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Determining the Interest Rate on Deposits in the Iranian Banking System: Cooperative or Competitive Game between the Central Bank and Followers?

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ABSTRACT

This paper studies the monetary policies of the central bank to determine the interest rate on deposits in the interaction with the Iranian banking system in the form of Stackelberg and Nash equilibrium games. The leader of the game is the central bank of the Islamic Republic of Iran, while the followers of the game include three banks called A, B, and C. The leader of the game regulates its monetary policies based on the relationship between inflation rate and interest rate on deposits in the form of three scenarios of "legal deposit ratio", "legal deposit award rate", and "the rate of commissions received" from the followers. The follower players also determine "the interest rate on deposits," based on the scenarios of the leader player. The results of this research (2010-2019) by MINITAB Software indicated that in the studied year (2019), the strategy of the players of this game has been mostly Nash (more competitive) rather than cooperative. If the players of this game had chosen cooperative strategy (Stackelberg game), they would have achieved greater profit. Also, the optimal tool for the monetary policy of the leader and follower players has been the "increasing the legal reserve reward rate".

1 Introduction

Today, the banking interest rate on deposits has various direct and indirect effects on economic indicators, which is often defined and relied upon under the support of monetary policies. An overview of the policies announced by central banks in different countries shows that controlling inflation, creating the right conditions to bring production and employment to potential levels and maintaining the value of the national currency are among their main aspirations. Monetary policy is a policy that seeks to achieve

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certain economic goals by changing and controlling the money supply and changing the level and structure of interest rates or other conditions for granting credit and financial facilities. Monetary policies affect the money supply and interest rates, and thus many economic goals; They affect the increase of employment, price stability, solving the problem of recession, etc [1]. Meanwhile, the main point is that there has always been some disagreement between the economists of the country regarding the effect of reducing the interest rate on deposits on the inflation rate as well as the precedence or antecedence of these two indicators. The proponents believe that according to the investment theory, with reduction of the interest rate on deposits, investment and hence national products grow, and with gradual reduction of inflation, the grounds for employment are provided. In other words, they believe that high interest rate of banking facilities leads to increased investment costs and elevated prime cost of commodities and hence diminished competitive power of domestic products. Accordingly, some economists do not consider a reduction of the interest rate on deposits as something leading to constraints of banks for resource mobilization. They believe that investment in banks does not have a direct association with inflation because of the low risk, guaranteed profit that is exempt from taxes, and limited domestic investment. It is because in Iran with the highest inflation rate compared to the interest rate on deposits, we have still observed high investment by banking investors. However, some others argue that with the reduction of the interest rate on deposits, banking resources are directed towards non-generative activities, setting the ground for inflation and unemployment. Indeed, it can be stated that considering the reduction of interest rate on the facilities offered by banks, the marginal profits of banks diminish considerably and can even subject banks to loss making.

Thus, reduction beyond the interest rate on banking facilities is not possible without lowering the interest rate on deposits, which may even jeopardize the banking system towards bankruptcy. Hence, considering the assumption of either the proponent or opponent groups, it can be stated that banks try to absorb deposits or offer facilities to customers with limited resources, where the central bank tries to determine the interest rate in the economic system of the country through the market mechanism. It implies that the interest rate set by the central bank is somehow the equilibrium interest rate of the market [2]. Based on the above points, the central bank can determine the equilibrium interest rate of the market for the banking system and investors (facility receivers) through applying proper "monetary policies" while also regulating inflation and liquidity. "Monetary policies" refer to the policy through which the central bank wants to achieve specific economic goals by changing the level and structure of "interest rate", altering and controlling the money volume or other conditions of offering credits and financial facilities. Thus, the monetary policy occurs through changing the money volume, the growth of the money volume, interest rate, or the conditions of offering financial facilities. The initiative of changing the money volume is mostly in the hands of the "central bank". In Iran's economy, monetary policy is mainly implemented through direct means of controlling interest rate and setting credit ceilings, as well as indirect instruments, including the ratio of legal deposits, central bank participation bonds and special bank deposits with the Central Bank [3]. The most important tools of monetary policy in the Iranian banking system include [4].

1- Interest rate: the money that is assigned to investment made by people, known as the interest rate on deposits.

2. The interest rate and ratio of legal deposit: the legal deposit means that the central bank or any institute that controllers credits necessitate banks to keep a specific ratio of sums received from people as the customers' deposits in the central bank. The legal reserve or deposit during critical conditions can become effective to resolve the problems of banks or licensed institutes, and exists in all banks of the

world. Accordingly, the legal deposit ratio is one of the indirect tools of the monetary policies of the central bank. Indeed, the central bank receiving this deposit aims to provide security for people's deposits, control liquidity and inflation, and uses it as a support for banks during possible confrontation with bankruptcy or any need to blocked liquidity. The legal sums banks invest in the central bank are assigned a low interest rate by the central bank, which is known as legal deposit rate or legal deposit award. Since the deposit kept by the central bank should be based on debt and virtually no investment occurs by banks in this area, the interest rate paid to the legal deposit is controversial all over the world.
3. Rediscount rate: this is an interest rate in which the central bank discounts timed documents (promissory notes and bills of exchange) of commercial banks, and gives loans to banks accordingly.
4. Open market operations: by adopting this policy, the central bank can affect the supply and demand of money and hence economic activity by selling or buying an open market security.
5. Determining the minimum and maximum interest rate and commission received and paid by banks
Based on the above mentioned points.
The importance of transparency in central bank monetary policy has been emphasized in various studies. But central banks usually pursue monetary policies in order to achieve their goals in a way that is hidden from the view of society's economic actors. This has increased uncertainty in monetary policy, which in turn could affect economic growth, inflation and unemployment. Increased uncertainty in monetary policy will lead to increased fluctuations in these economic variables [5].
In this paper after investigating the effect of monetary policies on macroeconomic indicators and studying the relationship between monetary policies and interest rate on banking deposits, in the literature section of the research, in the third section, the methodology of the research has been presented alongside introduction of the research variables and indicators. Section 4 deals with data analysis, and section 5 concludes the paper while also presenting necessary recommendations in this area.

2 Literature Review

In the section of reviewing past research, the monetary policies in different countries, both developed and developing, have been examined. Also, the relationship between monetary policies and macroeconomic variables, including the inflation rate has been explored. Klose [6] studied "real equilibrium interest rate for BRICS[1] countries". He founds that in the studied countries, there were fundamental differences between the real interest rate and equilibrium rate, suggesting asymmetry in the monetary policies across the BRICS countries. Doojav and Gantumur [7] examined the main stimulator factors of the natural interest rate in a commodity exporting economy (Mongolia) based on a new Keynesian structural model covering both external factors such as demand for exporting commodities and their price. They observed that the real natural interest rate estimated was unscientific, and based on the characteristics of the Mongolia economy, two-digit natural interest rate which is high is justifiable. The results also showed that external shocks are the main determinants of the real natural interest rate, as they claim 40% of fluctuations in the interest rate.
Elsewhere, dealing with monetary policies. Hayo and Henseler [8] explored the sensitivity of interest rate to the performance of the banking sector of Europe within a specific period of time, where the interest rate was (close to) zero. The findings indicated that banks benefit from increasing the interest rate in a setting with a low interest rate. Naiborhu [9] in Indonesia and Sun [10] in China and Akcelik and Talasli [11] in Turkey have compared monetary policy instruments in the studied countries and found that central banks should reconsider some instruments or change some tools. Goczek, and Partyka

[1] BRAZIL, RUSSIA, INDIA, CHINA, SOUTH AFRICA

[12] found that the monetary policy of the European Central Bank affects the domestic interest rates of European countries. Abuka et al. [13] found that monetary contractive policy, including a monetary contraction reduces bank credit supply—increasing loan application rejections and tightening loan volume and rates—especially for banks with more leverage and sovereign debt exposure, especially for banks with more leverages as well as larger governmental debts, increases the banking credits. Sen et al. [14] found that there seems to be a long-run positive relationship between actual rates of inflation rates and nominal interest rates (as one of the principal tools of monetary policy) supporting the validity of the ex-post Fisher hypothesis for all the Countries surveyed (Brazil, India, Indonesia, South Africa, and Turkey) and the depreciation of their currencies creates inflation through raising the prices of imported goods. Airwing Fisher argues that in the long term, one-unit increase in the inflation rate (p) will heighten the nominal interest rate (i) by one unit, while the real interest rate (r) remains constant.

(Fisher equation); $i=r+\beta p$, $\beta=1$

Ghorbani et al. [15] note that according to John Batis Clark (1895), the interest rate should change in line with the inflation rate. In other words, the interest rate has a direct relationship with inflation rate, and in case inflation rate drops (grows) by 2%, the interest rate should also fall (increase) by 2%. Ebrahimi et al. [16] determined and analyzed the relationship between interest rate as one of the principal tools of monetary policy and some macro economy variables including the GDP, inflation rate, and unemployment rate in Iranian economy. They observed that although an increase in the interest rate has a positive and significant relationship with GDP in the short term, its consequences should absolutely be carefully examined. This is because based on the results, as the interest rate increases, so will the inflation rate.

Hesami Azizi et al. [17] indicated that there is a powerful causal relation between interest rates on deposits and interest rate on facilities, where the effective interest rate of facilities in the Iranian banking system is affected by the effective interest rate on deposits, which is most similar to the principles of conventional banking. Nevertheless, there is no significant correlation between the effective interest rate on facilities and the approved rates announced by the central bank. Bakhshi Dastjerdi et al. [18] concluded that the increase in the legal deposit rate against short-term deposits up to 100% and removing the loan-giving power of banks of this type of deposits as well as increasing the legal deposit rate in exchange for long-term deposits and determining an equilibrium rate by the central bank reduce money generation power of these banks, causing fixation in the money supply, stability of level of prices along with production costs in the long run. Khanizad and Montazer [19] compared the profitability of banks in competitive and cooperative games. They concluded that the profit of banks through coalition is greater the activity of each bank alone in banking markets, thus reducing their operational costs, which can be sustained with increase in demand and greater presence of banks.

Anwar and Nguyen [20] conclude that monetary shocks have a strong tendency to have a major impact on Vietnam's economic output. Mosavi Jahromi et al. [21] concludes that the overall conclusion is that if the government does not have the role of the dominant leadership and, on the contrary, the central bank is responsible for implementing monetary policy through open market operations (central bank independence), the minimum social losses will be minimized. Engwerda et al. [22] conclude that the value of social welfare was more, when government and central bank behaved in framework of cooperative than non-cooperative. Tavasoli et al. [23] conclude that the most important goal of monetary policy is to create stability in prices, which the central bank achieves through various tools. Mansouri et al. [24] believe that the minimum of social loss along with improving speculators welfare (less loss) is obtained through central bank independence from the government. And finally, Mahmoudinia et al.

[25] , [26] in 2 researches conclude that in a Stackelberg game between the government and central bank In the cooperative game between the government and the central bank, more profit will be given to the players and more welfare will be given to the society. As seen in previous studies, various studies have been conducted on the Importance and necessity of monetary policy and relationship between monetary policy and economic variables (both micro and macro). In most of these researches, correlation and regression methods have been used. Also, the most important monetary policy tool in previous studies is the interest rate or interest rate on deposits. But none of the previous studies has examined monetary policy and its instruments as a game with the presence of the central bank and the banking network and in the form of cooperative and non-cooperative or competitive games.

3 Methodology[2]

Game theory and dynamic decision process have been considered as the method used in this research. Thus, based on the characteristics, a "quantitative method" is used for developing the model and solving the problem. Quantitative research methods seek to examine a scientific hypothesis in a statistical sample. This is done by investigating a model based on concepts and their interrelationships in a statistical sample. The components of the model (i.e. concepts) should be captured with proper measures which are relevant, complete, and clear. Accordingly, the game of determining the interest rate on banking deposits in the Iranian banking system includes three main players as follows:

1. Central-bank of Islamic Republic of Iran (leader of the game)

2. Bank C (follower player)

3. Iranian banking system, including the competitors of bank C (Bank A and Bank B as follower players).

Table 1: Comparing the interest rates applied by the banking system with the values of inflation rate and interest rate announced by the central bank

No.	Year	The inflation rate announced by the central bank	The interest rate on banking deposits announced by the central bank (game leader)	average interest rate across the banking system (followers)*
1.	2009	10.8	14.5	-
2.	2010	12.4	12.68	8.97
3.	2011	21.5	11.62	9.16
4.	2012	30.5	13.5	12.4
5.	2013	34.7	13.5	14.28
6.	2014	15.6	16	18.24
7.	2015	11.9	19	17.65
8.	2016	9	15	17.82
9.	2017	9.6	15	16.76
10.	2018	31.2	15	16.02
11.	2019	41.2	15	15.35

* The average interest rate across the banking system has been extracted based on the audited financial statements of 23 banks and private and semi-public financial institutions from the Codal[3] site (information on Public banks is not available in this site).

The current status of determining the interest rate on deposits and its implementation of the banking

[2] -Because Bank C did not submit its audited financial statements in 2020, all information provided and calculations are based on the audited financial statements of the three banks by the end of 2019.
[3] . www.Codal.ir

system. The interest rate on deposits announced by the central bank of the Islamic Republic of Iran during the study period is shown in Table 1. The banks of the banking system as the followers of the game for pricing the interest rate of banking deposits must adhere to the interest rate announced by the central bank. Accordingly, Table 1 provides the interest rate announced by the central bank (leader of the game), inflation rate, and the average interest rate applied by the banking system (followers) in 2009-2019.

According to Table 1, comparison of the interest rate applied by the banking system against the inflation rate and the interest rate announced by the central bank across all of the studied years shows that there has been a difference between the interest rate announced by the central bank and the inflation rate reported by this bank, with this difference being far more dramatic especially in 2011, 2012, and 2013. Accordingly, in some years, the interest rate reported by the central bank has been greater than the reported inflation rate, while in some years this rate has been lower than the inflation rate announced. Also, across all of the studied years, the banking system (followers) has never applied the interest rate approved by the central bank (leader of the game); in some years (3 periods), the interest rate applied by the banking system has been lower than the interest rate approved by the central bank, while in some other years (5 periods), it has been vice versa. Figure1 shows the information presented in Table 1 is illustrated.

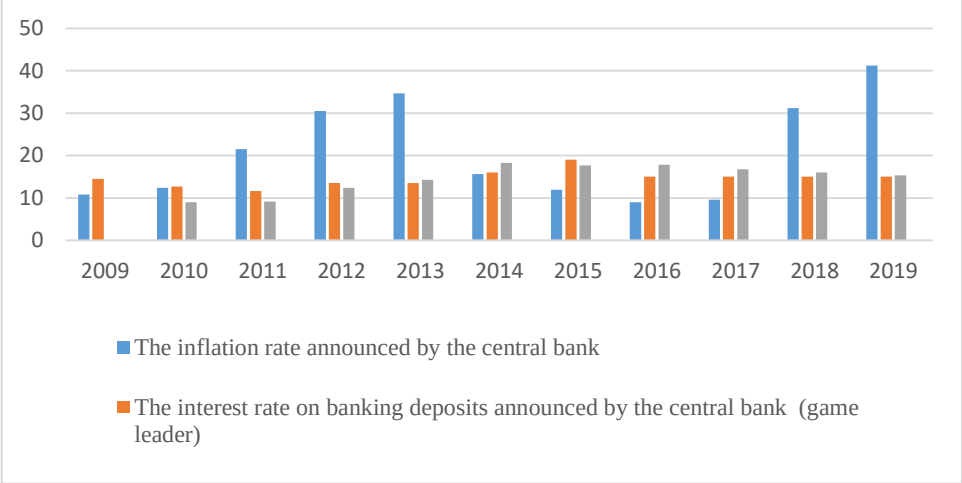

Fig. 1: Comparison of Inflation Rate with Interest Rates on Deposits in the Banking Network

Table 2 lists the interest rate on deposits across the Iranian banking system based on the financial statements of these banks in 2009-2019.

Table 2: The Interest Rate on Deposits Across the Iranian Banking System in 2009-2019

No	Bank name	The interest rate of timed deposits within 2010-2019(%)									
		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1	A	2.1	2	12.8	13.65	16.05	16.64	15.3	14.14	11	11
2	B	10.67	9.94	11.68	10.97	15.2	15.63	15.7	13.55	11.4	10.19
3	C	7.53	8.05	11.61	14.87	16.47	17.66	16.38	19	16.29	16.9

3.1 Results and Discussion

Table 3 outlines the indices and symbols of modelling the game of pricing interest rate on banking deposits across the Iranian banking system:

Table 3: The Specifications of the Symbols of Modelling the Game of Pricing the Interest Rate On Banking Deposits Across the Iranian Banking System

Notations	Definitions
i_i	the interest rate on the deposits absorbed by the i_{th} bank
i_j	the interest rate on the deposits absorbed by the competitor bank
r_i	the interest rate on the facilities offered by the i_{th} bank
$\Delta i=r_i-i_i$	the margin of interest rate on banking deposits (the difference between the interest rate on facilities and interest rate on deposits)
r'_i	the interest rate on the investments by the i_{th} bank
X_i	the deposits of the i_{th} bank or the entire capital collected from the society by the i_{th} bank
α_β	legal deposit rate in the central bank (annual) (based on article 14 of the monetary and banking law ($0.1 \leq \alpha_\beta \leq 0.3$)
$Z = \alpha_B * X_i$	the entire legal reserve/deposit in the central bank
k	Facility coefficient ($0.6 \leq k \leq 0.7$)
$S_i=k* Xi$	percentage of the entire capital (resources) collected from society (X_i) offered by banks as facilities (loan) to the society
$F_i= X_i-\alpha_B X_i-S_i$	the level of free resources (all the resources subtracted from legal deposit subtracted from facilities paid subtracted from the Cash(funds)and ATM
r_B	the legal deposit award rate of the central bank
X_e	the level of overdraft from the central bank resources or reserves (borrowing)
r_p	the type of penalty for overdraft from the reserves of central bank (borrowing) paid by each bank to the central bank in case of the physical resources(r_p=0.34)
U(B)	Central bank utility
y_0	Revenues of the government including (oil sales, taxes, selling bonds, etc.)
$y_1 = Z + y_0$	the level of facilities paid by the central bank to the government, governmental companies, as well as governmental institutes and banks
t_B	the rate of commissions received by the central bank from the followers (banking system)
R_i	Revenues of i_{th} bank
C_i	Costs of i_{th} bank
β_i	Coefficient (line slope) of the deposits absorbed by each bank
a_i	the intercept (constant value) of the deposits absorbed by each bank
γ_j	Coefficient (line slope) of the deposits absorbed by the competitor bank(s)
π_i	The profit of the i_{th} bank which is obtained through subtracting the costs from the bank revenues
Ω	coefficient of importance of the components of utility function (social welfare) of the central bank including the social and economic sectors($0< \Omega \leq 1$)
Φ_B	the facilities coefficient paid by the central bank to the government, governmental companies, as well as governmental institutes and banks ($0< \varphi_B \leq 1$)

Overall, the research hypotheses are as follows:

Hypothesis 1: the strategy of the banking system, players in determining the interest rate on banking deposits is competitive rather than cooperative.

Hypothesis 2: the cooperative game strategy (Stackelberg) of the players of the banking system is more profitable for them than competitive game strategy (players).

4 Discussion

In this part of the study, data have been analysed and the model of the research has been introduced. Accordingly, the game of pricing the interest rate on banking deposits between the leader player (central bank of the Islamic Republic of Iran) and selected followers (banks A,B,C) is investigated. This game is modelled in the form of three scenarios, and based on the inflation rate announced by the leader of

the game. The tools and variables of the game leader will be based on the background of the subject including "legal deposit award rate", "legal deposit ratio", and "commissions received" by the central bank from the follower banks. The tool and variable of the follower players are "interest rate on banking deposits". In order to determine the relationship between the banking interest rate and interest rate on deposits across the follower banks, based on the financial statement data of banks in 2009-2019, Minitab software has been used. Accordingly, in each of the scenarios, using Matlab software and for a specific period of time (2019), in the form of Stackelberg and Nash games, while determining the value of the leader player variable, the value of the variable of follower players (interest rate on banking deposits) has also been determined alongside the values of the objective function of both players. Eventually, the optimal game has been determined for all players.

4.1 Introducing the Scenarios of the Leader Player Against the Follower Players

Based on the review of the theoretical literature, the central bank of the Islamic Republic of Iran, in addition to economic responsibilities and monetary policies, has also social responsibilities and is in charge of creating "social welfare" across the country. Indeed, the central bank has concurrent "economic" and "social" responsibilities. Accordingly, this bank as the leader of the game for pricing the interest rate on banking deposits in Iran through determining monetary policies can regulate and correct this rate by the following three variables. Then, the follower banks by taking the policies announced by the central bank into account in determining the interest rate on deposits as well as fiscal leverages and allocation of resource mobilization, can determine the interest rate of deposits:

A- legal deposit award rate

B- legal deposit ratio

C- the commission rates received from backs

Table 4: The Optimal Rate of Interest Rate on Banking Deposits Announced by The Central Bank Considering the Inflation Rate

NO	Year	The inflation rate announced by the central bank (%)	The interest rate on deposits announced by the central bank (game leader) (%)	The optimal range of the interest rate on deposits* (%)
1	2009	10.8	14.5	12.8-15.8
2	2010	12.4	12.68	14.4-17.4
3	2011	21.5	11.62	23.5-26.5
4	2012	30.5	13.5	32.5-35.5
5	2013	34.7	13.5	36.7-39.7
6	2014	15.6	16	17.6-20.6
7	2015	11.9	19	13.9-16.9
8	2016	9	15	11-14
9	2017	9.6	15	11.6-14.6
10	2018	31.2	15	33.2-36.2
11	2019	41.2	15	43.2-46.2

* The optimal range of the interest rate on deposits based on ghorbani et al [15] and abounoori et al[27] is equal to the inflation rate plus 2 to 5 percent.

Since according to the data in Table 1, the central-bank has not followed a specific or constant trend in determining the interest rate on banking deposits according to the inflation rate, this section has dealt with determining the interest rate on banking deposits considering the inflation rate in the study year (2019) based on the study by Sen et al. [14] and Ghorbani et al. [15]. In this research and examining the

economic conditions of Iran, the real interest rate in the mentioned years has been considered as around 2-5%. Hence, the optimal rate of interest rates on central- bank deposits concerning the inflation rate in 2009-2019 is according to Table 4. As can be seen in Table 4, the central bank in 2009-2019 has applied the optimal interest rate on banking deposits in proportion to the inflation rate only in 2009, while in other years, this optimal rate has not been applied, and it even grew to above 25% in some years. Also, in 2019 (for which the researchers calculations have been performed), the interest rate on deposits announced by the central bank has been at least 28% more than the optimal rate.

4.2 Introducing the Objective Functions of the Leader and Follower Players in Applying the Scenarios for Determining the Interest Rate On Deposits

In order to determine the two models of games, Stackelberg (leader- follower) and Nash on pricing the interest rates of banking deposits between the central-bank and three selected follower banks, the objective functions of both players are investigated. Accordingly, in the first section, the leader- follower game (Stackelberg) is investigated, and in the second section, Nash equilibrium game is examined. Eventually, the real state (current scenario) between the players is tested, and then the obtained results are compared with each other.

4.2.1 Stackelberg (Leader- Follower) Game Between the Central Bank and Selected Banks in Determining the Interest Rate On Deposits

In Stackelberg game, in order to determine the objective function of the three selected banks, "A", "B", and "C" as the game followers, the following equations are introduced based on the symbols shown in Table 3.

$$X_i = a_i + \beta_i\, i_i - \sum_{j\neq i} \gamma_j i_j \tag{1}$$

$$Z = \sum_{i=1}^{i=n} Zi = \alpha_B * X_i \tag{2}$$

$$R_i = r_i(X_i - Z_i)S_i + r_i^{'}(X_i - Z_i)(1 - S_i) + \alpha_\beta X_i r_B \tag{3}$$

$$C_i = X_i i_i + t_B\left(X_i - \alpha_\beta X_i - S_i\right) + r_p X_e \tag{4}$$

$$\pi_i = R_i - C_i = \left(r_i S_i - r_i S_i \alpha_\beta + r_i^{'} - r_i^{'} S_i - r_i^{'}\alpha_\beta + r_i^{'}\alpha_\beta S_i + \alpha_\beta r_B - i_i - t_B + \alpha_\beta t_B\right)\left(a_i + \beta_i i_i - \sum_{j\neq i} \gamma_j i_j\right) + t_B S_i - r_P X_e \tag{5}$$

Equations (1) and (2) are embedded in Equations (3) and (4), and then Equation (5) is formed. Eventually, to calculate the value of the follower player variable (i_i), π_i variable is derived in relation to i_i, and the result is set to zero. Then we have Equation (6):

$$r_i S_i\beta_i - r_i S_i\beta_i\alpha_\beta + \beta_i r_i^{'} - r_i^{'}\beta_i S_i - r_i^{'}\alpha_\beta\beta_i + r_i^{'}\alpha_\beta S_i\beta_i + \alpha_\beta r_B\beta_i - a_i - 2\beta_i i_i + \sum_{j\neq i}\gamma_j i_j - \beta_i t_B + \alpha_\beta t_B\beta_i = 0 \tag{6}$$

Based on the equation (6), the value of i_i will be equal to Equation (7):

$$i_i = \frac{r_i S_i\beta_i - r_i S_i\beta_i\alpha_\beta + r_i^{'}\beta_i - r_i^{'}\beta_i S_i - r_i^{'}\alpha_\beta\beta_i + r_i^{'}\alpha_\beta S_i\beta_i + \alpha_\beta r_B\beta_i - a_i + \sum_{j\neq i}\gamma_j i_j - \beta_i t_B + \alpha_\beta t_B\beta_i}{2\beta_i} \tag{7}$$

In order to determine the objective function of the central bank as the leader of the game, in addition to Equations (1) and (2) and considering the parameters introduced in Table 3 of the research, the objective function of the central bank as the leader of the game has been considered as Equation (8):

$$U(B) = (1-\Omega)[\sum_{i=1}^{n} X_i + y_1] + \Omega\left[\sum_{i=1}^{n} t_B\left(X_i - \alpha_\beta X_i - S_i\right) + \sum_{i=1}^{n} r_p X_e + \varphi_B y_1 - r_B \sum_{i=1}^{n} Z_i\right] \quad (8)$$

By incorporating y_1 ,S_i, x_i from Table 3 and Equation (2) in the place of $\sum_{i=1}^{n} Z_i$, eventually the utility function of the game leader is changed into Equation (9) as follows:

$$\boldsymbol{U(B)} = \sum_{i=1}^{n} a_i + \sum_{i=1}^{n} \beta_i i_i - \sum_{i=1}^{n}\sum_{j\neq i} \gamma_j i_j + \alpha_\beta \sum_{i=1}^{n} a_i + \alpha_\beta \sum_{i=1}^{n} \beta_i i_i - \alpha_\beta \sum_{i=1}^{n}\sum_{j\neq i} \gamma_j i_j - \Omega \sum_{i=1}^{n} a_i - \Omega \sum_{i=1}^{n} \beta_i i_i + \Omega \sum_{i=1}^{n}\sum_{j\neq i} \gamma_j i_j - \Omega\alpha_\beta \sum_{i=1}^{n} a_i - \Omega\alpha_\beta \sum_{i=1}^{n} \beta_i i_i + \Omega\alpha_\beta \sum_{i=1}^{n}\sum_{j\neq i} \gamma_j i_j + \Omega t_B \sum_{i=1}^{n} a_i + \Omega t_B \sum_{i=1}^{n} \beta_i i_i - \Omega t_B \sum_{i=1}^{n}\sum_{j\neq i} \gamma_j i_j - \Omega\alpha_\beta t_B \sum_{i=1}^{n} a_i - \Omega\alpha_\beta t_B \sum_{i=1}^{n} \beta_i i_i + \Omega\alpha_\beta t_B \sum_{i=1}^{n}\sum_{j\neq i} \gamma_j i_j - k\Omega t_B \sum_{i=1}^{n} a_i - k\Omega t_B \sum_{i=1}^{n} \beta_i i_i + k\Omega t_B \sum_{i=1}^{n}\sum_{j\neq i} \gamma_j i_j + r_p \Omega \sum_{i=1}^{n} X_e + \Omega\alpha_\beta \varphi_B \sum_{i=1}^{n} a_i + \Omega\alpha_\beta \varphi_B \sum_{i=1}^{n} \beta_i i_i - \Omega\varphi_B \alpha_\beta \sum_{i=1}^{n}\sum_{j\neq i} \gamma_j i_j + \Omega\varphi_B y_0 - \Omega r_B \alpha_\beta \sum_{i=1}^{n} a_i - \Omega r_B \alpha_\beta \sum_{i=1}^{n} \beta_i i_i + \Omega r_B \alpha_\beta \sum_{i=1}^{n}\sum_{j\neq i} \gamma_j i_j = \left(1 + \alpha_\beta - \Omega - \Omega\alpha_\beta + \Omega t_B - \Omega\alpha_\beta t_B - k\Omega t_B + \Omega\alpha_\beta \varphi_B - \Omega r_B \alpha_\beta\right)\left(\sum_{i=1}^{n} a_i + \sum_{i=1}^{n} \beta_i i_i - \sum_{i=1}^{n}\sum_{j\neq i} \gamma_j i_j\right) + \Omega r_P \sum_{i=1}^{n} X_{ei} + \Omega \varphi_B Y_0 \quad (9)$$

In the next stage, in Equation (9), i.e. the leader equation, instead of variable i_i (the variable of the follower player), Equation (7) is incorporated. Now, to determine the policies of the leader player and to examine the response of follower players, in three main scenarios of the monetary policy of the leader player, the value of variables of leader and follower players is calculated:

4.2.2 First Scenario: Applying the Monetary Policy Considering the Legal Deposit Award Rate Variable (r_B)

By incorporating Eq. (7) In Eq. (9), and by deriving from U(B) function in relation to the variability of the leader player, which in this scenario is the legal deposit award rate (r_B), and by setting the resulting equation to zero, Eq. (10) will be obtained as follows:

$$\Omega\alpha_\beta r_B \sum_{i=1}^{n} \beta_i = \frac{1}{2}\sum_{i=1}^{n} \beta_i + \frac{\alpha_\beta}{2}\sum_{i=1}^{n} \beta_i - \frac{\Omega}{2}\sum_{i=1}^{n} \beta_i - \frac{\Omega}{2}\alpha_\beta \sum_{i=1}^{n} \beta_i - \frac{k\Omega t_B}{2}\sum_{i=1}^{n} \beta_i + \frac{\Omega\varphi_B\,\alpha_\beta}{2}\sum_{i=1}^{n} \beta_i - \frac{\Omega}{2}\sum_{i=1}^{n} r_i' \beta_i + \frac{\Omega\alpha_\beta}{2}\sum_{i=1}^{n} r_i \beta_i - \frac{\Omega}{2}\sum_{i=1}^{n} a_i + \Omega t_B \sum_{i=1}^{n} \beta_i - \Omega\alpha_\beta t_B \sum_{i=1}^{n} \beta_i + \frac{\Omega}{2}\sum_{i=1}^{n}\sum_{j\neq i} \gamma_j i_j \quad (10)$$

Considering Eqs. (7) and (10), and assuming the values of α_β, t_B, β_i, r_i, r'_i, S_i, a_i, γ_j, Ω, φ_B as known, for a special period of time (e.g. 2019), in order to determine the value of leader and follower variables including legal deposit award rate r_B, interest rate on deposits for bank A (i_1), interest rate on deposits for bank A (i_2), and interest rate on deposits for bank C (i_3), a system of 4 equations and 4 unknowns has been formed consisting of the equations of leader (central bank) and three followers. These equations have been solved in MATLAB software. Table 5 presents the known values of the above system of equations for 2019, (for all scenarios) extracted based on the financial statements of the follower banks. Based on the data in the above Table, in order to determine the values of the objective function of the leader and follower players, different values are considered for the coefficient of importance of the components of the function (social welfare) of the central bank including social and economic sectors, as well as the facilities coefficient paid by the central bank to the government, companies, as well as governmental institutions and banks.

Table 5: values and Parameters Related to the Leader and Follower Players in the Game of Pricing the Interest Rate on Banking Deposits Across the Iranian Banking System in All Scenarios (2019)

Row	Variables and their values									
	Bank name	t_B	α_B	a_i	γ_i	β_i	r_i	S_i	r'_i	K
First scenario (r_B:unknown)	Central	0.34	0.13	-	-	-	-	-	-	-
	A	-	-	a_1= -20156	γ_2= -68,976 γ_3= -127,290	β_1= -44,030	r_1=0.16	S_1=0.87	r'_1=0.09	0.7
	B	-	-	a_2= 163,335	γ_1= -99,279 γ_3= 286,515	β_2= -174,594	r_2=0.20	S_2=1.00	r'_2=0.06	0.7
	C	-	-	a_3= -360,398	γ_1= -50,444 γ_2= -41,603	β_3= 122,321	r_3=0.18	S_3=1.65	r'_3=0.08	0.7
Second Scenario (α_β:unknown)	Bank name	t_B	$\boldsymbol{r_B}$	a_i	γ_i	β_i	r_i	S_i	r'_i	K
	Central	0.34	0.01	-		-	-	-	-	-
	A	-	-	a_1= -20156	γ_2= -68,976 γ_3= -127,290	β_1= -44,030	r_1=0.16	S_1=0.87	r'_1=0.09	0.7
	B	-	-	a_2= 163,335	γ_1= -99,279 γ_3= 286,515	β_2= -174,594	r_2=0.20	S_2=1.00	r'_2=0.06	0.7
	C	-	-	a_3= -360,398	γ_1= -50,444 γ_2= -41,603	β_3= 122,321	r_3=0.18	S_3=1.65	r'_3=0.08	0.7
Third scenario (t_B: unknown)	Bank name	α_β	$\boldsymbol{r_B}$	a_i	γ_i	β_i	r_i	S_i	r'_i	K
	Central	0.13	0.01	-		-	-	-	-	-
	A	-	-	a_1= -20156	γ_2= -68,976 γ_3= -127,290	β_1= -44,030	r_1=0.16	S_1=0.87	r'_1=0.09	0.7
	B	-	-	a_2= 163,335	γ_1= -99,279 γ_3= 286,515	β_2= -174,594	r_2=0.20	S_2=1.00	r'_2=0.06	0.7
	C	-	-	a_3= -360,398	γ_1= -50,444 γ_2= -41,603	β_3= 122,321	r_3=0.18	S_3=1.65	r'_3=0.08	0.7

By solving the system of 4 equations and 4 unknowns consisting of the equations of the leader (central bank) and three followers in MATLAB software and then incorporating Deb obtained values in Eqs. (5) and (9), the results presented in Table 6 have been obtained.

4.2.3 Second Scenario: Applying Monetary Policy While Considering the Legal Deposit Ratio α_β

At this stage, considering the legal deposit ratio α_β as the variable of the game leader, first Equation (9) is derived in relation to this variable, and then the result is set to zero. Next, instead of i_i variable, Equation (7) is used. Eventually, a relation as Equation (11) is obtained:

$$\left[\frac{1}{2}\sum_{i=1}^{n} r_i S_i \beta_i - \frac{\alpha_\beta}{2}\sum_{i=1}^{n} r_i S_i \beta_i + \frac{1}{2}\sum_{i=1}^{n} r_i' \beta_i - \frac{1}{2}\sum_{i=1}^{n} r_i' S_i \beta_i - \frac{\alpha_\beta}{2}\sum_{i=1}^{n} r_i' \beta_i + \frac{\alpha_\beta}{2}\sum_{i=1}^{n} r_i' S_i \beta_i + \frac{\alpha_\beta}{2} r_B \sum_{i=1}^{n} \beta_i + \frac{1}{2}\sum_{i=1}^{n} a_i - \frac{t_B}{2}\sum_{i=1}^{n} \beta_i + \frac{\alpha_\beta}{2} t_B \sum_{i=1}^{n} \beta_i - \frac{1}{2}\sum_{i=1}^{n}\sum_{j\neq i} \gamma_j i_j\right](1 - \Omega - \Omega t_B + \Omega \varphi_B - \Omega r_B) = 0 \quad (11)$$

Table 6: Determining the Variables and Objective Functions of the Leader and Follower Players by Applying the Monetary Policy Through the Legal Deposit Award Variable (2019)

NO	Variable	Ω	φ_B	Notations	Value of variable (%)	Follower interest rate margin Δ_i	Objective function values (billion Rials)
1	Legal deposit award rate of the central bank	0.5	0.5	r_B	3.28	-	U(B)=1071059
2	The interest rate on Bank A deposits			i_1	48.24	Δ_1=-0.32	π_1 = -144663
3	The interest rate on Bank B deposits			i_2	3.06	Δ_2=0.1	π_2 = 571661
4	The interest rate on Bank C deposits			i_3	41.71	Δ_3= -0.23	π_3 = -11510
5	Legal deposit award rate of the central bank	0.75	0.75	r_B	1.82	-	U(B)= 1166786
6	The interest rate on Bank A deposits			i_1	19.85	Δ_1= -0.03	π_1 = -30188
7	The interest rate on Bank B deposits			i_2	2.48	Δ_2=0.175	π_2 = 22236
8	The interest rate on Bank C deposits			i_3	22.4	Δ_3= -0.044	π_3= -15054
9	Legal deposit award rate of the central bank	1	1	r_B	1.45	-	U(B)= 1817791.2
10	The interest rate on Bank A deposits			i_1	12.53	Δ_1=0.034	π_1 = -15228
11	The interest rate on Bank B deposits			i_2	2.35	Δ_2=0.176	π_2 = -23014
12	The interest rate on Bank C deposits			i_3	16.58	Δ_3=0.0032	π_3 = -14613
13	Legal deposit award rate of the central bank	1	0.45	r_B	3.13	-	U(B)= 1349074
14	The interest rate on Bank A deposits			i_1	23.4	**Δ_1=** -0.15	π_1= -467050
15	The interest rate on Bank B deposits			i_2	17.61	**Δ_2=**-0.023	π_2= -615491
16	The interest rate on Bank C deposits			i_3	38.21	**Δ_3=** -0.2	π_3= -625911

Assuming the values of α_β, t_B, β_i, r_i, r'_i, S_i, a_i, γ_j, Ω, φ_B as known for a specific period of time (2019), in order to determine the leader and follower variables including the legal deposit ratio α_β, the interest rate on bank A deposits (i_1), the interest rate on bank B deposits (i_2), and the interest rate on bank C deposits (i_3), a system of 4 equations 4 unknowns is created consisting of leader (central bank) and three followers' equations. Table 5 indicates the known values of the above system of equation for 2019, which have been extracted based on the financial statements of the follower banks. According to Equation (11), in which the multiplication of the two statements has been set to zero, we will have Equation (12):

$$(1-\Omega-\Omega t_B+\Omega\varphi_B-\Omega r_B)=0 \quad (12)$$

By embedding t_B=0.34 and r_B=0.01 from Table 4 (second scenario) in the above statement, we will have Equation (13):

$$\Omega(1.35-\varphi_B)=1 \quad (13)$$

Hence, based on the mentioned equation and considering the equations/constraints in Table 3, the optimal (maximum) values for coefficients Ω and φ_B are as follows:

Ω=1 , $\varphi_B = 0.35$

Hence in this scenario, the optimal value of the coefficient of importance of the components of utility function (social welfare) of the central bank including the social and economic factors has been equal to 1, and the facilities coefficient paid by the central bank to the government, governmental companies, as well as governmental institutes and banks has been equal to 0.35. Indeed, in this state, the coefficient of importance of the utility function (social welfare) of the control back is maximum. Nevertheless, central bank as the leader of the game will have at most 35% ability in offering facilities to the government, companies, as well as governmental institutes and banks. Next and considering the values of Table 4 (second scenario), by solving the system of 4 equations and 4 unknowns in MATLAB software, and then by embedding he obtained values in Equations (5) and (9), the outcomes have been presented in Table 7.

Table 7: Determining the Variables and Objective Functions of Leader and Follower Players by Applying the Monetary Policy Through the Variable of Legal Reserve Ratio (2019)

NO	Variable name	notations	Value (%)	Follower interest rate margin Δ_i	Objective function values (billion Rials)
1	Legal deposit ratio of the central bank	α_β	0.253	-	U(B)= 672671.2
2	The interest rate on Bank A deposits	i_1	51.5	Δ_1= -0.355	π_1 = 300
3	The interest rate on Bank B deposits	i_2	9.82	Δ_2=0.101	π_2 = - 71500
4	The interest rate on Bank C deposits	i_3	32.13	Δ_3= -0.141	π_3 = 169496

4.2.4 Third Scenario: Applying Monetary Policy While Considering the Commission Rates Received from the Banks (t_B)

At this stage, considering the variable of commission rates received by the central bank from the banks (t_B) as the leader variable of the game, first Equation (9) is derived in relation to this variable, and the result is set equal to zero. Next, instead of i_i variable, Relation (7) is used. Eventually, the obtained relation takes the following form (Equation (14)):

$$\left[\frac{1}{2}\sum_{i=1}^{n} r_i S_i \beta_i - \frac{\alpha_\beta}{2}\sum_{i=1}^{n} r_i S_i \beta_i + \frac{1}{2}\sum_{i=1}^{n} r_i' \beta_i - \frac{1}{2}\sum_{i=1}^{n} r_i' S_i \beta_i - \frac{\alpha_\beta}{2}\sum_{i=1}^{n} r_i' \beta_i + \frac{\alpha_\beta}{2}\sum_{i=1}^{n} r_i' S_i \beta_i + \frac{\alpha_\beta}{2} r_B \sum_{i=1}^{n} \beta_i + \frac{1}{2}\sum_{i=1}^{n} a_i - \frac{t_B}{2}\sum_{i=1}^{n} \beta_i + \frac{\alpha_\beta}{2} t_B \sum_{i=1}^{n} \beta_i - \frac{1}{2}\sum_{i=1}^{n}\sum_{j\neq i} \gamma_j i_j\right](\Omega - \Omega\alpha_B - k\Omega) = 0 \quad (14)$$

Assuming the values of α_β, t_B, β_i, r_i, r'_i, S_i, a_i, γ_j, Ω, φ_B as known for a specific period of time (such as 2019), in order to determine the variables of leader and player including the commission rates received by the central bank from the banks t_B, the interest rate on deposits for bankA(i_1), the interest

rate on deposits for bankB (i_2), and the interest rate on deposits for bankC(i_3), a system of 4 equations and 4 unknowns develops consisting of the leader (central bank) and three followers' equations. Table 4(third scenario) reports the known values of the above system for 2019, extracted based on the financial statements of the follower banks. Based on Equation (14), in which the multiplication of two terms has become zero, we will have Equation 15:

$$(\Omega - \Omega\alpha_B - k\Omega) = 0 \quad (15)$$

Considering the constraints in Table 3, the above statement is wrong. This is because the condition for this equation to hold is the equality of Ω value to zero, or the quality of k value to 0.87, where both of these values violate the mentioned constraints. Hence, this equation will be independent of Ω and φ_B values, and as with scenario 1, three states are considered in determining the value of the leader and follower variables as well as their objective functions. Accordingly, considering the values of Table 4, by solving the system of 4 equations and 4 unknowns in MATLAB, and incorporating the obtained values in Equations (5) and (9) for three different states of Ω and φ_B, the results obtained in Table 8 have been presented.

Table 8: Determining the Variables and Objective Functions of the Leader and Follower Players by Applying the Monetary Policy Through the Variable of Commission Rates Received from The Banks (2019)

NO	Variable	Ω	φ_B	Index	Value (%)	Follower interest rate margin Δ_i	Objective function values (billion Rials)
1	The commission rate received by the central bank from the banks	0.5	0.5	t_B	15	-	U(B)= 446307
2	The interest rate on Bank A deposits			i_1	3.6	Δ_1=0.124	π_1 = 3090
3	The interest rate on Bank B deposits			i_2	3	Δ_2=0.17	π_2 = -48520
4	The interest rate on Bank C deposits			i_3	8.25	Δ_3=0.09	π_3 = -31439
5	The commission rate received by the central bank from the banks	0.75	0.75	t_B	15	-	U(B)= 1031757
6	The interest rate on Bank A deposits			i_1	3.6	Δ_1=0.124	π_1 = 3090
7	The interest rate on Bank B deposits			i_2	3	Δ_2=0.17	π_2 = -48520
8	The interest rate on Bank C deposits			i_3	8.25	Δ_3=0.09	π_3 = -31439
9	The commission rate received by the central bank from the banks	1	1	t_B	15	-	U(B)= 1836236
10	The interest rate on Bank A deposits			i_1	3.6	Δ_1=0.124	π_1 = 3090
11	The interest rate on Bank B deposits			i_2	3	Δ_2=0.17	π_2 = -48520
12	The interest rate on Bank C deposits			i_3	8.25	Δ_3=0.09	π_3 = -31439

4.2.4 The Real Scenario (Current Scenario) of the Leader and Follower Players as Well as Their Objective Functions in the Banking System

After investigating the research scenarios, which have been based on three variables of legal deposit award rate, the legal deposit ratio, and commission rates received from the banks for the leader player (central bank) and the variable of interest rate on deposits for the followers (selected banks), in the final

state the actual situation of the mentioned variables including (Ω=1,φ_B=0.45, t_B=0.34, r_B=0.01, α_β = 0.13) and interest rates on deposits (i_1=0.11, i_2=0.101, i_3=0.169) have been explored based on Table 2 in 2019 across the banking system. Based on that, the values of the objective function of leader and follower players have also been determined. The obtained results are shown in Table 9.

Table 9: Determining the Objective Function Value of the Leader and Follower Players Based on the Real Value of Parameters in 2019

Row	Real values of variables and objective functions of the leader and followers in the research												
Bank name	φ_B	α_β	r_B	t_B	a_i	γ_i	β_i	r'_i	S_i	r_i	i_i	Δ_i	Objective function values (billion Rials)
Central	0.45	0.13	0.01	0.34	-	-	-	-	-	-	-	-	U(B)=1191671
A	-	-	-	-	a_1= -20156	γ_2= -68,976 γ_3= -127,290	β_1= -44,030	r'_1=0.09	S_1=0.87	r_1=0.16	0.11	0.05	π_1 = 5715
B	-	-	-	-	a_2= 163,335	γ_1= -99,279 γ_3= 286,515	β_2= -174,594	r'_2=0.06	S_2=1.00	r_2=0.20	0.101	0.099	π_2 = -93001
C	-	-	-	-	a_3= -360,398	γ_1= -50,444 γ_2= -41,603	β_3= 122,321	r'_3=0.08	S_3=1.65	r_3=0.18	0.169	0.011	π_3 = -74989

4.2.5 Comparing the Values Obtained in the Three Main Scenarios with The Current Situation in Stackelberg Game

After investigating the three scenarios of determining the variable of follower players (the interest rate on deposits) and variables of the leader player (central bank), as well as their objective functions, and investigating the real value of the mentioned variables in 2019 and the objective functions, this section has dealt with comparing the values obtained from the scenarios and real value. Accordingly, Table 10 compares the values obtained in the previous stages with each other.

Based on Table 10, we observe that in scenario 2, the value of α_β variable does not hold in constraints, and hence this scenario is not acceptable, and is no longer investigated as a better scenario. From among the remaining scenarios, 1-3 and 3-3 have the maximum value of the objective function of the central bank, and the values of the objective function of followers are also better compared to the objective function in the current status. Hence, scenarios 1-3 and 3-3 are chosen as the superior scenarios in the game of pricing interest rate on deposits between the two players, leader (Central bank) and followers (selected banks: A, B, and C).

Table 10: Comparing the Scenarios with The Real Value Achieved for The Research Variables in Stackelberg State

Scenario-case No.	Values of leader variable			Values of followers' variable			The leader objective function value	The followers' objective function value		
	r_B	$\beta\alpha$	t_B	i_1	i_2	i_3	U(B)	π_3	π_2	π_1
Scenario1-1	3.28	0.13	0.34	0.482	0.03	0.417	1071059	-11510	571661	-144663
Scenario1-2	1.82	0.13	0.34	0.198	0.024	0.224	1166786	-15054	22236	-30188
Scenario1-3	1.45	0.13	0.34	0.125	0.023	0.166	1817791.2	-14613	-23014	-15228
Scenario1-4	3.13	0.13	0.34	0.234	0.176	0.382	1349074	-625911	-615491	-467050
scenario 2	1	0.253	0.34	0.515	0.098	0.321	672671.2	169496	- 71500	300
Scenario3-1	1	0.13	0.15	0.036	0.03	0.082	446307	-31439	-48520	3090
Scenario3-2	1	0.13	0.15	0.036	0.03	0.082	1031757	-31439	-48520	3090
Scenario3-3	1	0.13	0.15	0.036	0.03	0.082	1836236	-31439	-48520	3090
Current status	1	0.13	0.34	0.11	0.101	0.169	1,191,671	-74,989	-93001	5,715

Although both scenarios are optimal but since in the Stackelberg game, the strategy of the following players is a function of the strategy of the leader player, in the next stage, the difference between the interest rates of the deposits of the following players has been compared in the superior two strategies with the optimal interest rate of deposits in 2019 which is determined by the player leader (Central Bank), according to Table 11.

Table 11: Select the Best Scenario of the Following Players According to the Strategy of the Leader Player

The number of superior scenario	i_1 (%)	i_2 (%)	i_3 (%)	The optimal range of the interest rate on deposits (%)
Scenario1-3	12.5	2.3	16.6	43.2-46.2
Scenario3-3	3.6	3	8.2	43.2-46.2
difference between the interest rates of the deposits (Scenario1-3)	-33.7 to -30.7	-43.9 to -40.9	-29.6 to -26.6	-
difference between the interest rates of the deposits (Scenario3-3)	-42.6 to -39.6	-43.2 to -40.2	-38 to -35	-
The optimum(best) scenario	Scenario1-3	Scenario3-3	Scenario1-3	**Scenario1-3**

As can be seen in the Table above, the difference between the deposit interest rates and the optimal interval is less in scenario 1-3, and as a result, this scenario is selected as the optimal scenario in determining the interest rates on deposits of the following players.

4.3 A Nash Equilibrium Game Between Central Bank and the Selected Banks for Determining the Interest Rate On Deposits

After examining the Stackelberg game between the central-bank and followers (the selected banks: A, B, and C), in the second section, Nash equilibrium game between the mentioned players is explored:

In Nash state, the players of a game only strive to maximize their profit without considering the profit of other players of the game. Indeed, in Nash equilibrium, systematically every player chooses its optimal strategy independently. Accordingly, in order to determine the variables of the leader player (central-bank), first Equation 9 is derived in relation to the three variables of the leader player including t_B, α_β, and r_B, and then we set the outcome to zero, as presented in Equations 16-18.

derivation of the leader function in relation to r_B variable

$$-\Omega\alpha_\beta\left(\sum_{i=1}^{n} a_i + \sum_{i=1}^{n} \beta_i i_i - \sum_{i=1}^{n}\sum_{j\neq i} \gamma_j i_j\right) = 0 \quad (16)$$

derivation of the leader function in relation to α_β variable

$$(1 - \Omega - \Omega * t_B + \Omega * \varphi_B - \Omega r_B)\left(\sum_{i=1}^{n} a_i + \sum_{i=1}^{n} \beta_i i_i - \sum_{i=1}^{n}\sum_{j\neq i} \gamma_j i_j\right) = 0 \quad (17)$$

$$\left(\Omega - \Omega\alpha_\beta - k\Omega\right)\left(\sum_{i=1}^{n} a_i + \sum_{i=1}^{n} \beta_i i_i - \sum_{i=1}^{n}\sum_{j\neq i} \gamma_j i_j\right) = 0 \quad (18)$$

In order to determine the variable of follower players, Relation (5) is derived in relation to i_i variable, and then the outcome is set to zero in the form of Equation 19:

derivation of the follower function in relation to i_i variable

$$r_i S_i\beta_i - r_i S_i\beta_i\alpha_\beta + \beta_i r_i' - r_i'\beta_i S_i - r_i'\alpha_\beta\beta_i + r_i'\alpha_\beta S_i\beta_i + \alpha_\beta r_B\beta_i - a_i - 2\beta_i i_i + \sum_{j\neq i}\gamma_j i_j - \beta_i t_B + \alpha_\beta t_B\beta_i = 0 \quad (19)$$

Table 12: The Values and Parameters Associated with the Leader Follower Players in the Game of Pricing the Interest Rate on Banking Deposits Across the Iranian Banking System (2019)

Row	Variables and their values									
	Bank name	t_B	α_B	a_i	γ_i	β_i	r_i	S_i	r'_i	K
First scenario (r_B:unknown)	Central	0.34	0.13	-	-	-	-	-	-	-
	A	-	-	a_1= -20156	γ_2= -68,976 γ_3= -127,290	β_1= -44,030	r_1=0.16	S_1=0.87	r'_1=0.09	0.7
	B	-	-	a_2= 163,335	γ_1= -99,279 γ_3= 286,515	β_2= -174,594	r_2=0.20	S_2=1.00	r'_2=0.06	0.7
	C	-	-	a_3= -360,398	γ_1= -50,444 γ_2= -41,603	β_3= 122,321	r_3=0.18	S_3=1.65	r'_3=0.08	0.7
Second Scenario (α_β:unknown)	Bank name	t_B	r_B	a_i	γ_i	β_i	r_i	S_i	r'_i	K
	Central	0.34	0.01	-		-	-	-	-	-
	A	-	-	a_1= -20156	γ_2= -68,976 γ_3= -127,290	β_1= -44,030	r_1=0.16	S_1=0.87	r'_1=0.09	0.7
	B	-	-	a_2= 163,335	γ_1= -99,279 γ_3= 286,515	β_2= -174,594	r_2=0.20	S_2=1.00	r'_2=0.06	0.7
	C	-	-	a_3= -360,398	γ_1= -50,444 γ_2= -41,603	β_3= 122,321	r_3=0.18	S_3=1.65	r'_3=0.08	0.7
Third scenario (t_B:unknown)	Bank name	α_β	r_B	a_i	γ_i	β_i	r_i	S_i	r'_i	K
	Central	0.13	0.01	-		-	-	-	-	-
	A	-	-	a_1= -20156	γ_2= -68,976 γ_3= -127,290	β_1= -44,030	r_1=0.16	S_1=0.87	r'_1=0.09	0.7
	B	-	-	a_2= 163,335	γ_1= -99,279 γ_3= 286,515	β_2= -174,594	r_2=0.20	S_2=1.00	r'_2=0.06	0.7
	C	-	-	a_3= -360,398	γ_1= -50,444 γ_2= -41,603	β_3= 122,321	r_3=0.18	S_3=1.65	r'_3=0.08	0.7

After obtaining the new equations, now we sum up the three leader equations (Equations 16-18) together, whose outcome is in the form of Equation 20:

The sum of Equations 16-18 for the leader player;

$$\left(1-\Omega t_B+\Omega\varphi_B-\Omega r_B-2\Omega\alpha_\beta-k\Omega\right)\left(3*\sum_{i=1}^{n}a_i+\sum_{i=1}^{n}\beta_i i_i-\sum_{i=1}^{n}\sum_{j\neq i}\gamma_j i_j\right)=0 \quad (20)$$

In the next stage, we solved the three relations of the follower player according to Relation 19 alongside Equation 20, as with Stackelberg step-by-step and considering different values of Ω and φ_B for the three variables of the leader player and in the form of three scenarios in a system of equations (Note that in Table 11, the known values of the problem have been presented for the three scenarios between the central bank and follower players in order to determine the unknown variables in 2019).

Table 13: The Values of Unknowns of the Problem in the First Scenario (Monetary Policy Considering the Legal Deposit Award Rate Variable)-2019

NO	Variable	φ_B	Ω	Index of variable	Value (%) of the variable	The follower's interest rate margin Δ_i	Objective function values (billion Rials)
1	The legal deposit award rate of the central bank	0.5	0.5	r_B	0.96	-	U(B)= 541692
2	The interest rate on deposits for bank A			i_1	2.96	Δ_1=0.13	π_1 = -3073
3	The interest rate on deposits for bank B			i_2	2.08	Δ_2=0.18	π_2 = -48685
4	The interest rate on deposits for bank C			i_3	9.27	Δ_3=0.087	π_3 = -13241
5	The legal deposit award rate of the central bank	0.75	0.75	r_B	1.42	-	U(B)= 989549
6	The interest rate on deposits for bank A			i_1	1.95	Δ_1=0.140	π_1 =-3392
7	The interest rate on deposits for bank B			i_2	11.7	Δ_2=0.09	π_2 = -53315
8	The interest rate on deposits for bank C			i_3	2.37	Δ_3=0.156	π_3 = -37567
9	The legal deposit award rate of the central bank	1	1	r_B	0.6	-	U(B)=1744489
10	The interest rate on deposits for bank A			i_1	-1.37	Δ_1=0.173	π_1 = 17036
11	The interest rate on deposits for bank B			i_2	4.75	Δ_2=0.152	π_2 = -37932
12	The interest rate on deposits for bank C			i_3	-0.72	Δ_3=0.187	π_3 =-22183

4.3.1 First Scenario: Applying Monetary Policy Considering the Legal Deposit Award Rate Variable (rB)

In this scenario, the value of the legal deposit award rate variable r_B is unknown while the values of α_β and t_B are known. Table 12 indicates the known values of α_β ، t_B ،β_i ،r_i ،$r_i^{'}$ ،S_i ،a_i ،γ_j ،Ω، φ_B for a specific period of time (e.g. 2019), extracted based on the financial statements of the follower banks in order to determine the value of leader and follower variables including the legal deposit award rate r_B, interest rate on deposits for Bank A (i_1), interest rate on deposits for bank B (i_2), and interest rate on deposits for bank C (i_3). Now, assuming different known values for Ω and φ_B in Table 13, the value of the unknowns of the problem has been presented.

4.3.2 Second Scenario: Applying Monetary Policy Considering the Legal Deposit Ratio Variable α_β

In this scenario, the value of the legal deposit ratio variable α_β is unknown while the values of r_B and t_B are known. Assuming different known values as three states for Ω and φ_B and solving Equation 20, α_β values will be as Table 14:

Table 14: Determining the Legal Deposit Percentage Variable for Three Different States of Ω and φ_b in the Second Scenario (2019)

NO	Scenario - state	φ_B and Ω Values of	Variable name	Index	Values (%)
1	2-1	φ_B =0.5 $\Omega = 0.5$	The legal deposit ratio (%) of the central bank	α_β	57.6
2	2-2	φ_B =0.75 $\Omega = 0.75$			41.28
3	2-3	φ_B =1 , $\Omega = 1$			38

Table 15: Determining the Variables and Objective Functions of the Leader and Follower Players by Applying Monetary Policy Through the Variable of Commission Rates Received from Banks (Third Scenario)-2019

NO	Variable name	Ω	φ_B	Index	Value (%)	Follower's interest rate margin Δ_i	Objective function values (billion Rials)
1	The commission rates received from the banks by the central bank	0.5	0.5	t_B	1.224	-	U(B)= -2601374
2	The interest rate on deposits for the Bank A	0.5	0.5	i_1	-1.36	Δ_1=0.173	π_1 =-2465536
3	The interest rate on deposits for the Bank B	0.5	0.5	i_2	-24.7	Δ_2=0.44	π_2 = -1394463
4	The interest rate on deposits for the Bank C	0.5	0.5	i_3	-91	Δ_3=1.09	π_3 =-1450538
5	The commission rates received from the banks by the central bank	0.75	0.75	t_B	0.89	-	U(B)= 1834972
6	The interest rate on deposits for the Bank A	0.75	0.75	i_1	-0.96	Δ_1=0.169	π_1 = 37013
7	The interest rate on deposits for the Bank B	0.75	0.75	i_2	0.715	Δ_2=0.19	π_2 = -656202
8	The interest rate on deposits for the Bank C	0.75	0.75	i_3	-67	Δ_3=0.85	π_3 =1241685
9	The commission rates received from the banks by the central bank	1	1	t_B	0.83	-	U(B)=2846064
10	The interest rate on deposits for the Bank A	1	1	i_1	-0.87	Δ_1=0.168	π_1 = 193210
11	The interest rate on deposits for the Bank B	1	1	i_2	0.845	Δ_2=0.191	π_2 = -2206477
12	The interest rate on deposits for the Bank C	1	1	i_3	-60.5	Δ_3=0.785	π_3 =-221998

As shown in Table 14, in all of the three states of the second scenario, the value of legal deposit ratio α_β violates the value set for this variable in Table 3, i.e. beyond 30%. Hence, since the value obtained from the leader variable does not match the mentioned limitation, the value of follower players as well as the objective value functions of the two players are no longer calculated in the scenario. Indeed, this scenario is excluded from the set of possible scenarios.

4.3.3 Third Scenario: Applying The Monetary Policy Considering the Commission Rates Received from Banks (t_B)

In this scenario, the value of variable of commission rates received from banks (t_B) is unknown while r_B and α_β are known. As with the two previous scenarios, assuming different known values and states for ω and φ_B, and solving Equation 20 followed by Equation 19, the values related to the variables of leader and follower players are obtained as Table 15.

Table 16: Comparison of the Different Scenarios of Nash Equilibrium State with the Real Value of the Research Variables (2019)

Scenario-state No.	Values of the leader variable			Values of followers' variable			The leader's objective function value	Values of followers' objective function		
	r_B	$\beta\alpha$	t_B	i_1	i_2	i_3	U(B)	π_1	π_2	π_3
Scenario 1-1	0.96	0.13	0.34	0.029	0.02	0.092	541692	-3073	-48685	-13241
Scenario 1-2	1.42	0.13	0.34	0.019	0.117	0.023	989549	-3392	-53315	-37567
Scenario 1-3	0.6	0.13	0.34	-0.013	0.047	-0.007	1744489	17036	-37932	-22183
Scenario 2-1	1	0.72	0.34	Due to violating the $0.1\leq\alpha_B\leq0.3$ constraint, it was excluded from the studied scenarios.						
Scenario 2-2	1	0.516	0.34							
Scenario 2-3	1	0.475	0.34							
Scenario 3-1	1	0.13	0.012	-0.013	-0.24	-0.91	-2601374	-2465536	-1394463	-1450538
Scenario 3-2	1	0.13	0.008	-0.009	0.007	-0.67	1834972	37013	-656202	1241685
Scenario 3-3	1	0.13	0.008	-0.008	0.008	-0.6	2846064	193210	-2206477	-221998
Current status	1	0.13	0.34	0.11	0.101	0.169	1,191,671	5,715	-93001	-74989

Table 17: Comparing the Scenarios in Nash and Stackelberg Games with the Real Value Found for the Research Variables (2019)

Scenario -state .No	Type of game	Value of leader objective function	Absolute value of the difference between objective function and current status	Value of objective function of follower 1	Absolute value of the difference between objective function and current status	Value of objective function of follower 2	Absolute value of the difference between objective function and current status	Value of objective function of follower 3	Absolute value of the difference between objective function and current status
		U(B)		π_1		π_2		π_3	
Scenario 1-1	Nash	541692	649979	-3073	2343	-48685	38668	-13241	61748
Scenario 1-2		989549	202122	-3392	2024	-53315	34038	-37567	37422
Scenario 1-3	Stackelberg	1817791.2	1206592	-14613	20029	-23014	64339	-15228	59761
Current status scenario	-	1,191,671	0	5416	0	-87353	0	-74989	0

4.3.4 Comparing Three Main Scenarios of the Problem with Real Values (Current Status) In Nash State

After investigating the three scenarios of determining the variable of follower players (the interest

rate on banking deposits) and variables of leader player (central-bank) along with their objective functions, as well as examining the real value of the mentioned variables in 2019 plus objective functions, this section compares the values obtained from the scenarios and the real value. Table 16 compares the values obtained in previous stages with each other.

As observed in Table 16, in addition to the second scenario which has been removed from the scenarios due to violating the constraint related to legal deposit, the third scenario is also excluded since the interest rate on deposits has become negative in it. From among the remaining scenarios, only scenarios 1-1 and 1-2 are acceptable. In other words, the two scenarios related to changing the legal deposit award rate with $\boldsymbol{\Omega = 0.5}$ and $\boldsymbol{\varphi_B = 0.5}$, as well as $\boldsymbol{\Omega = 0.75}$ and $\boldsymbol{\varphi_B = 0.75}$ are considered the optimal scenarios in the Nash equilibrium state of the game of pricing the interest rate on banking deposits between the central bank and the three selected banks. Table 17 lists the optimal values related to Stackelberg and Nash games alongside the values of the current status.

4.3.5 Predicting the Loss and Profit of Bank C Based on the Values of Research Variables According to ARIMA Test

predicting the loss and profit of Bank C, as the main beneficiary of the research, has been done based on the values of research variables according to ARIMA test in the latest part of chapter 4 of the research within a seven-year period and according to the trend of eight periods 2010-2019 and based on the value of research variables in the loss and profit function of this bank. For this prediction, ARIMA timeseries test has been employed in Minitab software. Accordingly, Table 18 presents the values of the main variables of the research for the loss and profit function of Bank C according to Eqs. (3) and (4) in 2010-2019.

Table 18: The Values of the Main Variables of the Research for the Profit and Loss Function of Bank C in 2010-2019

the loss and profit of Shahr bank (π_3) (billion Rials)	the level of overdraft from resources or reserves of the central bank (borrowing) (Xe_3) (billion Rials)	percentage of the total investment (resources) collected from community (X_i) offered to this community as facilities by the bank (S_3)	the interest rate on the investments of the i_{th} bank (r'_3)	the interest rate on facilities (r_3)	the interest rate on deposits (i_3)	the value of deposits (X_3) (billion Rials)	Year
-85829	0	0.087	0.02	0.11	0.0753	11765	2010
-182029	306000	0.094	0.05	0.12	0.0805	20756	2011
-90305	7365	0.29	0.04	0.14	0.1161	50122	2012
-90014	38437	0.6	0.09	0.17	0.1487	89224	2013
-124801	39500	0.176	0.03	0.18	0.1647	149635	2014
-83301	22675	0.84	0.09	0.19	0.1766	255645	2015
-60702	43000	1.65	0.08	0.18	0.1638	395732	2016
-157000	338620	1.6	0.08	0.20	0.19	498969	2017
-97856	0	1.65	0.08	0.18	0.162	771605	2018
-74989	0	1.65	0.08	0.18	0.169	866519	2019

In order to conduct ARIMA test, Box-Jenkins prediction method is employed in Minitab software. This method essentially involves fitting an ARIMA model onto the data. Indeed, one of the most complete models can be ARIMA, which is often called autoregressive integrated moving average model. This model consists of three parts. The first part, as the name suggests, determines the autoregressiveness of the data and models them. The second part is integration and the third is the moving average,

which is employed to smoothen the timeseries values. Combination of these models leads to a complete and powerful model. An ARIMA timeseries model has different parameters that should be identified and estimated by the data. These parameters represented by p for autoregressive model (AR), parameter d or degree of subtraction (integration part) for the integrated model, and parameter q for the moving average model are considered the main characteristics of ARIMA model. Such a model based on these parameters is shown according to the following:

ARIMA (p, d, q)

A suitable tool to identify the orders of the model is drawing the ACF diagram or autocorrelation function as well as partial autocorrelation function (PACF) along with their correspondence against the major patterns of ARIMA model. Accordingly, it seems that selecting moving average model order q=1 would be suitable. In this way, ARIMA (0,1,1) model will be used to create the timeseries model of the data. The obtained results are presented in Table 19 for 7 replications.

Table 19: The Results Obtained for Predicting the Trend of Profit on Deposits and Profitability of Bank C During the Seven-Year Period

year	Loss/profit (π_3) (billion Rials)	Interest rate on deposits (i_3)	SSE	Repeat
2020	0.081	0.195	32064150187	
2021	395	0.225	27693932261	1
2022	722	0.375	23809733217	2
2023	1047	0.525	20432003996	3
2024	1430	0.675	17522910824	4
2025	1843	0.825	15021127207	5
2026	2189	0.975	12883751138	6

As seen in Table 19, although according to the research model as well as the profit/loss function of the follower players, the profitability of Bank C has been negative, i.e. it incurred losses during 2010-2019, with gradual increase in the interest rate on the banking deposits in this bank, its profit and loss improves; in 2020, bank C finds a profitable status and until the end of 2026, the profitability of the bank would range within 0-2100 billion Rials. Thus, according to the loss/profit function of the follower player in the research model, bank C, with increase in the interest rate of deposits, would first exit the loss state and gradually its profitability would grow. Now, the research hypotheses are examined:

Hypothesis 1: the strategy of the players in the banking system in determining the interest rate on banking deposits is a competitive rather than cooperative strategy.

As shown in Table 20, overall, there is minimal difference between scenario/state 1-2 (the variable of legal deposit award rate in a Nash equilibrium state with $\boldsymbol{\Omega = 0.75}$ and $\boldsymbol{\varphi_B = 0.75}$ and the current status scenario. Hence, the above scenario/state is chosen as the dominant scenario/state in the game of pricing the interest rates on banking deposits between the central-bank and selected banks. Thus, the first hypothesis of the research suggesting that the current strategy of the banking system players in determining the interest rate on deposits is competitive rather than cooperative is confirmed.

Hypothesis 2: Cooperative game strategy (Stackelberg) of the banking system, players is more profitable than a competitive game strategy for them.

In order to examine the second research hypothesis, the results in Table 20 show that the objective

function values of players in both scenarios/states of cooperative (Stackelberg) and competitive games are larger than their values of the current status, and one of these two scenarios/states should be chosen. Accordingly and based on the data in Table 20, to choose the superior scenario/state, since the central-bank is the leader of the game of pricing interest rates on banking deposits, in case the players of this game (the central-bank and selected banks) use the cooperative game (Stackelberg) scenario/state as scenario 3-3 ($\boldsymbol{\Omega = 1}$ and $\boldsymbol{\varphi_B = 1}$) (receiving a commission rate of 15% by the central-bank instead of 34% from the followers), greater profitability will be gained for the players in comparison to the competitive game scenario/state. Hence, the second hypothesis of the research suggesting that the co-operative game strategy (Stackelberg) of the banking system, players is more profitable for them than competitive strategy is confirmed. Thus, the optimal strategies of all players of the studied year (2019) in this scenario are as follows:

Table 20: Optimal Strategies of Players in the Game of Pricing the Interest Rates on Bank Deposits in 2019

NO	Player's name	Relevant variable	Value (%) announced	Optimal value (%)	Optimum monetary policy	Strategy outcome
1	Central bank of Islamic Republic of Iran (leader)	The announced interest rate on deposits across the banking system	15	43.2-46.2	legal deposit award rate	Determining interest rate on deposits less than the inflation rate
2	Bank C	Interest rate on deposits for Bank C (i_3)	16.9	16.6	legal deposit award rate	Determining interest rate more than the interest rate set by the central bank
3	Bank A	Interest rate on deposits for Bank A (i_1)	11	12.5	legal deposit award rate	Determining interest rate less than the interest rate set by the central bank
4	Bank B	Interest rate on deposits for Bank B (i_2)	10.19	2.3	legal deposit award rate	Determining interest rate less than the interest rate set by the central bank

5 Conclusion

The results of the study indicated that in the game of pricing the interest rate on banking deposits across the Iranian banking system, the trend of interest rate determination for the banking deposits over the studied years of the central-bank has not been in line with the inflation rate in the country. Further, the banks of the banking system have not implemented the interest rate approved by the central bank. Although the relationship between inflation rates and banking interest rates Ebrahimi et al. [16] and Sen et al. [14] as well as the relationship between liquidity and banking interest rates in economics is evident, this issue has remained neglected by the central bank as the main responsible for the monetary policies in the country.

For example, within the time period when the inflation in the country was reported to be over 30% of the central bank, determination of the banking interest rate less than 20% has resulted in outflow of banking deposits from the banking system and increased volume of liquidity in the society. In fact, government intervention in the financial markets by setting the interest rate ceiling on bank deposits lowers the bank interest rate to a level lower than the inflation rate and as a result negative real interest rate. This condition is called financial repression in economic texts. In the Iranian economy over the past few decades, the financial system has suffered from many restrictions, the most important of which is to determine the interest rate on a mandatory basis for deposits. In addition, the results in line with the findings of Hesami Azizi et al. [17] show that there is no significant correlation between the effective

interest rate of deposits and the approved or announced rates by the central bank. On the other hand, there is a strong causal relationship between the interest rate on deposits and the interest rate on facilities. This suggests that the banking interest rate margin is obtained by subtracting the interest rate on facilities and the interest rate on deposits; the more positive it is, the greater the bank profitability will be. With this explanation, if the central bank (leader of the game) determined the interest rate on deposits based on the inflation rate and considering the nominal and real interest rates, and the selected banks also determined the interest rate on deposits within a range close to that of the central bank (as followers of the leader of the game), the gain of both players would increase compared to their current strategy.

The results of this study showed that although within the time range studied, the game of determining the interest rate on deposits (as one of the monetary policies) between the central-bank and selected banks has been in the form of Nash game and competitive, in case the players of this game reoriented their direction towards Stackelberg cooperative game (leader-follower), they would gain more profit, which is congruent with the results of Khanizad and Montazer [19]. The issue of selecting optimal Stackelberg strategy (leader-follower) has concurred with the results of previous studies regarding the superior strategy of cooperative game compared to uncooperative game when contrasting against fiscal and monetary policies (between the government and central bank as well as the contrast between them) Mahmoudinia et al. [25] ,[26], along with extraction of the optimal rule for monetary and fiscal policy in Iranian economy [22]. They concluded that the value of social welfare is greater when the government and central bank treat each other within a cooperative game framework rather than an uncooperative game. Meanwhile, in a cooperative game, in contrast to uncooperative game, a larger share of the government revenues is kept by the central-bank as foreign/external reserves, since in cooperative games, players can agree with each other imperatively. Also, the individuals can commit themselves completely to a special strategy.

The results also showed that regardless of the type of optimal monetary policy adopted by the central bank, whenever the importance coefficient of the components of utility function (social welfare) of the central bank including social and economic sectors as well as the coefficient of facilities paid by the central bank to the government, governmental organizations, as well as governmental institutes and banks is equal to its maximum (=1), the utility of the central bank (leader of the game) and followers (selected banks) increases, which concurs with the results of Mahmoudinia et al.[26]. As found in this research, the optimal scenario of the central bank involved "increasing the legal deposit award rate" and "reducing the commission rates received" from the banking system. On the other hand, the scenario of changing the "legal deposit ratio" as one of the monetary policies, concerning the range of the rate approved by the monetary and banking law of the country (10-30%) is not considered an optimal tool for determining the interest rate on deposits in the game of pricing the interest rate on banking deposits between the central bank and banking system, and is not efficient. In spite of the inefficiency of the monetary policy of legal deposit ratio, in case the central bank intends to use this tool, correcting the range of the rate approved by the monetary and banking law of the country and increasing it to more than 30% (at least 38%) seems to be inevitable under the current economic conditions of the country. The issue of increasing the legal deposit rate confirms the finding obtained by Bakhshi Dastjerdi [18], who concluded that increasing the legal deposit rate in exchange for time/term deposits contributes to controlling the inflation rate in the long run. Overall, there is no single approach towards legal deposits among economists and central banks even in developed countries. Some countries such as Britain, New Zealand, Australia, and Sweden have changed their banking system to "no legal deposit". This is be-

cause in these countries, banks are controlled and constrained by "the required capital", and some believe that this index, which is also sometimes characterized by the "capital adequacy" ratio, is considered more important than legal deposit or reserve even in countries with "banking with legal reserve" system. In the common modern monetary system in the world, even in countries such as USA, which have still maintained their legal deposit system, similar to the case of dealing with management of "money supply", the intention is to target the interest rates for controlling the liquidity supply, and controlling the monetary flow with targeting the base monetary value or legal deposit has been abolished for many years. Further, among developed economies, only Brazil, India, Russia, and China use the system of changing the legal reserve ratio (legal deposit rate) to change the liquidity value.

With this explanation, two other policies, including changing the "legal deposit award rate", and "determining the commission rates received from the banking system" by the central-bank of the Islamic Republic of Iran are considered optimal policies. According to the [4] article 14 of the banking, monetary law updated in 2019, "determining the legal deposit interest rate and ratio of banks" by the central bank of the Islamic Republic of Iran is one of the main responsibilities of this bank. Thus, the central bank as a governmental Institute and the main responsible for monetary and credit policies, and with the aim of encouraging banks to good faith legal deposit at the end of the year, considers sums under the title of "legal deposit award" for banks. Hence, although the central bank uses legal deposit as a means for monetary policies to regulate the liquidity in the society or for other goals, its usage as a tool should not be considered a barrier or a justified reason for not paying the interest rate assigned to the part of people's deposits kept by the central bank as legal deposit. Nevertheless, the weak role of legal deposit award rate in the central-bank policies across the studied years is something evident and important; across all of the studied years, the legal deposit award rate has been constant, 1%. On the other hand, the research results indicated that in 2019 and in the optimal Stackelberg scenario, the optimal rate of legal deposit award should be beyond 1% and grow to around 1.45%. In this case, the interest rate on the banking deposits of two selected banks diminishes compared to the interest rate of their current status, and the utility of the central-bank (leader) and followers (selected banks) would increase. Evidently, in case the legal deposit award rate increases from 1 to 1.45%, the tendency of banks for deposition in central bank would increase, thereby augmenting the value of domestic money and effectively controlling the inflation rate. Also, investigation of the research scenarios in the monetary policy of changing the legal deposit award rate indicated that the elevation of this rate in the range 1.8-3.28% would yield a lower profit for the players compared to the optimal state (1.45%). However, their objective function in the legal deposit award rate of 3.28% and the importance coefficient of the components of utility function (social welfare) of the central-bank as well as the coefficient of facilities paid by the central bank equal to 50%, the legal deposit award rate 1.82% and the importance coefficient of the components of utility function (social welfare) of the central bank and the coefficient of facilities paid by the central bank equal to 75% would have better value compared to the current status scenario.

Considering the scenario of reducing the rate of commission rates received by the central bank from the banking system, it can be stated that the monetary policy of high rate of commission received from the banks by the central bank (leader of the game), which has been constant at 34% over the studied years, should be revisited. This is because the commission rates received by the central bank from the followers apply for their free resources (followers). These free resources are an outcome of subtraction of the sum of the legal deposit ratio and the facilities paid from the total resources of the bank. The results of a research in 2019 showed that reduction of the interest rates from the followers by the central bank from 34% to 15% would improve the utility of both the leader and follower. Indeed, the scenario of

reducing the commission rates by the central bank, regardless of the importance coefficient of the components of utility function (social welfare) of the central bank and the coefficient of facilities paid by this bank, while reducing the interest rate on deposits of the follower players compared to their current status offered the maximum gain across all scenarios for the leader (central-bank) and follower (selected banks) players.

6 Appendices

1. Research on how the central bank is independent of the ruling governments.

(Independence of the central bank of the Islamic Republic of Iran of its government is considered the most important factor for success of the monetary policies of this bank. In this regard, it seems that the process of choosing the director general of the central bank by the presidents of governments governing Iran should be absolutely reviewed, and he/she should be chosen by a nonpolitical, independent, scientific, economic, and policymaker reference or Institute.)

2. How to manage the triangle of inflation, liquidity and interest rates on deposits

(Concerning determination of the interest rate on banking deposits and the policy of reducing this rate and in turn decreasing the interest rate on facilities, among "inflation", "liquidity", and "interest rate on banking deposits", the central bank should first controlled the inflation rate, then manage the liquidity in the society, and eventually reduce the interest rate on banking deposits to decrease the interest rate on facilities and enhance the prosperity of production and economy. Accordingly, in most countries with advanced economy in the world, the main or unique goal of central banks is creating economic stability or controlling inflation, while other goals are considered secondary. Also, imperative reduction of the banking interest rate regardless of the improper mechanisms of current conditions and when the main problem of banks has still remained unresolved, would lead to increased financial corruption in paying facilities and higher chance of outflow of capital from banks and rushing into parallel markets. Hence, to reduce the banking interest rate and to resolve the problems of the banking system, solutions can be recommended such as repayment of the government debt to banks, creating a Organized market for inter-bank interest, the central bank fining banks for institutes with no permission, establishing installments for the debt of banks to the central bank, observing discipline in the performance by banks and reducing the interest rate on facilities through enhancing the performance efficiency).

3- Development of research on optimal monetary policy instruments based on the general policies of the Central Bank of the Islamic Republic of Iran.

(Since the tool of legal deposit ratio (legal deposit rate) has not been optimized in the monetary policies of the country, revisiting and making new attempts for determining the legal deposit rate seem to be inevitable. This should be done by references or Institute such as the Islamic Council, central bank, as well as the monetary and credit council after precise investigations and considering macro- as well as macroeconomic indicators and conditions. Meanwhile, the central banks of the world have begun to review their goals, policies, and monetary tools in response to the economic transformations worldwide and in their countries. In this regard, banks have left direct monetary tools and have found a tendency towards indirect tools, which mostly include free-market operations and rediscount rate. Thus, the central bank of the Islamic Republic of Iran should have various monetary tools at its disposal considering the monetary and banking loss. For example, in addition to the legal deposit rate and its

award rate, this bank should revive the rediscount rate, quasi facilities, and revisiting the method of presenting bonds (bonds that can have anti-inflation effects and tradability in the secondary market). Clarification of the central-bank decisions and targeting on the inflation rate and creating a workshop for supervising and implementing control systems as well as coordination between monetary policies seem to be essential in this regard.)

4- Investigating the reasons for banks' non-compliance with the central bank in applying interest rates on bank deposits

(In investigating the interest rate on banking deposits across the Iranian banking system within the study time range, we conclude that most banks of the Iranian banking system (follower players) had not adhered to the interest rate determined by the central-bank (leader) in 2009-2019. Regardless of determining the interest rate on deposits not in line with the inflation rate in the country by the central-bank as the leader of the game of pricing the interest rate on banking deposits, the Iranian banking system disobeying implementation of the interest rate determined by the central-bank suggests improper status of these banks for absorbing resources and in turn offering facilities to bank customers. Hence, banks should absolutely revisit the policies of equipping and mobilizing resources and focusing on indicators such as improving the capital adequacy and reducing claims.)

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