and results in general elevation of prices.

After investigating the behavior of macroeconomic variables in interaction with monetary policies, initially, the system dynamics as well as two multi-criteria decision-making techniques called DEMATEL and ANP are introduced. System dynamics is a mathematical modeling technique and method for framing, understanding, and discovering complex issues. Principally, system dynamics methodology uses six steps for problem solving.

Step one: identification and definition of problem: it is the first step in problem-solving using system dynamics methodology. In this study, again the problem of interest is identifying the effect of monetary policies of the central bank on the macroeconomic indicators, based on the reviewed literature and investigating the opinions of scholars in this area, and then analyzing different dimensions of this problem.

Step two: conceptualization of system: this step involves determining the boundary of the model, identifying cause-and-effect relations, and framework of policy.

Step three: complete configuration of the model: in the third step, conceptualization of the system should be translated into complete configuration of the model as feedback loops, physical and information flows, as well as variables and parameters. For this purpose, the model studied in this paper has been designed in the form of cause-and-effect diagrams as well as flow diagram followed by extraction of the relations between model variables, whereby the model behavior has been explained internally. Further, in this stage, after formulating the relations between variables, VENSIM software has been used for simulating the model. VENSIM software is the most common software of simulation based on system dynamics technique. In this software, mathematical equations and the numbers related to each of the parameters are inputted, and then the desired analyses are performed on the model and the results are obtained.

Step four: simulation and validation: For practical usage of system dynamics model, this model should be validated. For this purpose, in the fourth step, the design model should be simulated and validated. In order to test the validity of the model, there are various tests including final limits test, testing part of the model components, balance states test, parametric sensitivity test, unconventional behavior test, and software test.

Step five: analysis and improvement of policies: the system dynamics methodology in the fifth step deals with analyzing and improving policies. The ultimate goal of the entire process is to model the design of improved policies which can ameliorate the system behavior. The design of policies is done based on the understanding resulting from the modeling. In this study also after modeling the effect of

monetary policies of the central bank on macroeconomic indicators and validating the model, three financial policies of "foreign exchange rate", "open market operations", and "interest rate on deposits/facilities" were chosen.

Step six: implementation of policies: this stage is the last step in problem-solving and has an executive nature. Implementation of new policies requires establishing changes in many sectors, which typically leads to numerous behavioral issues.

Generally, in systemic thinking, tools are used in order to visualize the structure of a system for its better understanding. Two important tools for systemic thinking are cause-and-effect diagrams and flow diagram. To develop a model from system dynamics which is also practical, cause-and-effect diagrams and the special flow of data problem should be prepared.

Since this study has dealt with exploring the effect of monetary policy tools on macroeconomic indicators, and these tools have been classified in the form of five options, and the economic indicators have been categorized as five criteria and there are also interrelations between the criteria, multi-criteria decision-making techniques called "DEMATEL" and fuzzy "ANP" are investigated and introduced further. The purpose of the Dematel technique is to identify the pattern of causal relationships between a set of criteria. This technique scores the intensity of communication, scores important feedback, and accepts non-transferable relationships. The advantage of this method over network analysis technique is its clarity and transparency in reflecting the interrelationships between a wide range of components, so that the direction and intensity of effects between factors can also be examined. The matrix obtained from the Dematel technique (internal communication matrix) is in fact part of the super matrix. In other words, the Dematel technique does not work independently; But rather it is as a subsystem of a larger system Same of ANP.

3.1 Fuzzy Theory

Individuals' judgments about priorities for precise numerical value estimation are often nontransparent. Further, fuzzy logic is useful for obtaining solutions of problems with ambiguity and uncertainty. Fuzzy theory was first presented by Zadeh (1965) for coordinating uncertainty of human understanding of the model. Fuzzy numbers are represented by "~" above the number. Triangular fuzzy number has been shown in (Figure 1).
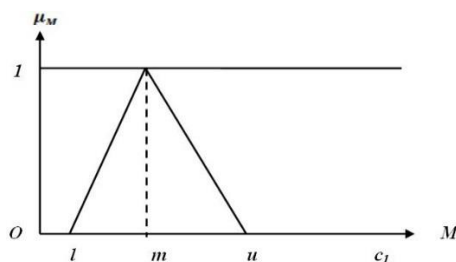

Fig. 1: Representation of Triangular Fuzzy Number

Triangular fuzzy numbers are presented as (l,m,u), where l, m, and u represent the smallest possible expected value, more probable expected value, and the maximum possible expected value.

3.2 Fuzzy DEMATEL

DEMATEL technique is one of the multi-criteria decision-making techniques whose goal is to evaluate the research factors in terms of cause-and-effect relations. The steps of fuzzy DEMATEL technique are presented further [19].

3.2.1 Calculating the Direct Correlation Matrix (D)

In this step, the respondents are asked to indicate the extent of influence of criterion i on criterion j using Table 2. In order to capture the opinion of all experts according to Relation 1, arithmetic mean is taken from them.

$$\tilde{z} = \frac{\tilde{x}^1 \oplus \tilde{x}^2 \oplus \tilde{x}^3 \oplus \dots \oplus x^p}{p} \tag{1}$$

In this formula, p represents the number of experts and $\tilde{x}^1$, $\tilde{x}^2, and\ \tilde{x}^p$ indicate the paired comparison matrix of expert 1, expert 2, and expected p, while $\tilde{z}$ denotes triangular fuzzy number as $\tilde{z}_{ij} = (l'_{ij}, m'_{ij}, u'_{ij})$.

Table 2: Five-degree Spectrum of Fuzzy DEMATEL Technique

Variable	Definite equivalent	Fuzzy equivalent
No effect	0	(0,0,0.25)
Little effect	1	(0,0.25,0.5)
Moderate effect	2	(0.25,0.5,0.75)
Large effect	3	(0.5,0.75,1)
Very large effect	4	(0.75,1,1)

3.2.2 Normalization of Direct Correlation Matrix

According to relations 2 and 3, the mean matrix is normalized which is called matrix H.

$$\widetilde{H}_{ij} = \frac{\tilde{z}_{ij}}{r} = (\frac{l'_{ij}}{r}, \frac{m'_{ij}}{r}, \frac{u'_{ij}}{r}) = (l''_{ij}, m''_{ij}, u''_{ij}) \tag{2}$$

where, r is obtained from the following relation:

$$r = \max_{1 \le i \le n} \left(\sum_{j=1}^{n} u'_{ij} \right) \tag{3}$$

3.2.3 Calculating Total Correlation Matrix of Criteria (T_C)

After calculating the above matrices, the total fuzzy correlation matrix is obtained by (4), (5), and (6).

$$T = \lim_{k \to +\infty} (\widetilde{H}^1 \oplus \widetilde{H}^2 \oplus \dots \oplus \widetilde{H}^k)$$

Where, each of its elements is a fuzzy number as $\tilde{t}_{ij} = \left(l^t_{ij}, m^t_{ij}, u^t_{ij} \right)$, and is calculated as follows:

$$\left[l^t_{ij} \right] = H_l \times (I - H_l)^{-1} \tag{4}$$

$$\left[m^t_{ij} \right] = H_m \times (I - H_m)^{-1} \tag{5}$$

$$\left[u^t_{ij} \right] = H_u \times (I - H_u)^{-1} \tag{6}$$

in these relations, I is a unity matrix, while H_l, H_m, and H_u each denote an n*n matrix whose elements constitute the lower, middle, and upper number of the triangular fuzzy numbers of matrix H.

3.2.4 Calculating the Intensity and Direction of Impact

According to Relations 7 and 8, we calculate the value of ri and cj indices. ri index represents the sum of i_{th} row and cj denotes the sum of j_{th} column of complete relations matrix (T). In order to draw and analyze the diagram, the effectiveness and impactability indices as well as the direction of effect are required, which are obtained by ri and cj. For each i=j, we have:

$$\widetilde{D} = \left(\widetilde{D_i}\right)_{n \times 1} = \left[\sum_{j=1}^{n} \widetilde{T}_{ij}\right]_{n \times 1} \qquad (7)$$

$$\tilde{R} = \left(\tilde{R_i}\right)_{1 \times n} = \left[\sum_{j=1}^{n} \widetilde{T}_{ij}\right]_{1 \times n} \qquad (8)$$

where, $\widetilde{D}$ and $\widetilde{R}$ represent the n*1 and 1*n matrices specifically.

In the next stage, the extent of importance of indices $(\widetilde{D}_i + \widetilde{R}_i)$ as well as the relation between criteria $(\widetilde{D}_i - \widetilde{R}_i)$ are identified. If $\widetilde{D}_i - \widetilde{R}_i > 0$, the mentioned criterion is effective, while if $\widetilde{D}_i - \widetilde{R}_i < 0$, the mentioned criterion is impactable.

- ri+dj = The intensity of effectiveness and impactability (in other words, the higher the ri+dj value, that factor will have greater interaction with other factors of the system).

- ri-dj= the direction of effectiveness or impactability (where, if ri-dj>0, that criterion is effective while if ri-dj<0, each will be impactable).

Considering the values calculated above, we obtain the value of ri+dj and ri-dj indices for criteria along with $\widetilde{D}_i + \widetilde{R}_i$ and $\widetilde{D}_i - \widetilde{R}_i$ for the dimensions, and then defuzzify using Relation 9:

$$\text{defuuzy} = \frac{\left((u - l) + (m - l)\right)}{3} + l \qquad (9)$$

3.2.5 Drawing the Network Relations Map (NRM)

In order to determine the network relations map (NRM), the threshold value should be calculated. Using this method, partial relations can be neglected and the network of noticeable relations can be drawn. Only the relations whose values are larger than the threshold value in matrix T will be represented in NRM. In order to calculate the threshold value of relations, it only suffices to obtain mean defuzzified values of matrix T. Once the threshold intensity was determined, all values smaller than the threshold will be zero, i.e. that cause-and-effect relation will not be considered.

3.3 Fuzzy ANP Method

Analytical hierarchy process (AHP) is one of the most well-known multi-criteria decision-making technique invented by Thomas L. Saaty in the 1970s. Ability in analyzing a decision-making problem into

a stage structure is the fundamental basis of using AHP, having a stage structure necessitates independence of possible preferences of an available level from the elements of lower levels. However, decision levels are not always independent of each other and usually interact with each other. Based on this point, AHP may present invalid results. Since AHP is not comprehensive enough, Saaty in 1980 presented a developed method entitled analytical network process (ANP). Indeed, he presented ANP as a generalization of AHP. In real world, many multi-criteria decision-making problems cannot be considered hierarchical because of internal and external dependencies as well as the relations and interactions between elements of clusters at decision-making levels. Thus, ANP with comprehensive framework can capture all interactions and relations between decision-making levels which constitute a network structure. Hasei et al [20] show that in fuzzy ANP method, in order to calculate weight of the paired comparisons, Buckley geometrical mean technique is employed for calculating the relative weights in the fuzzy paired comparisons. The steps of this method are provided further. Assume that $\tilde{P}_{ij}$ is a set of preferences of decision-makers about an index in relation to other indices. The paired comparisons matrix is formed as follows:

$$\tilde{A} = \begin{bmatrix} 1 & \tilde{P}_{12} & \tilde{P}_{1n} \\ \tilde{P}_{21} & 1 & \tilde{P}_{2n} \\ \tilde{P}_{n1} & \tilde{P}_{n2} & 1 \end{bmatrix}$$

where, n is the number of relevant elements in each row. The fuzzy weights of each index of the paired comparisons matrix are obtained using the Buckley geometrical mean method [20]. The geometrical mean on the value of paired comparisons of index i to any index is obtained by Relation 10.

$$\tilde{r}_i = \left(\prod_{j=1}^{n} \tilde{P}_{ij} \right)^{1/n} \qquad i = 1,2,3,\dots,n \tag{10}$$

Next, the fuzzy weight of the i_{th} index using a triangular fuzzy number is shown based on Relation 11.

$$w_i = r_i \otimes (r_1 \oplus r_2 \oplus \dots \oplus r_m)^{-1} \tag{11}$$

After calculating the fuzzy weight factors, using Relation 12, the weights are defuzzified and then normalized.

$$w_{crisp} = \frac{l + 2m + u}{4} \tag{12}$$

In this research, to calculate the weight in the paired comparisons, verbal statements and triangular fuzzy numbers listed in Table 3 have been used.

3.3 Data Gathering

The information related to the data of macro variables and monetary policy tools within 2009-2021 has been extracted from the website of Iran's statistic centers, central bank of Islamic Republic of Iran, and Codal website according to the following (Table 4).

Table 3: Verbal Statements and Fuzzy Numbers to Give Weight to the Criteria

Code	Priorities	Fuzzy equivalent of priorities		
		Lower limit (L)	Average limit (m)	Upper limit (u)
1	Same importance	1	1	1
2	Same importance to relatively more important	1	2	3
3	Relatively more important	2	3	4
4	Relatively more important to large importance	3	4	5
5	Large importance	4	5	6
6	Large importance to very large importance	5	6	7
7	Very large importance	6	7	8
8	Very large to absolutely more important	7	8	9
9	Absolutely more important	8	9	10

Table 4: The Information Related to the Macro/general Variables of Researching the Banking System in 2009-2021 (%)

Name of variable	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Deposits interest rate announced by central bank (%)	14.5	12.68	11.62	13.5	13.5	16	19	15	15	15	18	18	18
Required reserve ratio announced by central bank (%)	13.2	12.3	12.3	11.5	11.1	13.5	10 to 13	10.3	10 to 13	13	15.7	13	13
Required reserve reward rate announced by central bank (%)	1	1	1	1	1	1	1	1	1	1	1	1	1
Inflation rate (%)	10.8	12.4	21.5	30.5	34.7	15.6	11.9	9	9.6	31.2	41.2	48.7	50
Liquidity volume (Billion Rials)	2,355,890	2,948,870	3,542,550	4,606,940	6,395,500	7,823,850	10,172,800	12,533,900	15,300,000	18,800,000	24,720,000	34,761,000	46,240,000
Liquidity growth rate (%)	24	25	20	30	39	22	30	23	22	23	31	41	33
Economic growth rate (%)	3	6	3	6.8-	1.9-	3	1.6-	12	4	4.9-	6.5-	4	5
Unemployment rate (%)	12	14	12	12	10	11	11	12	12	12	11	10	9
Misery index (%)	23	26	34	43	45	26	23	21	22	43	52	58	59
Minimum monthly wage (Rials)	2,635,300	3,030,000	3,030,000	3,900,000	4,872,000	6,089,100	7,124,250	8,121,660	9,299,310	11,141,400	15,170,000	18,354,270	26,554,950
Government revenue (billion Rials)	625,160	778,068	1,114,379	1,014,724	1,329,451	1,783,200	2,017,100	2,831,600	3,200,000	3,898,000	4,104,551	5,631,444	12,100,000
Rate of each square meter of housing (thousand Rials)	6,118	5,701	6,389	8,179	10,680	11,695	10,796	11,164	12,269	19,630	46,808	106,003	----
Foreign exchange rate (Rials)	10,000	11,000	18,000	38,000	36,000	35,500	36,000	34,250	42,500	107,830	129,183	231,500	260,000
Pride vehicle rate (million Rials)	82,000,000	84,000,000	87,000,000	170,000,000	185,000,000	203,500,000	212,000,000	225,000,000	236,000,000	470,000,000	610,000,000	1,230,000,000	1,900,000,000
Bahar Azadi Coin Rate (Rials)	2,880,000	4,350,000	6,300,000	9,100,000	10,600,000	9,650,000	9,360,000	11,710,000	16,000,000	35,542,000	46,181,000	118,320,000	123,000,000

**Table 4:** The Information Related to the Macro/general Variables of Researching the Banking System in 2009-2021 (%)

Total Stock Index	---	----	----	38,041	79,015	62,532	80,219	77,230	99,817	178,659	512,903	1,307,000	1,367,000

4 Data Analysis

4.1 Sampling and Sample Size in the DEMATEL Method

In order to calculate the sample size in DEMATEL method similar to statistical methods, Cochran formula or Morgan table are not applicable. The population of interest in multi-criteria decision-making techniques is the experts of the study area. First and foremost, their expertise criteria should be defined. For this purpose, typically level of education and working background are used. Generally, the sample size in multi-criteria decision-making methods has been proposed between 5 and 30 individuals [21]. For the sampling, a non-probabilistic and purposeful sampling method is used. If the examined experts are in a special organization, considering the expertise criteria, the eligible individuals are referred to purposefully. If the sample of interest is scattered and across an industry, snowball sampling method is used to achieve the desired sample.

Accordingly, the statistical population in this research consisted of experts in economic and monetary areas at level of academic professors (include the assistant professor, associate professor, and full professor with degrees in economics and financial management), and their number was determined 10. These experts evaluated research model using DEMATEL technique and ANP process as (Figure 2).
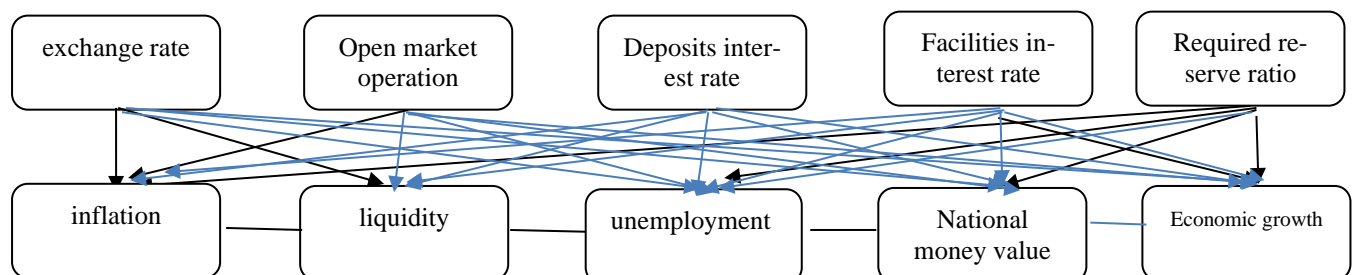
Fig. 2: Conceptual Model of the Research

Some basic data such as exchange rate, inflation rate, liquidity rate, economic growth rate, unemployment rate, interest rate on deposits and legal deposit ratio in 2009 to 2021 have been collected from the website of the Central Bank of the Islamic Republic of Iran. In addition, data such as the minimum wage rate, gold price, housing price and car price in the above period have been collected from the website of the Statistics Center of Iran. According to the conceptual model of the research, pairwise comparisons of experts to determine the prioritization of monetary policy instruments and macroeconomic indicators have been as follows:

In their comparisons, the experts first compared the importance of criteria (macroeconomic indicators include of inflation, liquidity, unemployment, national money value, economic growth). In such a way that the effect of each indicator on other indicators was expressed in a fuzzy way and in the linguistic spectrum from "No effect" to "Very large effect". After extracting the priority criteria (macroeconomic indicators) in the next step, experts have compared pairs of monetary policy instruments (include of exchange rate, open market operation, Deposits interest rate, Facilities interest rate, Required reserve ratio with each other in terms of macro indicators in a fuzzy way and in the linguistic spectrum from

Same importance to Absolutely more important. After prioritizing the criteria (macroeconomic indicators) and options (monetary policy instruments) in the next step, using fuzzy decision-making techniques and in order to better explain the relationship between indicators and instruments, the dynamics diagram of the systems for them (options and instruments) is drawn using Vensim software. Formulation in the above software is often done by the researcher based on the study of the literature review and previous research as well as the economic conditions prevailing in Iran from 2009 to 2021.

4.2. The Results of Fuzzy DEMATEL

Formation of direct correlation matrix

In this section, the DEMATEL matrix was provided to 10 experts so that based on spectrum 0-4 in (Table 5), the effectiveness of each criterion on other criteria would be identified. Next, using Relation 1, the opinions of respondents were merged, with the results provided in Table 5.

Table 5: Direct Correlation Matrix of Criteria

	C1	C2	C3	C4	C5
C1	(0,0,0.25)	(0.4,0.65,0.875)	(0.675,0.925,0.975)	(0.6,0.85,1)	(0.25,0.5,0.7)
C2	(0.075,0.3,0.55)	(0,0,0.25)	(0.325,0.575,0.825)	(0.225,0.475,0.725)	(0.55,0.8,0.975)
C3	(0.575,0.825,1)	(0.125,0.375,0.625)	(0,0,0.25)	(0.4,0.625,0.875)	(0.4,0.65,0.85)
C4	(0.525,0.775,0.95)	(0.275,0.525,0.775)	(0.5,0.75,0.975)	(0,0,0.25)	(0.675,0.925,1)
C5	(0.175,0.4,0.625)	(0.475,0.725,0.9)	(0.375,0.625,0.85)	(0.3,0.55,0.775)	(0,0,0.25)

Normalizing the direct correlation matrix

At this step, using Relations 2 and 3, we normalized a direct correlation matrix of Table 6. For the normalization, the maximum row sum of upper limits of the direct correlations matrix should be obtained, which has been found as 3.95 in this section. Next, all numbers of the direct correlation matrix (Table 6) are divided by 3.95, with the results outlined in (Table 6).

Table 6. Normalized Direct Correlation Matrix of Criteria

	C1	C2	C3	C4	C5
C1	(0,0,0.063)	(0.101,0.165,0.222)	(0.171,0.234,0.247)	(0.152,0.215,0.253)	(0.063,0.127,0.177)
C2	(0.019,0.076,0.139)	(0,0,0.063)	(0.082,0.146,0.209)	(0.057,0.12,0.184)	(0.139,0.203,0.247)
C3	(0.146,0.209,0.253)	(0.032,0.095,0.158)	(0,0,0.063)	(0.101,0.158,0.222)	(0.101,0.165,0.215)
C4	(0.133,0.196,0.241)	(0.07,0.133,0.196)	(0.127,0.19,0.247)	(0,0,0.063)	(0.171,0.234,0.253)
C5	(0.044,0.101,0.158)	(0.12,0.184,0.228)	(0.095,0.158,0.215)	(0.076,0.139,0.196)	(0,0,0.063)

Formation of complete correlation matrix (T)

At this step, using 4, 5. and 6, we form a complete relations matrix (T). In order to calculate T, first the identity matrix (I_{5*5}) is formed. Thereafter, we subtract identity matrix from the normal matrix and inverse the resulting matrix. Eventually, we multiply the normal matrix by the inverse matrix, with the results shown in (Table 7).

Table 7. Total Relationships Matrix of Criteria

	C1	C2	C3	C4	C5
C1	(0.071,0.273,2.035)	(0.148,0.4,2.179)	(0.235,0.513,2.43)	(0.206,0.464,2.31)	(0.147,0.435,2.331)
C2	(0.058,0.27,1.868)	(0.038,0.196,1.807)	(0.124,0.362,2.134)	(0.094,0.316,2.005)	(0.177,0.41,2.125)
C3	(0.185,0.41,2.108)	(0.082,0.317,2.045)	(0.073,0.282,2.177)	(0.153,0.387,2.195)	(0.158,0.418,2.261)
C4	(0.185,0.435,2.245)	(0.128,0.383,2.223)	(0.2,0.483,2.498)	(0.073,0.288,2.215)	(0.233,0.514,2.453)
C5	(0.086,0.304,1.922)	(0.149,0.364,1.986)	(0.142,0.389,2.183)	(0.117,0.346,2.056)	(0.06,0.257,2.012)

Development and analysis of cause-and-effect diagram

At this step, based on Relations 7 and 8, the sum of rows (D) and sum of columns (R) of the total relationships matrix (Table 8) are obtained, and then the values of D+R and D-R are calculated. In this phase, for defuzzification of values, Relation 9 is used, with the results presented in (Table 8). Accordingly, the sum of elements of each row (D) represent the extent of effectiveness of that factor on other factors of the system. Thus, the national money value criterion (C4) has had the largest effectiveness. The sum of elements of the column (R) for each factor indicated the extent of impact ability of that factor from other factors of system. As such, the liquidity criterion (C3) has been heavily impactable. The vertical vector (D-R) indicates the power of effectiveness of each factor. Generally, if D-R is positive, the variable is considered a cause variable, while if it is negative, it is regarded as an effect variable. Accordingly, in (Figure 3), the criteria that are above the horizontal axis are cause, while those that are below the horizontal axis are regarded effect.

Table 8. D and R Values of Criteria

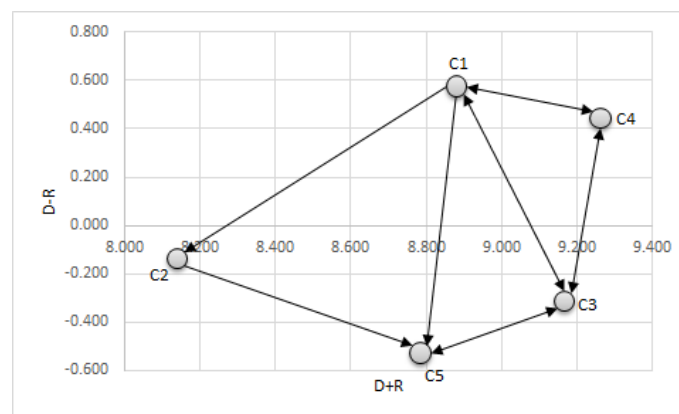|	Di	Ri	$(Di)^{defuzzy}$	$(Ri)^{defuzzy}$	Di+Ri	Di-Ri
C1	(0.808,2.084,11.286)	(0.585,1.691,10.178)	4.726	4.152	8.877	0.574
C2	(0.49,1.555,9.938)	(0.545,1.66,10.24)	3.995	4.148	8.143	-0.154
C3	(0.652,1.815,10.787)	(0.775,2.029,11.422)	4.418	4.742	9.160	-0.324
C4	(0.819,2.102,11.635)	(0.643,1.801,10.781)	4.852	4.408	9.260	0.444
C5	(0.554,1.659,10.158)	(0.776,2.034,11.182)	4.124	4.664	8.787	-0.540

Fig. 3: Cause-and-Effect Diagram of Criteria (Effect and Impact Ability of the Macroeconomic Indicators)

4.3 The Results of Fuzzy ANP Method

In order to implement the fuzzy ANP method, first we obtained the weights in paired comparisons using Buckley geometrical mean method. Then, by incorporating these weights into the initial super matrix of ANP, Mohanty et al. [22] calculate the balanced and extreme super matrix, in order to obtain the final weights of fuzzy ANP. Further, Ghadiklaei et al and Yousefi et al [23],[24] show that the fuzzy DEMATEL total relationships matrix is normalized in a columnar way (each element is divided by the sum of the elements of the column) and then incorporate as the internal relations of factors in the ANP super matrix. For example, the paired comparisons of options in relation to the inflation criterion are presented. These paired comparisons were performed by 10 experts based on fuzzy 1-9 spectrum presented in (Table 9). They were then merged using geometrical mean method provided in (Table 9). Eventually, the weight of the options is calculated by Relations 10-12.

Table 9. Paired Comparisons of the Options in Relation to the Inflation Criterion (Inconsistency Rate: 0.08)

	A1	A2	A3	A4	A5	WEIGHT
A1	(1,1,1)	(1.149,1.644,2.048)	(0.591,0.771,1.121)	(2.232,2.951,3.97)	(0.16,0.195,0.258)	0.142
A2	(0.488,0.608,0.871)	(1,1,1)	(0.488,0.652,0.972)	(0.419,0.547,0.78)	(0.14,0.164,0.198)	0.079
A3	(0.892,1.297,1.692)	(1.029,1.534,2.048)	(1,1,1)	(2.259,3.34,4.379)	(0.164,0.197,0.247)	0.157
A4	(0.252,0.339,0.448)	(1.282,1.827,2.387)	(0.228,0.299,0.443)	(1,1,1)	(0.195,0.245,0.332)	0.082
A5	(3.874,5.131,6.266)	(5.044,6.091,7.122)	(4.043,5.073,6.093)	(3.016,4.077,5.116)	(1,1,1)	0.539

Similarly, for other criteria, paired comparisons are also done and eventually the initial super matrix is formed, as presented in (Table 10). This super matrix is composed of the normalized fuzzy DEMATEL total relationships matrix and the weights of options in relation to criteria. Next, the Limited super matrix is obtained from exponentiation of the initial super matrix and data convergence; in this research, the initial super matrix has converged at the power 5, as presented in (Table 11).

Table 10. The Initial Super Matrix

	C1	C2	C3	C4	C5	A1	A2	A3	A4	A5
C1	0.191	0.219	0.223	0.225	0.208	0	0	0	0	0
C2	0.176	0.164	0.184	0.183	0.194	0	0	0	0	0
C3	0.217	0.196	0.178	0.207	0.203	0	0	0	0	0
C4	0.230	0.220	0.224	0.195	0.229	0	0	0	0	0
C5	0.186	0.201	0.191	0.190	0.166	0	0	0	0	0
A1	0.142	0.121	0.101	0.086	0.134	0	0	0	0	0
A2	0.079	0.104	0.095	0.074	0.104	0	0	0	0	0
A3	0.157	0.110	0.145	0.126	0.202	0	0	0	0	0
A4	0.082	0.184	0.170	0.200	0.135	0	0	0	0	0
A5	0.539	0.481	0.490	0.514	0.425	0	0	0	0	0

Table 11. Limited Super Matrix

	C1	C2	C3	C4	C5	A1	A2	A3	A4	A5
C1	0.2133	0.2133	0.2133	0.2133	0.2133	0	0	0	0	0
C2	0.1803	0.1803	0.1803	0.1803	0.1803	0	0	0	0	0
C3	0.2006	0.2006	0.2006	0.2006	0.2006	0	0	0	0	0
C4	0.2189	0.2189	0.2189	0.2189	0.2189	0	0	0	0	0
C5	0.1868	0.1868	0.1868	0.1868	0.1868	0	0	0	0	0
A1	0.1164	0.1164	0.1164	0.1164	0.1164	0	0	0	0	0
A2	0.0904	0.0904	0.0904	0.0904	0.0904	0	0	0	0	0
A3	0.1478	0.1478	0.1478	0.1478	0.1478	0	0	0	0	0
A4	0.1536	0.1536	0.1536	0.1536	0.1536	0	0	0	0	0
A5	0.4918	0.4918	0.4918	0.4918	0.4918	0	0	0	0	0

The weights obtained in the extreme super matrix (Table 11) are the final weight of criteria and options based on which the rankings are performed, with the final results shown in (Figure 4) and (Figure 5) respectively.
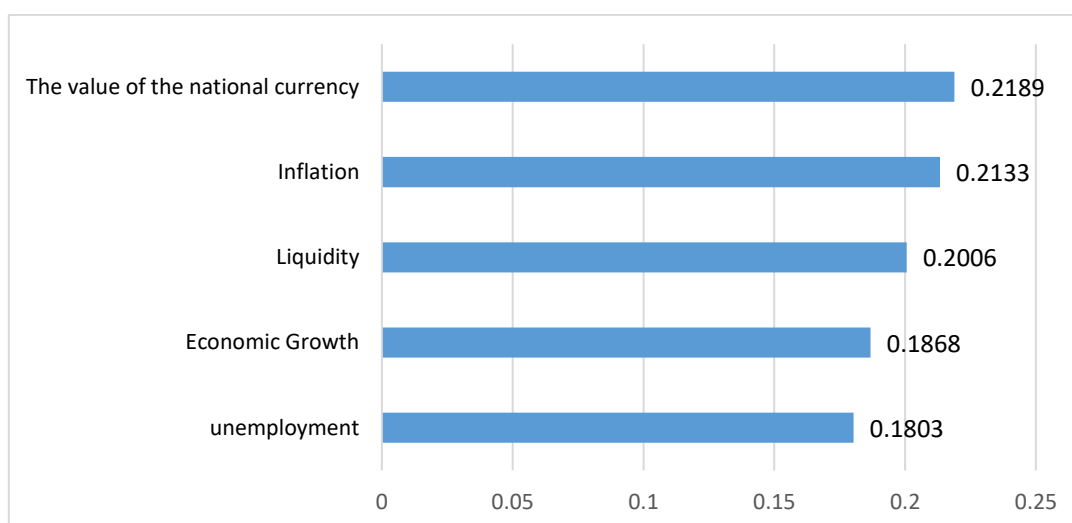
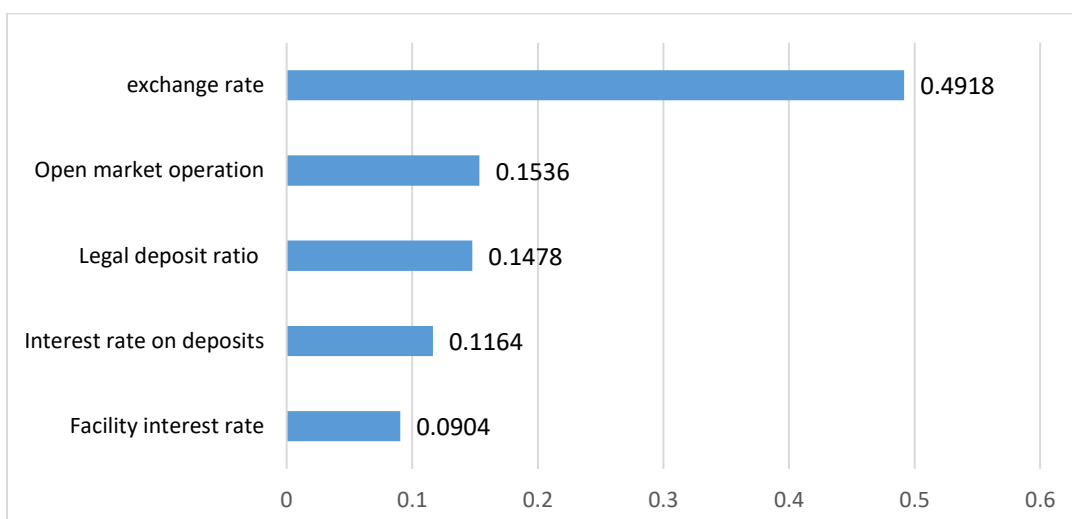**Fig. 4:** The Weight and Priority of Criteria (Macroeconomic Indicators)

Fig. 5: The Weight and Priority of Options (Monetary Policy Tools)

4.4 Cause-and-Effect Diagrams and Flow of Macro Variables Associated with Monetary Policies

After determining the priority of criteria (macroeconomic indicators) and options (monetary policy tools), the relevant cause-and-effect and flow diagrams have been drawn in VENSIM software. Accordingly, in (Figure 6), the cause-and-effect diagram of macro variables and associated with the monetary policies of the central banking Iran's economy are presented as Fig. 6.

No matter how useful cause-and-effect diagrams are, they merely present an image for better understanding of the model. Indeed, in order to proceed the model towards a mathematical model and present the results as equations, the model flow diagram is also required. Thus, after drawing the cause-and-effect diagrams of macro variables associated with monetary policies in VENSIM software, the relevant flow diagrams have also been drawn in the same software. (Figure 7) displays the flow diagram of the effect of monetary policies on macroeconomic variables with the presence of banking system players:
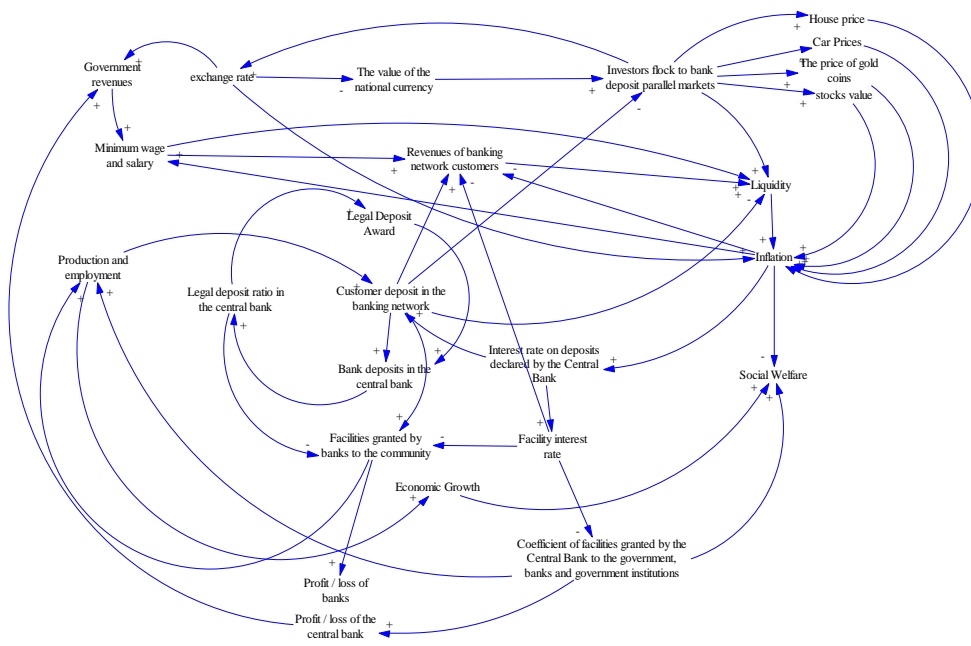
Fig. 6: Cause-and-Effect Diagram of Macro Variables Associated with Monetary Policies of Central Bank in Iran's Economy
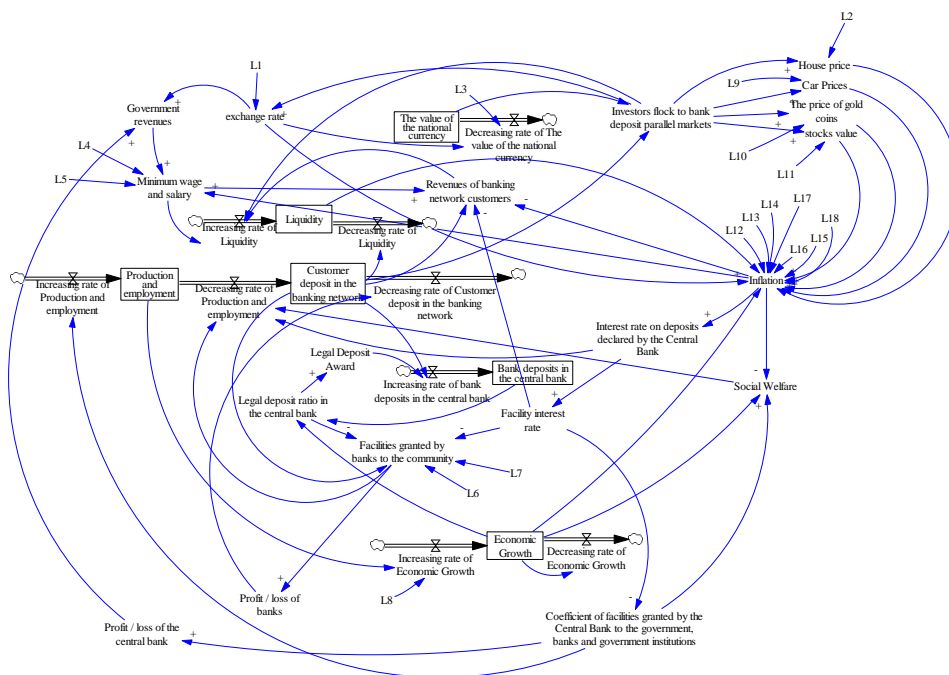

Fig. 7: The Diagram of Flow of Macro Variables Associated with Monetary Policies of Central Bank in Iran's Economy

The main aim of displaying the flow diagram is to indicate the relations between rate and state variables in Vensim software as well as dynamic modeling of the research problem which is indeed the effect of monetary policy tools of central bank on macroeconomic indices. In order to draw the flow diagram,

first the surface (state) variables which essentially represent aggregation or integral of flow over time are identified, after which the rate and auxiliary variables are introduced into the model to complete the diagram.

4.4.1. Mathematical Relations of the Model

Bank deposits in the central bank= INTEG (Increasing rate of bank deposits in the central bank, 1e+006)

Car Prices= L9(Investors flock to bank deposit parallel markets)

"Coefficient of facilities granted by the Central Bank to the government, banks and government institutions" =   0.5*Facility interest rate

Customer deposit in the banking network= INTEG (Decreasing rate of Production and employment-Decreasing rate of Customer deposit in the banking network, 1e+009)
Decreasing rate of Customer deposit in the banking network=   "Profit / loss of banks"

Decreasing rate of Economic Growth=   0.1*Economic Growth

Decreasing rate of Liquidity=   0.1*Customer deposit in the banking network

Decreasing rate of Production and employment= Facilities granted by banks to the community+Social Welfare+Interest rate on deposits declared by the Central Bank

Decreasing rate of the value of the national currency= 3.5*L3(exchange rate)

Economic Growth= INTEG (Increasing rate of Economic Growth-Decreasing rate of Economic Growth, 0.05)

exchange rate= L1(Investors flock to bank deposit parallel markets)
Units: Rial

Facilities granted by banks to the community=   Customer deposit in the banking network+L6(Facility interest rate) +L7(Legal deposit ratio in the central bank)

Facility interest rate=   Interest rate on deposits declared by the Central Bank

Government revenues= exchange rate+"Profit / loss of the central bank"

House price=   L2(Investors flock to bank deposit parallel markets)
Units: Thousand Rials / square meter

Increasing rate of bank deposits in the central bank= Legal Deposit Award+Customer deposit in the banking network

Increasing rate of Economic Growth=   L8(Production and employment)

Increasing rate of Liquidity=   Minimum wage and salary+Revenues of banking network customers+Investors flock to bank deposit parallel markets

Increasing rate of Production and employment= 0.7*"Coefficient of facilities granted by the Central Bank to the government, banks and government institutions"

Inflation= RAMP (0.5*L12(stock's value)

+0.5*L13(Economic Growth)

+0.2*L14(Car Prices)

+0.7*L15(The price of gold coins)

+0.5*L16(House price)

+2*L17(exchange rate)

+2*L18(Liquidity), 1392, 1396)

Interest rate on deposits declared by the Central Bank= 0.8*Inflation

Investors flock to bank deposit parallel markets= 1/ (The value of the national currency+Customer deposit in the banking network)

L1([(0,10000) -(10,42500)], (0,10712.7), (0.611621,18125), (2.11009,26535.1), (3.73089 ,32664.5), (6.11621,37796.1), (8.3792,40219.3), (9.93884,41502.2))

L10([(0,2.88e+006) -(10,1.23e+008)], (0.0611621,1.289e+007), (1.34557,4.292e+007) , (3.42508,7.03158e+007),(6.48318,9.56042e+007),(8.68502,1.05087e+008),(9.93884,1.08775e+008)

L11([(0,10010)-(10,1.367e+006)],(0.030581,63575.4),(0.489297,319499),(1.71254, 587326),(3.21101,783732),(5.1682,968235),(7.18654,1.08727e+006),(9.20489,1.17655e+006),(9.938 84,1.20035e+006))

L12([(1010,9)-
(1.367e+006,50)],(9364.68,11.8772),(126330,21.0482),(351907,31.8377),(644320,37.2325),(965975, 41.7281),(1.24586e+006,44.2456),(1.35447e+006,44.9649))

L13([(-6.8,9)-(12,50)],(-6.74251,49.4605),(-5.07523,39.9298),(-
1.85566,32.0175),(2.39878,22.8465),(4.98593,16.7325),(7.4581,14.3947),(9.52783,12.7763),(11.942 5 ,11.1579))

L14([(8.2e+007,9)-(1.9e+009,50)],(9.86789e+007,11.3377),(2.59908e+008,19.7895) ,(5.4345e+008,28.9605),(8.54789e+008,35.9737),(1.19393e+009,39.9298),(1.46079e+009 ,43.5263),(1.72209e+009,46.5833),(1.9e+009,48.3816))

L15([(2.88e+006,9)-
(1.23e+008,50)],(3.61468e+006,11.6974),(1.24308e+007,20.6886),(2.85938e+007,28.6009),(5.02668 e+007,36.693),(7.67152e+007,41.1886),(9.80209e+007 ,44.0658),(1.16388e+008,46.4035),(1.22633e+008,47.6623))

L16([(11174,9)-
(106003,50)],(11754,11.6974),(18423.9,20.3289),(28573.8,27.7018),(44233.7,35.9737),(60473.5,39.2 105),(81353.3,42.807),(95273.1,44.7851),(105133 ,46.0439))

L17([(10000,9)-(260000,50)],(12293.6,10.9781),(26055,19.0702),(48990.8,26.443) ,(94862.4,34.3553),(143792,38.4912),(188135,41.7281),(225596,44.4254),(253119 ,46.943),(258471,48.2018))

L18([(25,9)-(4.624e+007,50)],(282838,10.4386),(2.12112e+006,17.0921),(6.50473e+006

,23.9254),(1.2161e+007,30.3991),(1.9797e+007,35.0746),(2.84228e+007,40.1096),(3.53517e+007,42.4474),(4.08665e+007,45.864),(4.56744e+007,48.3816),(4.60986e+007,48.5614))

L2([(0,5701)-(10,106003)],(0.030581,12299.8),(1.03976,40894.7),(2.44648,62010.9),(4.25076,76528.3),(6.54434,89725.9),(8.80734,95884.8),(9.93884,99404.2))

L3([(10000,0)-(42500,10)],(10198.8,10),(14969.4,7.0614),(22721.7,4.47368),(32163.6,2.9386),(37729.4,1.92982),(42500,1.62281))

L4([(0,2.5e+006)-(0.8,4e+006)],(0.00489297,2.56579e+006),(0.0880734,2.94737e+006),(0.207951,3.23026e+006),(0.384098,3.42763e+006),(0.707034,3.71053e+006),(0.792661,3.76316e+006))

L5([(1e+007,2.5e+006)-(1e+009,4e+006)],(1e+007,2.56579e+006),(1.18991e+008,2.90789e+006),(3.36972e+008,3.22368e+006),(6.51835e+008,3.40789e+006),(8.78899e+008,3.53289e+006),(9.90917e+008,3.57895e+006))

L6([(0,100000)-(0.3,1e+006)],(0.00183486,127632),(0.0293578,368421),(0.121101,723684),(0.231193,861842),(0.29633,905263))
L7([(0,100000)-(1,1e+006)],(0.0030581,151316),(0.0519878,293421),(0.171254,451316),(0.318043,569737),(0.498471,652632),(0.749235,778947),(0.865443,778947),(1,794737))

L8([(100,0)-(1000,1)],(108.257,0.0964912),(212.844,0.311404),(386.239,0.578947),(603.67,0.719298),(854.128,0.837719),(994.495,0.877193))

L9([(0,8.2e+007)-(10,1.9e+009)],(0.0917431,2.01605e+008),(0.764526,5.52447e+008),(2.72171,9.83026e+008),(5.68807,1.38968e+009),(8.28746,1.56511e+009),(9.90826,1.61295e+009))

Legal Deposit Award= Legal deposit ratio in the central bank

Legal deposit ratio in the central bank= Economic Growth+Bank deposits in the central bank

Liquidity= INTEG (Increasing rate of Liquidity-Decreasing rate of Liquidity, 100000)
Units: Billion rials

Minimum wage and salary= L4(Inflation)+L5(Government revenues)
Units: Rial

Production and employment= INTEG (Increasing rate of Production and Employment-Decreasing rate of Production and employment, 100)

"Profit / loss of banks"= Facilities granted by banks to the community

"Profit / loss of the central bank"= 5*"Coefficient of facilities granted by the Central Bank to the government, banks and government institutions"

Revenues of banking network customers= Customer deposit in the banking Network+Minimum wage and salary-Inflation- Facility interest rate

Social Welfare= Economic Growth+"Coefficient of facilities granted by the Central Bank to the government, banks and government institutions"
-Inflation

stocks value= L11(Investors flock to bank deposit parallel markets)

The price of gold coins= L10(Investors flock to bank deposit parallel markets)

The value of the national currency= INTEG (-Decreasing rate of The value of the national currency, 1000)

5 Results

Considering the explanations presented in the flow diagram, as well as prioritization of tools (monetary policies) and macroeconomic variables based on the fuzzy logic criteria decision-making techniques, the diagrams and the output results resulting from simulation in VENSIM software are interpreted as follows:
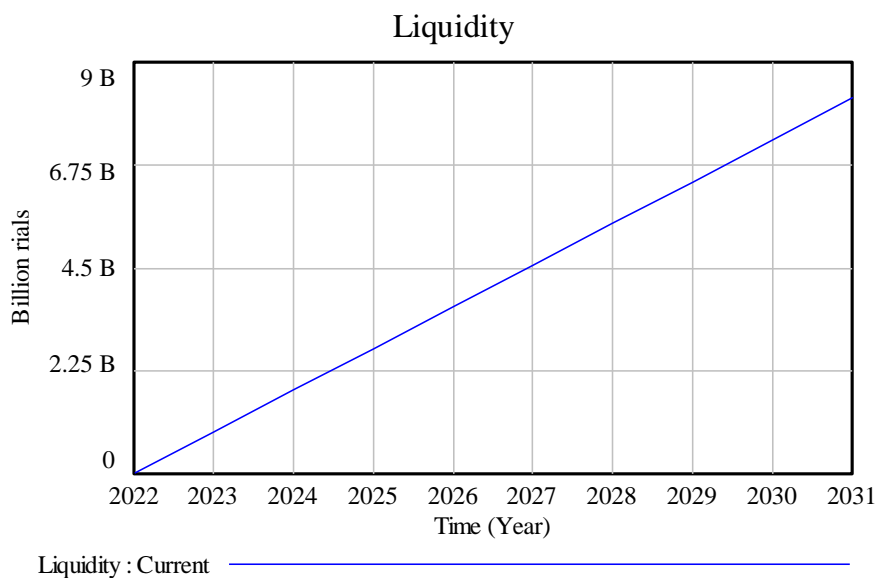

Fig. 8: Predicting the Volume of Liquidity in Iran's Economy Based on Monetary Policies of Central Bank within the 10-Year Period

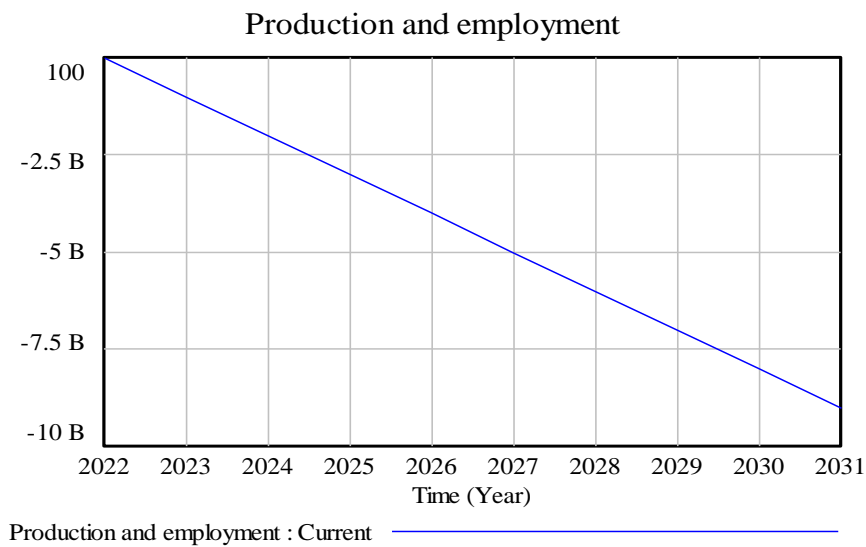## Production and employment

Production and employment : Current

Fig. 9: Predicting the Extent of Production and Employment in Iran's Economy Based on Monetary Policies of Central Bank within the 10-Year Period

The value of the national currency
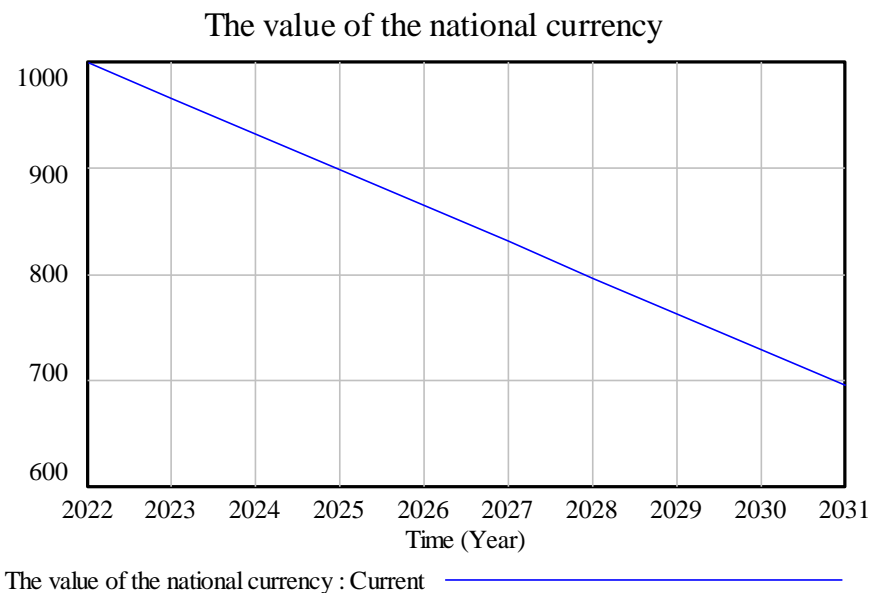

The value of the national currency : Current

Fig. 10: Predicting the National Monetary Value in Iran's Economy based on Monetary Policies of Central Bank within the 10-Year Period

Based on the opinion of economic experts using fuzzy ANP method, "foreign exchange rate" as one of the monetary policy tools has been the most important effective variable on economic indicators (including inflation, liquidity, unemployment, national monetary value, and economic growth). Further, based on fuzzy DEMATEL method, the most important macroeconomic indicators that should receive attention by monetary policymakers are "national monetary value" and the "inflation rate".

Accordingly, with increase in the foreign exchange rate, the price of goods also increases, causing an ascending inflation (hidden tax) and reducing the national monetary value [25]. This leads to increased wandering liquidity across the society and causes the investors to rush into parallel markets, thereby

increasing demand in these markets and in turn inflation/price elevation in parallel markets. The inflation that occurs here causes decreased social welfare as well as reduced society incomes (customers of the banking system) [26].
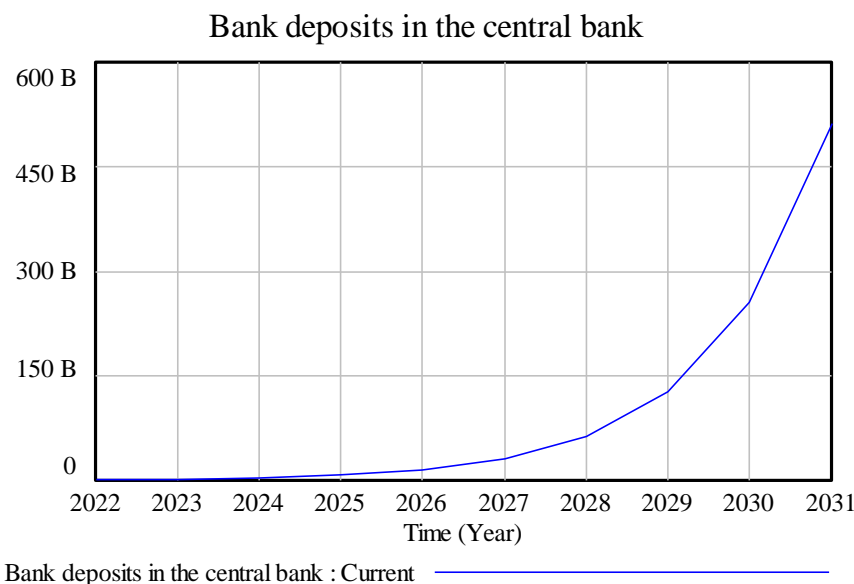
Bank deposits in the central bank

Bank deposits in the central bank : Current

Fig. 11: Predicting the Level of Deposit of Banks in Central Bank in Iran's Economy within the 10-Year Period

Meanwhile, elevation of the foreign exchange rate results in higher government/central bank revenues. One the one hand, it leads to increase in the level of salary and wages of employees plus customers of the banking system, while on the other it causes increased liquidity and inflation rate in the society [27]. Thus, again reduction of social welfare and incomes of the banking system customers occur. When inflation (hidden tax) rises, the central bank has to raise interest rates on deposits as much as inflation. This causes increased investment by customers in banks. In this way, the extent of deposition of banks in the central bank also grows (increased legal reserve ratio) [28]. In response to this, the legal deposit bonus of the central bank should also increase and this loop continues. Evidently, with increase in the interest rate on deposits, the interest rate on facilities also rises. Hence, the extent of facilities granted by banks to the society decreases. Furthermore, since the central bank has adopted a contractive policy with increase in the legal reserve ratio, it would also announce the order of reducing provisional facilities to banks. Meanwhile, since the central bank has elevated the interest rate on facilities, the coefficient of facilities granted to governments, banks, and governmental institutes decreases [29]. Hence, in this way the profitability of the central bank also declines and so does the social welfare. With reduction of income and profitability of the central bank, the governmental revenues also drop. Reduction of the extent of facilities granted by the central bank and the banking system leads to decreased production and employment as well as increased unemployment rate. Thus, first the extent of investment in the central bank by customers diminishes and then the extent of economic growth falls. Following reduction of economic growth, the social welfare also declines [30]. Therefore, overall with increase in the foreign exchange rate, since both the inflation rate and unemployment rate have increased, eventually the misery index heightens (which in economics is sum of inflation and unemployment).

With these explanations, in Figures 8-11, based on the available data in 2009-2021, the diagram of predicting the state variables of the problem has been drawn for a 10-year period. Based on the mentioned diagrams, prediction of economic variables in the flow diagram drawn within a 10-year period from 2022 to 2031 shows that the variable of the national monetary value will decrease linearly and by about 30% throughout this period [31]. The liquidity volume present in the Iran's economy will also grow linearly. Furthermore, the production volume and employment will drop linearly in the mentioned period; the extent of production and employment at the end of the 10th year compared to the starting year will diminish by about 1.1 times. Moreover, the volume of investment of banks in the central bank will grow exponentially and gradually; the volume of investment of the banking system in the central bank will grow by twice as large at the end of the 10th year compared to its previous year.

Thus, in case of not controlling the inflation rate (hidden tax), resulting from elevation of the foreign exchange exchange rate, the national monetary value will drop; the volume of liquidity will increase, and the volume of production and net job creation in the economy of the country will also diminish within the 10-year period [32].

6 Conclusion

According to the opinion of economic experts in this research, the most important monetary policy tool of central bank in Iran has been "foreign exchange rate", which should be considered for managing the most important macroeconomic indicator in Iran, i.e. "national monetary value". In other words, as long as the foreign exchange rate or the Rial against dollar equality rate does not improve in Iran's economy, the unbridled inflation in Iran cannot be controlled. Accordingly, study of the trend of economic indicators of Iran during the years of conducting this research according to Table 2 indicated that the foreign exchange rate "in the open market" has grown by more than four times from the beginning until the end of the researched period. This fourfold increase of exchange rate alongside mismanagement of supply and demand has resulted in double-digit inflations in seven periods out of the nine studied periods. Meanwhile, the important point has been improper policymaking on the interest rate on banking deposits against the inflation rate. This is because the existence of relationship between inflation rate and interest rate of banking deposits in economics is evident, and it has remained neglected by the central bank as the main responsible for monetary policies of the country. Accordingly, throughout nine periods examined in this research and at times when the inflation rate has grown by more than 30%, the interest rate on deposits has experienced a number lower than half of this inflation rate.

For example, within the period the inflation governing the country was estimated about 34%, determination of banking interest rate lower than 15% led to withdrawal of the banking deposits from the banking system and increased liquidity around the society This itself due to increase of demand by the society has led to elevation of inflation rate in the not very favorable economy of Iran. Meanwhile, the wandering liquidity withdrawn from banks has been guided towards parallel markets including foreign-exchange foreign exchange, golden coin, land, housing, and vehicle, which in addition to increasing the level of demand in these markets has led to growth of inflation in these markets. Accordingly, the mismatch between interest rate on banking deposits and the inflation rate has resulted in loss of attractiveness of banking deposition in Iran's economy, and the investors/customers, because of feeling loss of their assets value, have begun to withdraw their deposits from banks and invest them in parallel markets of banking deposits. This has led to increased "wandering liquidity" in Iran's economy; the liquidity volume of Iran's economy in the final year of the research compared to the first year of the researched

period has grown by 20 times. With increase in the wandering liquidity in the economy which is con-current with investors rushing into parallel markets of bank deposit (foreign exchange, gold and coin, land and housing, vehicle markets) for investment to maintain the value of assets, because of increase in demand and lack of proper supply, inflation and elevation of general level of prices have been exacerbated. In this regard, the range of changes in inflation rate within the research period has been about 41%. Further the maximum and minimum values of misery index within the research period have been 59.4 and 21.4% respectively.

Hence, the course of performance of the central bank of Islamic Republic of Iran regarding management of inflation and liquidity has been unfavorable and the results of this study confirm the findings of Askari and Krigin; the monetary policies of the central bank for changing the interest rate as well as increasing credits and creating liquidity have been a major factor of incidence of economic crisis in Iran. Meanwhile, with continuation of the current trend, with increase in the foreign exchange rate and reduction of the national monetary value, the extent of liquidity will also rise. In other words, if the foreign exchange rate is controlled and managed in a smart way, the liquidity volume will not increase considerably, which is in line with the findings of. Furthermore, prediction of the extent of production and employment within the next 10-year period confirms the results of. This is because the crises resulting from the monetary policies of the central bank will lead to reduced production and employment. In addition, it can be stated that concurrent with the increase in the liquidity volume within the next 10 years, the extent of production and employment in Iran's economy will diminish, which concurs with the results of Ghafarifard et al. regarding the effect of increasing money volume on reduction of production and employment in the long run. Considering prediction of increase in the extent of investment by banks in the central bank (legal deposit ratio) within the next 10 years, it can be stated that when the foreign exchange rate is ascending and in turn inflation rises, the interest rate on deposits should also increase. This leads to enhanced investment by customers in the banking system, in response to which banks also increase the extent of their investment in the central bank.

In the final section of the paper, policy-economic recommendations and suggestions are presented in four paragraphs:

1. Independence of the central bank of Islamic Republic of Iran from governments is considered the most important factor for success of monetary policies of this bank. In this way, "government" and "central bank" would be separated from each other and the interactions between them can be executed and implemented. In this regard, it seems that in the first step, the process of electing the chair of the central bank by presidents of governments in the country requires fundamental revision, and election of the chair of the central bank should be outside the responsibility of governments, and relegated to an absolutely nonpolitical, independent, scientific, and economic authority or institution with executive power. The interactions of the central bank of Iran with governments regarding monetary policies should be similar to powerful central banks of the world including US Federal Reserve.

2. The central banks of the world have transformed in response to economic changes worldwide and in their own countries, and they have begun to review their goals, policies, and monetary tools. In most countries, the main goal or the unique goal of central banks is establishing "economic stability" or "controlling inflation". Other goals are considered as secondary. Thus, since the priority of the legal deposit ratio tool (legal deposit rate) in the monetary policies of the country has been set low, it seems inevitable to review the determination of legal deposit rate. This rate should be revisited by authorities or institutions such as Islamic Consultative Assembly, central bank, the committee of money and credit after precise investigations and by considering the conditions as well as both micro and macroeconomic

indicators. Further, it should be noted that central banks have abandoned direct monetary tools and found tendency to indirect tools, mostly including open market operations and rediscount rate. Accordingly, the central bank of Islamic Republic of Iran should possess numerous monetary tools considering the monetary and banking rules. For example, this bank should take measures for reviving rediscount rate, quasi-facilities rate, and review the way participation bonds are granted (bonds that can have anti-inflationary effects and could be traded in secondary market). Making the central bank's decisions transparent and goal setting for inflation rate as well as formation of work groups to supervise and implement controlling systems as well as coordination between monetary policies are required in this regard.

3. Between the three issues of "inflation", "liquidity", and "interest rate on banking deposits", the central bank should first control the inflation, then manage the liquidity circulating in the society, and finally reduce the interest rate on banking deposits in order to lower the interest rate on facilities and enhance production as well as economic prosperity. For this purpose and in order to prevent speculation and investors rushing to markets parallel to the banking deposit, the central bank should first "**improve the national monetary value**". Evidently, ameliorating the national monetary value cannot be done only through monetary and domestic economic financial policies; rather, numerous optimal domestic and foreign policymaking is required for establishing proper relations with economic powers of the world and lifting the extensive sanctions against Iran.

4. Naghdi and Efatabaran, say that, it seems that the anti-inflationary policies in Iran have mostly focused on the demand side of economy, while the experience of developed and developing countries on inflation reduction shows that sustainable reduction of inflation cannot be realized only through demand-side tools and no country can have inflation find a descending trend unless they get equipped with available tools for improving the total productivity of all production agents effectively and efficiently.

Acknowledgments

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