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Original Research Article

Analyzing the Factors Affecting the Efficiency of Iran's Central Bank: An Application of System Dynamics Modeling

Hooman Hasanzadeh Dastfroosh[*] **Sakine Owjimehr**[†]
Ali Hussein Samadi[‡]

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The central bank is the most important economic institution of any country, and for this reason, the efficiency of this institution is of particular importance. Study on the efficiency of the Central Bank of Iran is an inevitable necessity due to the instability of prices and significant non-performing loans in the banking system. In this study, first, efficiency of the Central Bank of Iran along with 15 different countries was calculated by Data Envelopment Analysis (DEA) method. The input variables for calculating the efficiency of the central bank contain fixed assets and personnel and administrative cost. The output variables include monetary policy and banking supervision, which banking supervision includes financial and banking freedom and the ratio of non-performing loans. Then factors affecting the efficiency of the Central Bank of Iran between the years 2012 to 2018 were analyzed by using the system dynamics modeling method. In the first step, the causal loop diagrams (CLD) and the stock-flow diagram (SFD) of factors affecting efficiency in Central Bank of Iran were drawn were drawn. Then model validation tests were performed. Finally, different scenarios were investigated. The results of this study showed that the Central Bank of Iran in 2012-2018 is one of the most inefficient central banks among the 16 studied countries and is a long way from the three countries on the efficiency frontier like South Korea, Canada, and Australia. Central bank Independence and the significant amount of non-performing loans of the banking system are the main reasons for the inefficiency of the central bank of Iran. By applying different scenarios to improve the efficiency of the Central Bank, it was concluded that the most important effective factors to improve the efficiency of the Central Bank of Iran are monitoring the banking system along with preventing the increase of government debt with the independence of the Central Bank.

Keywords: Efficiency, Central Bank, Non-Performing Loans, System Dynamics. Iran.
JEL Classification: E42, E47, E58, C54.

[*] Department of Economics, Shiraz University, Shiraz, Iran; hooman.microsoft@gmail.com
[†] Department of Economics, Shiraz University, Shiraz, Iran; s.ojimehr@shirazu.ac.ir (Corresponding Author)
[‡] Department of Economics, Shiraz University, Shiraz, Iran; asamadi@rose.shirazu.ac.ir

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1 Introduction

Iran is a country that has been under severe economic sanctions. In addition to economic sanctions, the failure of the Central Bank of Iran to implement appropriate monetary policy also caused Iran to experience double-digit inflation in most years. One of the most important indicators by which the situation of the Central Bank can be analyzed is the efficiency index. Knowing the efficiency index of the central bank compared to other countries, as well as determining the main factors influencing it, can be a helpful guide for economic policymakers, especially in the monetary field.

Farrell (1957) first introduced the concept of efficiency. Efficiency calculations show how much a firm can produce by using its inputs. Efficiency is calculated relative to a goal, which can be maximum output, maximum profit, or minimum cost. Efficiency in general is the measurement of the difference between the current performance of the firm and the expected performance. The concept of efficiency is widely used in economic research, especially in the banking system sector. The studies of Hasanzade (2007), Eisazadeh & Shaeri (2013), Salem & Khatibi (2016), Amiri (2018), Řepková (2015), Yilmaz et al. (2015), Yannick et al. (2016), Boussemart et al. (2019), Saeed et al. (2020) and Korneyev et al. (2022) among the studies that calculated the efficiency of the banking system and analyzed various factors that have an influence on the efficiency of the banking system.

Despite the existence of many studies related to the efficiency of the banking system, little attention has been paid to the efficiency of the central bank. The reason is that the central bank is not comparable to any other type of financial enterprise or even banking system, both in terms of the type of inputs and outputs and in terms of goals and tasks. Can conventional methods be used to calculate the efficiency of the central bank?

In response to this question, few researches have been done about the efficiency of the central bank. Mester (2003), McKinley & Banaian (2005) and Ranjbar et al. (2007) considered central bank inputs to be labor and capital, which include central bank staff, workplace space, and data analysis equipment. They have also determined the output of the central bank according to the goals of the central bank. Supervision of the banking system and monetary policies are the output of the central bank, which aims to stabilize the financial system and sustainable economic growth. In fact, by considering these activities as products of the central bank, it is easier to calculate the efficiency of the central bank and measure the cost-efficiency of the resources of these products.

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Among researchers, McKinley and Banaian (2005) and Ranjbar et al. (2007) have calculated the efficiency of the central bank of different countries. They used the most common parametric method in calculating efficiency, the Stochastic Frontier Analysis, but research shows that no study has examined the factors affecting central bank efficiency.

Therefore, in the present study, first of all, the efficiency of the Central Bank of Iran during 2012-2018 is calculated by using the Data Envelopment Analysis (DEA) method. The DEA method will not have the problem of specification bias because it does not need to specify the model, and in this respect, it is superior to the stochastic frontier analysis method. After calculating the efficiency of the central bank, we will look for answers to these questions: what factors affect it, how can the efficiency be improved, and if the policies are not reformed, what will the efficiency of the central bank go? One of the frameworks that can answer all the questions well is the System Dynamics Model. The art of modeling dynamic systems is to discover and represent the process of information feedback that determines the dynamics of a system through the structure of stock, flow, delay, and nonlinear relationships.

Thus, the present article is organized in such a way that after the introduction, an overview of the policies and efficiency situation of the Central Bank of Iran, is reported. In section 3 and 4, theoretical background and literature review are stated, respectively. Section 5 and 6 are devoted to Methodology and modeling, respectively. In Section 7, the validity of the model has been evaluated. In Section 8 different scenarios are analyzed. Final Section is devoted to concluding remarks.

2 An Overview of the Central Bank of Iran: Policies and Efficiency

The Central Bank of Iran was established in 1960 and the Monetary and Banking Law of Iran was regulated in the same year. Money printing, implementation of monetary policy, and supervision of the banking system are among the tasks of the Central Bank of Iran. Considering the focus of the study, monetary policy, and banking system supervision as two important outputs in discussing the efficiency of the central bank, the status of monetary policy implementation and banking system supervision by the Central Bank of Iran is reviewed.

One of the important indicators that can show the monetary policy of the Central Bank of Iran is the rate of inflation. Figure 1 shows the inflation trend in Iran during 1991-2020. As can be seen in Figure 1, the inflation rate in Iran

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between 1991 and 2020 is high and fluctuating. Even the lowest inflation rate in these years, which is 9%, is considered high inflation, and this indicates the undesirable situation of the monetary policies of the Central Bank of Iran to stabilize prices. Large-scale lending to the government, due to the lack of central bank independence, huge budget deficits, and the imposition of interest rates in the banking system, make monetary policies instruments ineffective in stabilizing prices.

In addition to direct lending to the government, there is also indirect lending to the government with government compulsory loans to the banking system that puts pressure on banks reserves and make banks borrow from the central bank and also the Central Bank has been legally authorized to buy government foreign currencies if the parliament agrees, which all of these leads to an increase in the monetary base out of control (Boustani & salavatitabar, 2017). Of course, since the summer of 2020, open market operations have been used by the Central Bank as one of the most important monetary policy tools, and this action of the Central Bank of Iran has updated monetary policies and made them more effective in stabilizing prices.

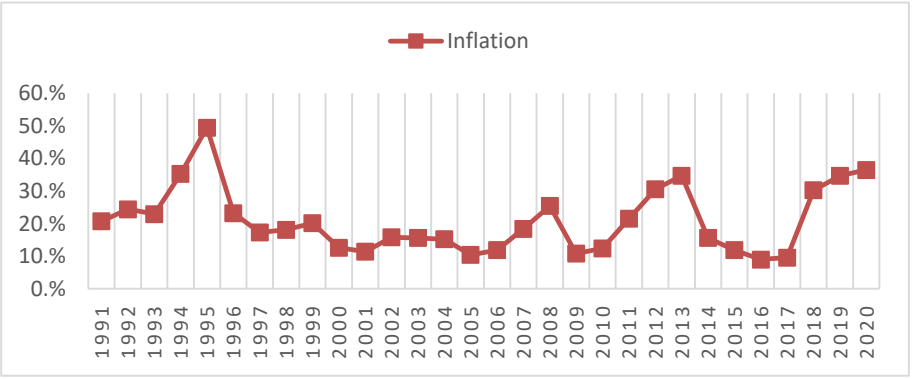

Figure 1. Inflation of Iran between 1991 and 2020
Source: Research Findings

Another important task of the Central Bank of Iran is banking system supervision. The Central Bank of Iran tries to reduce the amount of non-performing loans to gross loans by monitoring banking contracts and accelerating the collection of non-performing loans, which is considered as an indicator for banking system supervision in the present study. Also, the Central Bank of Iran prevents the insolvencies of banks by informing the

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banks about the adequacy of capital and obliging the banking system to comply with it. The amount of non-performing loans to total gross loans of the Iranian banking system experiences a minimum of 9% and a maximum of over 16% in the last 10 years, which indicates the weak supervision of the Central Bank of Iran over the banking system. On the other hand, the Central Bank of Iran needs the cooperation of legislature and the judiciary institutions to the banking system supervision, and without the cooperation of these institutions with the Central Bank, it will not be possible to supervise the banking system. The index of financial and banking freedom in Iran is 10 out of a total score of 100, and this shows that the Iranian banking system is near complete government interference (Miller et al., 2020).

Efficiency is an aspect of a firm's performance. The performance of a firm can be examined from three aspects, which include Scale Economies, Scope Economies, and Efficiency. Efficiency is calculated with respect to a goal, which can be maximum output, maximum profit, or minimum cost. Following Mckinley & Banaian (2005), the efficiency of the central banks of 16 countries was calculated between 2012 and 2018 using the DEA method. The most important advantage of this method is that there is no risk of specification bias. The specification bias appears in the selection of explanatory variables and the selection of the functional form of the model. The criterion for calculating the efficiency in the proposed method for all decision-making units is obtained by maximizing the ratio of weighted outputs to weighted inputs in the constraint and condition that this ratio is less than or equal to one for all decision-making units[1]. Due to the importance of the central bank's outputs compared to its inputs and also the fact that the central bank is different from other commercial and financial institutions, DEA is a suitable choice.

The input variables for calculating the efficiency of the central bank are Fixed Assets (as an index for capital) and Personnel and Administrative Cost. The output variables include monetary policy and banking supervision, which

[1] In this study, the CCR model, which is a kind of DEA method, has been used for central bank efficiency calculation. The CCR model was first introduced by Charnes Cooper & Rhodes in 1978. The mathematical model of CCR is as follows:

Max $h_0=\frac{\sum_{i=1}^{n} u_i y_{i0}}{\sum_{j=1}^{m} v_j x_{j0}}$ Subject to: $\frac{\sum_{i=1}^{n} u_i y_{iK}}{\sum_{j=1}^{m} v_j x_{jK}} \leq 1$; K=1, …, k,

$u_i, v_j \geq 0$; i=1, …, n, j=1, …, m

In relation above, y_{iK} and x_{jK} are the inputs and outputs of the kth decision-making unit, and their values are all positive, and u_i and v_j are variable and positive weights. MATLAB optimization toolbox is used to calculate the CCR model.

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banking supervision includes financial and banking freedom and the ratio of non-performing loans[1].

The study countries were selected based on access to Central Bank data from developed and developing countries in North America, Europe, and Asia: Canada, Spain, France, Czech Republic, Lithuania, Ukraine, Romania, Russia, Portugal, Croatia, Turkey, Azerbaijan, Australia, South Korea, Indonesia, and Iran.

The results of the efficiency calculation show that the efficiency of the Central Bank of Iran due to the lack of change in the financial and banking freedom index, the very high level of non-performing loans to total gross loans compare to countries in the efficiency frontier and the weak monetary policy index has low rankings. The efficiency results of the Central Bank of Iran along with other countries are also shown in Figure 2.

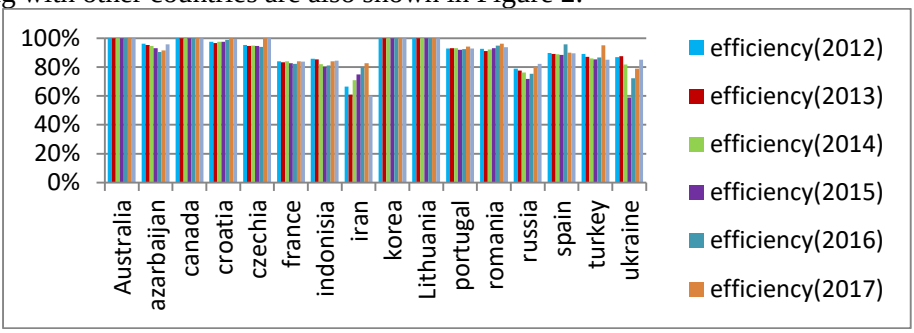

Figure 2. Efficiency calculation results (%)
Source: Research Findings

3 Theoretical Background

The central bank is the most important policy-making institution in monetary and banking affairs in a country. In many advanced economies, monetary policies are set and implemented almost independently by the central bank. The most important goal of monetary policies is the stability of the price level.

One of the best criteria for evaluating the central bank's performance is efficiency. But central bank is not comparable to any other type of financial enterprise or even banking system, both in terms of the type of inputs and outputs and in terms of goals and tasks. Can conventional methods be used to calculate the efficiency of the central bank?

[1] All data for each country was gathered from central bank's balance sheet, heritage foundation economic freedom report and the World Bank data bank.

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Mester (2003), McKinley & Banaian (2005) and Ranjbar et al. (2007) considered central bank inputs to be labor and capital, which include central bank staff, workplace space, and data analysis equipment. They have also determined the output of the central bank according to the goals of the central bank. Supervision of the banking system and monetary policies are the output of the central bank, which aims to stabilize the financial system and sustainable economic growth. In fact, by considering these activities as products of the central bank, it is easier to calculate the efficiency of the central bank and measure the cost-efficiency of the resources of these products. Due to the clarity of the inputs, we will limit ourselves to a brief explanation of the outputs: Supervision of the banking system and monetary policies.

3.1 Supervision of the Banking System

Supervision of the banking system is one of the important tasks of the central bank. When banks give loans to their customers, they expose themselves to credit risk in the sense that the borrower may have problems repaying debt to the bank. When the debt repayment to the bank is postponed, these types of loans are called non-performing or deferred loans. Loans are considered overdue or non-performing by banks when 90 days have passed since the receipt of the loan repayment. Overdue loans reduce the banks' receipts and cause losses to the banks. The banking system with high overdue loans will not be able to lend to households and companies, and this is generally detrimental to the economy.

Central banks can set a specific criterion on the banking system that will stop crediting by default, by setting programs to monitor the performance of banks and crediting contracts, and try to collect written off loans and the dismissal of the bank manager to prevent delay in the repayment of debts. These measures will reduce the amount of apparently good loans that can be seen through the ever greening loans in the balance sheets of banks and is a clear warning to the banking system that the debts must be repaid (Caprio & Klingebiel, 1996).

One of the important variables that can have an effect on crediting loans is the capital adequacy ratio, which is also called the regulatory capital ratio. The capital adequacy ratio is actually the ratio of the bank's total Tier 1 and Tier 2 capital to risk-weighted assets. The capital adequacy regulations are notified to the banks, so that if the capital adequacy becomes less than the specified amount, the central bank warns the bank in question and the bank must improve the capital adequacy ratio.

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3.2 Monetary Policies

Even a limited approach to efficiency that examines only the efficiency of resources also requires an objective function for monetary policy makers and measuring the output and input of these policies. The central bank's monetary policies should be directed towards price stability, stable growth and financial stability (Mester, 2003). The central bank implements its monetary policy by changing the volume of banks' reserves, which leads to controlling their lending power and credits. The most important tools in the hands of the central bank for the implementation of monetary policies are the reserve requirements rate, the discount rate and open market operations. Each of these tools can have a different effect on the efficiency of the central bank, and therefore one of the scenarios proposed in this research is what effect each of these tools has on the efficiency of the central bank separately.

4 Literature Review

In this section, three categories of studies have been collected. The first category is the studies in which the efficiency of the central bank is calculated. The second category is the studies in which the efficiency of the banking system is calculated. The third category is the studies in which the factors affecting the efficiency of the banking system have been estimated.

The first category: Mester (2003) investigated the efficiency calculation method in a research and proposed the random frontier method for efficiency of central bank. McKinley and Banaian (2005) and Ranjbar et al. (2007) calculated the efficiency of the central bank of 32 countries using the random frontier method.

The second category: Sherman & Gold (1985), Yudistira (2004), Hasanzade (2007), Yilmaz & Güneş (2015), Yannick et al. (2016), Boussemart et al. (2019), Bahiraie et al. (2020) and Korneyev et al. (2022) calculated and analyzed the efficiency of the banking system with the non-parametric data envelopment analysis method. Salem & Khatibi (2016) have calculated the efficiency of the banking system of Iran using the random frontier parametric method.

The third category: Soori et al. (2010) investigated the effect of the expansion of the competitive environment, the merger of competing banks and the expansion of electronic banking on the efficiency of the money market efficiency in Iran using the random frontier method. Eisazadeh & Shaeri (2013), Amiri (2018) and Tarkhani et al. (2020) to investigate the effective macroeconomic factors on efficiency of the banking system through panel data. Řepková (2015) and Saeed et al. (2020) investigated and analyzed

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macroeconomic factors, especially price stability and inflation, on the efficiency of the banking system. Sari et al. (2022) first calculates the efficiency of Indonesian banks using data envelopment analysis (DEA) and then examines the effect of banking industry competition on the efficiency of commercial banks in Indonesia from 2010 to 2019.

The difference between this study and other studies is that in the studies conducted on the efficiency of the central bank, only the efficiency of the central bank was calculated, but in the present study, an effort will be made to model the efficiency of the central bank of Iran in the framework of systemic dynamics and the variables affecting the efficiency of the Central Bank will be analyzed along with their cause and effect relationships, and this study is innovative in this respect. Also, unlike the studies conducted on the efficiency of the central bank, which only calculated the efficiency of the central bank in one year, in the present study, the efficiency trend of the central bank will be examined with the current conditions in a specific time horizon, and then in order to achieve the expected goals in This time horizon will analyze the scenarios and policies, whether applied separately or in combination, and the resulting process over time.

5 Methodology

In this research, the system dynamics method will be used to analyze the efficiency of the Central Bank of Iran. System dynamics is a method used in learning complex systems. This method was first developed by jay W. Forrester at MIT University .The steps for modeling dynamic systems by Sterman (2001) and Mashayekhi (2017) are summarized as follows:

- Causal loop diagrams (CLD): These diagrams show the causal relationships between variables with arrows from cause to effect.
- Stock flow diagrams (SFD): Stock and flow diagrams emphasize the physical structure that generates those feedbacks. State variables show the stock of variables, and flow variables show the increase or decrease of stock variables.
- Model validity test: At this stage, part of the test is to compare the simulated behavior of the model with the actual behavior. Then the model is examined through other tests such as extreme condition tests, etc. to determine whether the model exhibits normal behavior in extreme and unstable conditions.
- Design and evaluate policies: the last step, the scenarios are determined. Scenarios answer the question; what environmental conditions can occur?

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Policy design is another element of this step, and attempts are being made to test new decisions, strategies, and structures possible in the real world.

6 Modeling

In this section, the factors affecting the efficiency of the central bank will be modeled by system dynamics. First, the causal loop diagrams (CLD) and the stock-flow diagram (SFD) will be drawn. Finally, the validity of the model and the implementation of scenarios to achieve the objectives of the research will be determined.

6.1 Causal Loop Diagram (CLD)

In general, in the present study, the efficiency of the central bank as a system consists of the effectiveness of monetary policy and supervision of the banking system. Monetary policy performance improves price stability, which reduces non-performing loans and improves the performance of the banking system. As a result of better monitoring of non-performing loans of the banking system and the provision of interest rates by the banking system, the banking system will face less liquidity crisis, and overdrafts from the central bank will be reduced, as a result of reducing overdrafts from the bank's resources it prevents the uncontrolled growth of liquidity and stabilizes prices, and as a result, the performance of monetary policy improves. As the performance of the banking system and monetary policy improves, the efficiency of the central bank also increases. Figure 3 shows the causal loop diagram of the factors affecting the efficiency of the central bank.

In Figure 3, loops B1, B2, and B3 are the three most important balance feedbacks of diagrams. In feedback B1, with the reduction of the banking system reserves, the banking system suffers from a liquidity crisis and on the other hand, the lending power of the banking system decreases. In B3 balance feedback, with the increase of banking system reserves, the lending power of the banking system increases and the rate of lending also increases, and with the increase of lending, the reserves of the banking system decrease. In B2, with the increase of non-performing loans, the Non-performing loans to total gross loans ratio also increase, and by increasing the Non-performing loans to total gross loans ratio, the central bank monitors the banking system more than before to prevent the increase of non-performing loans. In Figure 3, loops R1 and R2 are the two reinforcing feedback of diagrams. In R1 feedback, with the increase of banking system lending loans, the income of the banking system also increases, which with the increase of the banking system income, the net profit of the banking system increases, and the reserves of the banking

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system increase. In R2 reinforcement feedback, as inflation increases non-performing loans also increase and because of increasing non-performing loans, banking system reserves decrease and make the banking system borrow from the central bank. The result of borrowing from the central bank increase in money supply and eventually inflation increase, which as a result of declining price stability, the monetary policy index decreases, and the efficiency of the central bank decreases. Stock flow diagram of factors affecting the efficiency of the central bank can be seen in Figure index 1.

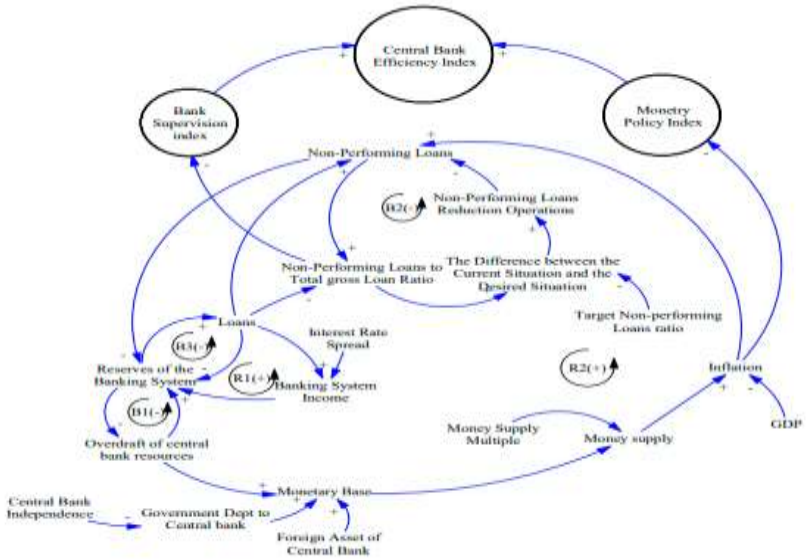

Figure 3. Causal loop diagrams of factors affecting the efficiency of the central bank
Source: Research Findings

7 Model Validation

To determine the validity of the model, three methods of alignment of the simulated model with the observed trend, extreme condition test, and sensitivity analysis have been used:

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7.1 Alignment of the Simulated Model Trend with the Observed Trend

The observed trend in the efficiency index of the Central Bank of Iran has been extracted from calculating the efficiency of the Central Bank of Iran and the observed trend of the consumer price index, monetary base and the non-performing loans to total gross loan ratio has been extracted from the central bank of Iran reports. Through Excel software, the process of simulated data is compared with the observed data, as can be seen in Figures 4 to 7. The early years of the simulated process with the observed process have alignment:

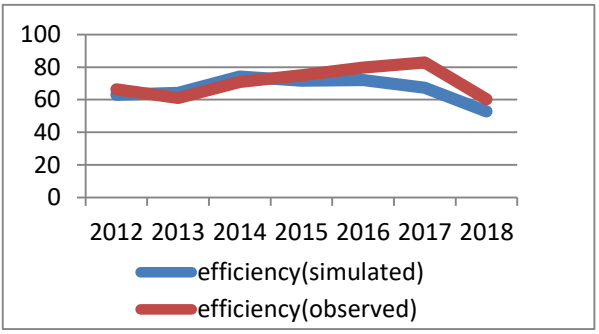

Figure 4. Central Bank efficiency index
Source: Research Findings

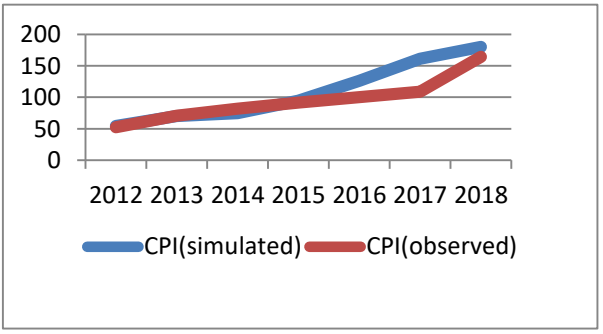

Figure 5. Consumer Price Index
Source: Research Findings

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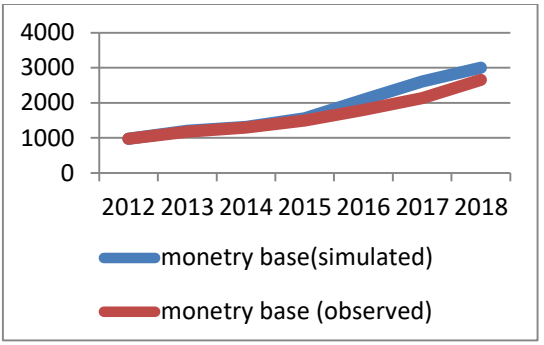

Figure 6. Monetary base
Source: Research Findings

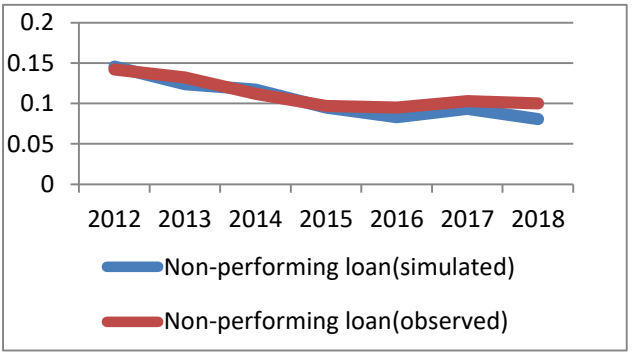

Figure 7. Non-performing loans Ratio
Source: Research Findings

In addition to aligning the simulated trend with the observed trend to further ensure the simulated trend validity, the error of the key variables was calculated based on root mean squares error (RMSE) and Theil's U statistic statistics (UT):

RMS: In this model, the lower the difference between real and simulated data, the more reliable the simulation result. The method for calculating RMSE is shown in Eq.1:

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$$RMSE = \sqrt{\frac{1}{\Theta}\sum_{i=1}^{\theta}\left(\frac{y_{T+1}^{S}-y_{T+1}^{a}}{y_{T+1}^{a}}\right)} \quad (1)$$

y_s is the amount of simulated data and y_a is the amount of data observed and Θ is the number of observations. The closer the value is to zero, the more reliable the simulation process is (Mousavi et al. , 2016).

UT: Another method for calculating the estimation accuracy is U-Theil statistics that is calculated from Eq. 2:

$$U = \sqrt{\frac{\sum_{t=1}^{n-1}\left(\frac{F_{t+1}-Y_{t+1}}{Y_t}\right)^2}{\sum_{t=1}^{n-1}\left(\frac{Y_{t+1}-Y_t}{Y_t}\right)^2}} \quad (2)$$

In Equation (2) Y is the observed data and F is the simulated data. If the value of U is greater than 1, the accuracy of the simulated data is invalid. If the value of U is equal to 1, the simulation accuracy is equal to the accuracy of a naïve estimate, and if the U is less than 1, the accuracy of the simulated data is better than a naive estimate (Wheelwright et al., 1998). The test results are calculated by Excel software and are shown in Table 1.

Table 1
Results of RMSE and UT statistics

variable	RMSE	UT
Central Bank efficiency index	0.043665	0.451374
CPI	0.045376	0.269441
Monetary Base	0.021944	0.203935
Non-performing loans ratio	0.038032	0.338931

Source: Research Findings

As can be seen from the results of Table 1, the 4-year validity of the simulated data of the key variables is acceptable.

7.2 Extreme Condition Test

To determine the validity of the model, the simulated model is tested under extreme conditions. To do this, the PULSE function is used and the amount of monetary base in 2017 increases by 100% for one year. As shown in Figure 8, after applying the extreme condition, the overall trend of the efficiency variable does not change and the system maintains its stability. The reason for sharp efficiency decrease in the year that extreme condition applied is a sharp rise in the monetary base and inflation and considering that the monetary

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policy index is calculated from the average inflation of the current year and the last two years, it will strongly affect and reduce the monetary policy index for following two years.

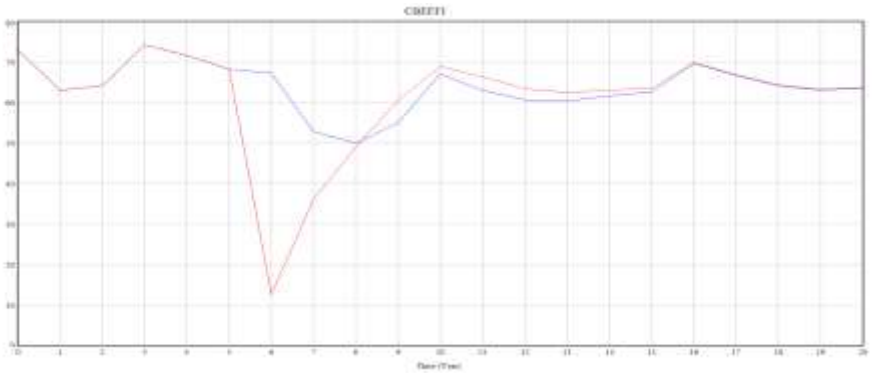

Figure 8. Extreme condition test.
Source: Research Findings
Note: Blue and red lines are Base condition and Extreme condition, respectively.

7.3 Sensitivity Analysis

Finally, sensitivity analysis was used to test the validity of the model. This test examines the sensitivity of the central bank's efficiency to the banking system supervision and monetary policy. As shown in Figure 9, with a 10% decrease in non-performing loans, the banking system supervision index increases, and the efficiency of the central bank also increases. Also, by reducing the monetary base by 5%, the monetary policy index will improve and increase the efficiency of the central bank.

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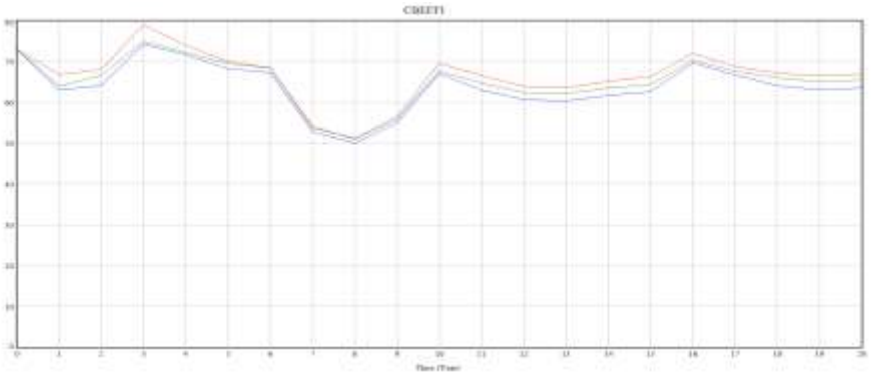

Figure 9. Sensitivity Analysis
Source: Research Findings
Note: Green, red and blue lines are Sensitivity test (banking system supervision), Sensitivity test (monetary policy) and Base condition, respectively.

8 The Scenarios

After the model validity test, the model and executive scenarios are analyzed. The efficiency of the Central Bank of Iran has been simulated by the system dynamics method in 20 years between 2012 and 2032:

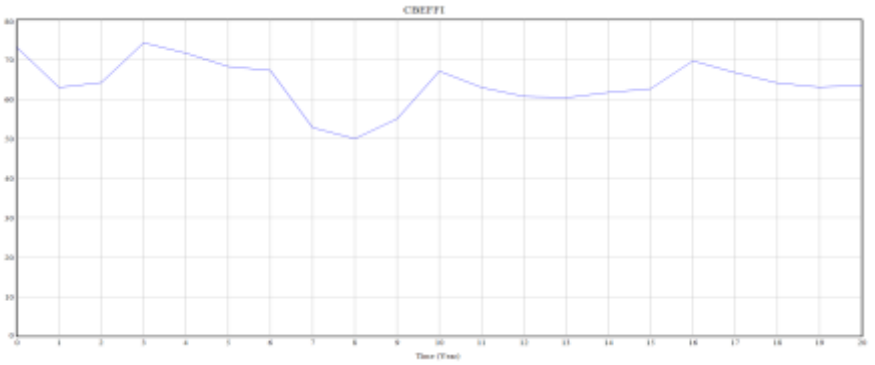

Figure 10. Result of simulating the central banking efficiency of Iran during 20 years between 2012 and 2032
Source: Research Findings

As can be seen in Figure 10, the simulation trend has been declining for 20 years and is significantly away from the efficiency frontier (100), and the

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Central Bank of Iran will not experience better efficiency if the current situation continues. Considering the efficiency trend, the scenarios and policies to improve the efficiency of the central bank will be implemented. The scenarios in improving the efficiency of the central bank are to improve the output of the central bank. Execution scenarios include the following:

- Scenario of reducing government debt to the central bank
- Scenario of Improving supervision of the banking system

8.1 Scenario of Reducing Government Debt to the Central Bank

If the increase in government debt can be prevented by using the independence of the central bank, then by reducing the amount of liquidity, the consumer price index will increase less and the monetary policy index will improve, and by improving the monetary policy index, efficiency will also increase. To implement this scenario, assuming that the central bank has a degree of relative independence and can prevent the increase of the monetary base by government debt and the monetary base increase rate through government debt, is reduced to zero. As shown in Figure 11, the efficiency of the central bank becomes better by preventing the increase of government debt:

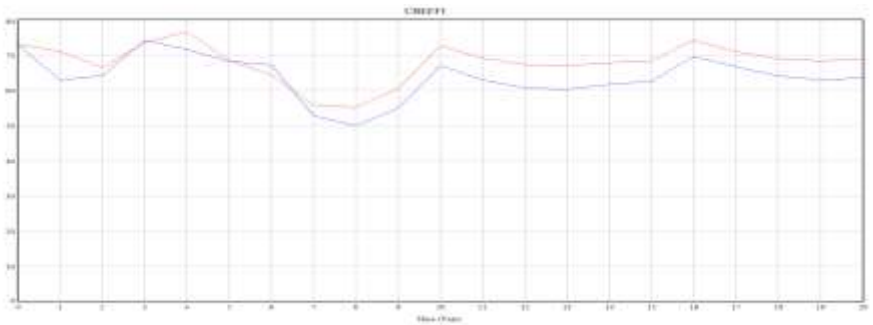

Figure 11. The scenario of reducing government debt to the central bank
Source: Research Findings
Note: Blue and red lines are Base conditions and the scenario of reducing government debt to the central bank, respectively.

8.2 Scenario of Improving Supervision of the Banking System

The central bank targets the amount of non-performing loans to total gross loans below 3% and prevents the increase of non-performing loans to achieve the desired goal with strict supervision, as shown in Figure 12 by implementing the supervision scenario on the banking system and reaching

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the desired non-performing loans ratio, the efficiency of the central bank increases. The reason for increasing the efficiency of the central bank in this scenario is, firstly, the banking system supervision index has improved by preventing the increase of non-performing loans that are directly involved in the efficiency of the central bank. Secondly, due to the reduction of non-performing loans, the reserves of the banking system are also under less pressure and the overdraft from the central bank's resources is reduced. Following monetary base reduction, the Monetary policy index increases, and the efficiency of the central bank also increases:

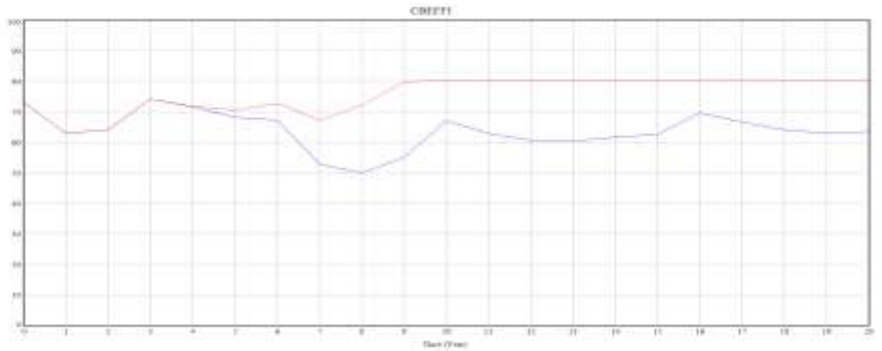

Figure 12. The scenario of improving supervision of the banking system
Source: Research Findings
Note: Blue and red lines are Base conditions and the scenario of Improving supervision of the banking system, respectively.

8.3 Combined Execution of Scenarios

In this section, all the actions performed in the previous scenarios are compared separately, and also the combined combination of the previous scenarios is performed. Comparison of the combined scenario with each of the implemented scenarios shows in figure 13 that the efficiency of the central bank with the implementation of the combined scenario is higher than other scenarios in most years and emphasizes the importance of simultaneous implementation of efficiency improvement policies.

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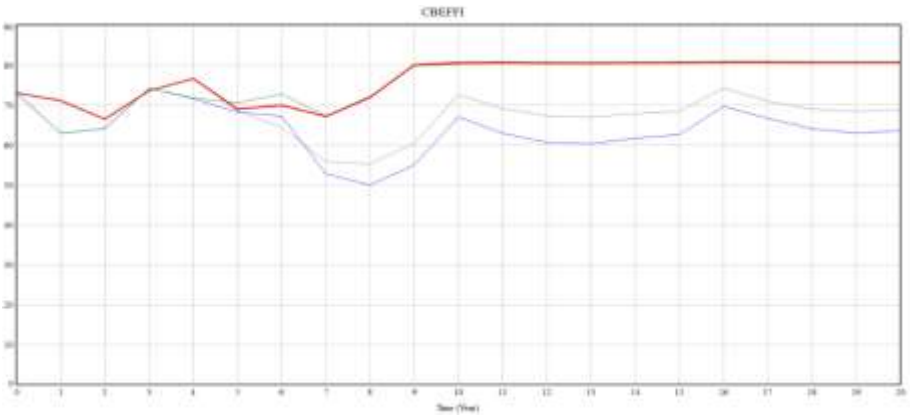

Figure 13. Combined execution of scenarios
Source: Research Findings
Note: Blue, red, green, and gray lines are Base conditions, Combined execution of scenarios, the scenario of Improving supervision of the banking system, and the scenario of reducing government debt to the central bank, respectively.

9 Concluding Remarks

In the present study, considering the importance of the central bank in banking system supervision and price stability, the efficiency of the central bank is analyzed by considering these two objectives, and to analyze the factors affecting the efficiency of the central bank, the system dynamics method is used. The results are summarized as follows:

- The efficiency of the Central Bank of Iran from 2012 to 2018 was the most inefficient central bank among the countries in the current study. The inputs of the central bank of Iran are nearly equal to those of frontier countries like South Korea, Canada, and Australia and the central bank of Iran is very costly compared to its low outputs and this causes the efficiency of the central bank of Iran to reduce even more. However, regardless of the input part of the Central Bank of Iran, the efficiency trend of the Central Bank of Iran during the studied years has been influenced by the output part of the Central Bank, and this issue clarifies the importance of the output part of the Central Bank.
- The simulated model of the present study showed that the efficiency of the central bank will not improve in the studied time horizon because the central bank is not able to influence its efficiency process with the existing mechanisms. Then different scenarios and policies were implemented and

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the efficiency of the central bank experienced a better trend. The separate scenario results show improving banking system supervision makes the central bank more efficient in the long term and the efficiency of the central bank with the implementation of the combined scenario is higher than other scenarios in most years and emphasizes the importance of simultaneous implementation of efficiency improvement policies.

In the simulated space, it was shown that by reducing non-performing loans to total gross loans ratio by the banking system supervision and preventing government fiscal domination by preventing the increase of government debt to the central bank, the efficiency of the central bank experiences a significant increase.

According to the research results, policy recommendations on the efficiency of the central bank are presented:

1) Supervising the banking system and reducing the non-performing loan ratio has the greatest impact on the efficiency of the central bank as a separate scenario. Given this result, the central bank should monitor the contracts more to prevent the increase of non-performing loans and also accelerate the process of non-performing loans repay.
2) Results showed that high government debt to the central bank and the existence of government fiscal domination causes the ineffectiveness of the central bank's monetary policy and the ineffectiveness of monetary policy reduces efficiency. Increasing the independence of the central bank can reduce government fiscal dominance and make the monetary policy of the central bank more effective, although the central bank alone is not able to increase its independence and requires the actions of higher institutions.

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Appendix

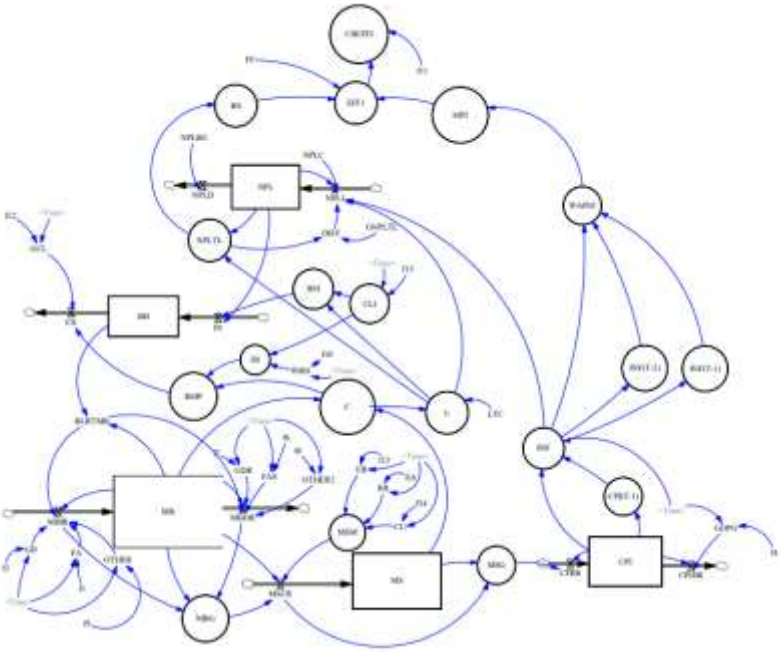

Figure 1A. Stock-flow diagram of factors affecting the efficiency of the central bank (SFD)
Source: Research Findings

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