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Investigating the impact of momentums in macroeconomic and banking variables on asset freezing in selected banks listed on the Tehran Stock Exchange

Fatemeh Davoodi Farkoush, Mohammad Ebrahim Mohammad Pourzarandi*, Mehrzad Minooie

Department of Financial Management, Central Tehran Branch, Islamic Azad University, Tehran, Iran

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Abstract

Freezing assets in the banking network cause a credit crunch in the economy. In Iran, due to the bank-oriented financial system, the majority of the financing of the economy is done through the money market. Meanwhile, banks play the main role in equipping and distributing resources in different sectors of the economy, especially supporting the production sector. The evidence shows that the problem of freezing bank assets in the country is relatively severe and the concerns to escape from this impasse are serious. Meanwhile, there are factors inside the bank and outside of it that affect the freezing of assets. In this research, the subject of investigating the impact of momentums in macroeconomic and banking variables on asset freezing in selected banks listed on the Tehran stock exchange in the period of 2010 to 2014 has been addressed, and the estimation of the model has been done using the Panel-Var method. At first, the incidence of asset freezing is estimated using the basis components analysis. Finally, the impact of momentums has been investigated and analyzed in macroeconomic variables and banking variables on asset freezing. According to the results obtained from the model estimation, macroeconomic and banking variables have a significant effect on asset freezing at a confidence level of 95%.

Keywords: macroeconomic variables, banking variables, asset freezing, listed banks, analysis of basic components
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1 Introduction

In modern monetary and financial economies, the performance of the real and financial sectors is interlinked and parallel; especially a portion of financial system activities, which involves aggregating and equipping savings and directing them towards investment projects, is connected to one of the key variables of the real economy, namely investment or capital formation, between the real and financial sectors. A healthy and active economic system should possess a financial system that can make the savings of society available to individuals who have productive investment opportunities. Evidence shows that the depth and breadth of financial markets have a significant impact on the growth of the real sector of the economy [27]. Meanwhile, one of the most important financial institutions, especially in developing countries, are banks; Therefore, all over the world, the banking industry is considered one of

*Corresponding author
Email addresses: fatemeh.davoodi12@gmail.com (Fatemeh Davoodi Farkoush), pourzarandi@yahoo.com (Mohammad Ebrahim Mohammad Pourzarandi), omm1344@yahoo.com (Mehrzad Minooie)

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the most important pillars of the economy of any country [3]; In other words, banks play a decisive role in the economic development and growth of countries due to the provision of various financial and credit services; so that they can be referred to as the driving force, accelerator, balancer and organizer of the country's economic sectors; Because due to the financial dependence of production sectors on banks, any inefficiency or crisis in the banking system may face many problems in different sectors of the economy. Also, this important financial institution, in addition to the role of money, has been responsible for financial and monetary exchanges in internal and external transactions, and since its establishment and formation, it has been both the trustee of the people and the facilitator of monetary exchanges. In addition, in developing countries, including Iran, in terms of capital market defects, banks play a key role in equipping deposits for investment purposes, and in the economy of these countries, the banking system can be considered the most important bridge between the supply and demand of monetary resources [5].

Cash assets are the lifeblood of banks. Basically, by holding cash assets, banks intend to carry out day-to-day operations and cover unexpected cash flows. While, holding excess liquidity hinders profitability, as such assets yield the least profitability if they exist. Therefore, liquidity management is one of the conventional duties of bank managers, which entails huge challenges. One of the challenges is that there are different types of liquid assets, from "higher cash and lower profitability" assets to "lower cash and moderate profit generating capacity" assets. Also, the size of the cash portfolio has a non-linear effect on the bank's performance. Banks with low liquidity are more fragile and may face a banking crisis due to depositors' mistrust [16, 34]. Montes and Peixoto [29] state that in many times before the severe financial crisis, bank managers tended to be too optimistic and maintained low levels of liquid assets. Such a strategy was good for an individual bank but bad for the system, to some extent because Asset and Liability Management (ALM) in banks is not responsible for the macroeconomic effects of their actions. Challenges have been examined in two distinct areas: asset liability management (ALM) at the micro-level and macro-prudential regulatory authority at the macro-level. From a micro perspective, a bank is a profit-making company. If asset and liability management measures and prudential macro regulations neglect this goal, they are doomed to failure. However, the literature on the relationship between liquidity management and bank profitability reports contradictory results [8].

In this article, the impact of macroeconomic variables and banking variables on asset freezing in selected stock market banks has been investigated using the PVAR method. In this article, according to the econometric literature related to PVAR models, firstly, the determination of the optimal interval in the research models is discussed. Then, using Johansen's test (effect test and maximum eigenvalues test), the long-term equilibrium relationship between model variables in both models is investigated separately, and then the model is estimated using PVAR method. After estimating the model and examining the coefficients of variables within the PVAR model, dynamic tests including sudden shock tests and variance decomposition tests have been conducted. In the sudden shock tests, we investigate how the response to a shock, equivalent to one standard deviation, impacts the asset freezing variable concerning macroeconomic and banking variables. In the variance decomposition tests, we aim to decompose the asset freezing variable over time and determine the contributions of macroeconomic and banking variables over time in explaining this variable, identifying which variables have the highest and lowest shares in explaining asset freezing. Finally, the stability of the models has been investigated using the inverse characteristic root test.

2 Literature review

Banks at the level of a country, region or at the level of the global community can influence the economic, social and cultural aspects. The positive and negative performance of a country's banking system can affect the amount and quality of business at the micro and macro levels. This impact on the economy can affect unemployment rates, inflation, economic growth, gross national product and other measures of desirability and well-being in the society. Although the performance of the bank can also be affected by these macro factors. Achieving high economic growth is not possible without adequate domestic or foreign financing. In countries where economy is bank-oriented, economic growth depends to a great extent on bank loans [32]. In recent years, the banking industry has undergone drastic changes. For this reason, banks try to be more efficient in terms of cost and profitability in order to stay competitive. Attaining adequate profit not only requires providing banking services at minimum cost but also necessitates maximizing revenues. In some cases, banks that are more inefficient and incur more costs earn more profit compared to banks that are cost efficient; Therefore, cost efficiency calculation is also an important source of information for bank management. Accordingly, in order to achieve more profit and better performance, the bank needs to examine both areas of cost and profitability [31].

The total income of the bank is classified into two shared and non-shared parts. The shared income, which accounts for the majority of the bank's income, is an income that is divided between the bank and the investor or the depositor. The non-shared income is also a part of the bank's income in which the depositors do not have a share, and of course,

it is usually a smaller amount than the shared income. Shared income includes interest and deposits received from payment facilities and profits from investments and partnerships. Non-shared income includes service fees, interest and facility commitment and other miscellaneous incomes that the depositor does not participate in. Fees for loans paid under the title of "Garz al-Hasaneh" are also considered as non-shared incomes [35].

Related income: Part of the bank's income can be traced to payment facilities. In the sense that for each item of the loan, the interest of the facility can be clearly determined. In the same way, the interest and deposit related to each category of loans and total loans can also be extracted. Interest and liabilities related to facilities are known as income related to facilities or in short as related income [35]. inquiring the financial statements of the banks shows that the granted facilities or bank claims account for approximately 50-70% of the total assets. Profit and loss statements of banks show that 40 to 70 percent of the total income earned by banks is related to interest received from facilities.

Total cost: The main costs of the bank are the interest paid on deposits, administrative and general costs, the cost of doubtful access to non-current and current facilities, the cost of paid fees and property depreciation, which is called the total cost. Bank deposits impose the highest cost to the bank under the title of interest paid to the deposit [31]. The total amount of bank claims will be related to the total cost of the bank. Because bank claims are created in line with the main activity of the bank and lead to the creation of bank expenses. Of course, the impact of each class of claims on the total cost must be different. On the one hand, the amount of each class and the average stay in each class are different, and this will have a different effect on the total cost. On the other hand, each class will have a specific cost-generating feature [31].

2.1 Characteristic factors affecting the assets of banks

2.1.1 Economic factors at the macro level and internal factors of the banking system

After the global financial crisis and since non-current claims have become the most serious problem of many banks and the banking system, several studies were published to understand the determining factors and dynamics of this phenomenon. The general empirical approach is that non-current claims are determined by two groups of factors: country-related and bank-related. In particular, macroeconomic conditions, such as GDP growth [2], unemployment [30], interest rates [26], inflation and deflation [36], currency rate [4], as well as trade balance deficit as a sign of loss of competitiveness are the main determinants of non-current claims. Factors related to the performance of the banking sector, such as the level of competition and the level of concentration, have also been estimated in cross-country studies that affect risk-taking and non-current claims [18]. Other bank-related characteristics that indicate management quality, such as cost efficiency [23], bank performance [2] and bank capital provision [15, 23] are also identified as which affects non-current claims.

According to Keynes [19], firms save transaction costs to obtain funds and avoid liquidating assets to make payments. Companies may use liquid assets to finance their activities and to invest when other sources of financing are lacking or if such sources are too costly. The first one is the motive of the transaction. They optimize cash balances subject to the flow of income from income-generating assets and a constant stream of optimal expenditures. The second is the motive of caution; Some managers prefer to hold cash to reduce liquidity risk and increase their discretion. In addition, a shortfall in cash flow may delay companies' quick response to profitable opportunities. These incentives are sensitive to the efficiency of the financial market. As companies with liquid stocks, they hold less cash [16]. In times of financial friction, firms may violate the usual optimal level of cash holdings. Liquidity management then leads to higher levels of liquidity to increase their ability to finance future projects. Since holding liquid assets imposes an opportunity cost, there is a trade-off to achieve the optimal amount of liquidity. Therefore, in practice, an increasing liquidity balance may be observed as cash flows increase. Companies try to create a liquidity buffer to finance future projects [22].

Low interest rates may create incentives for asset managers to take more risks for contractual, behavioral or institutional reasons. For example, in 2003-2004, many investors shifted from low-risk government bonds to higher yield and riskier corporate and EME bonds [1]. The second way in which a monetary policy can affect the bank's risk-taking is through asset substitution, which was stated by Fishburne and Porter [12]. According to this view, bank assets are divided into assets with low risk and low return and assets with high risk and high return. In this theory, based on the level of risk-taking of banks, expansionary monetary policy can increase or decrease the risk of asset portfolio. In risk-taking and risk-neutral banks, by applying expansionary monetary policy and interest rate reduction, the yield of risky assets will decrease and banks will decide to increase risky assets in their asset portfolio in order to prevent the decrease in profitability. In this situation, the presence of a small real yield in the risk-free asset will cause its weight in the banks' asset portfolio to decrease; Therefore, by reducing the interest rate of risk-taking and risk-neutral banks, they increase their demand for high-risk assets. In contrast, risk-averse banks reduce their

risky asset portfolio. In oil-exporting countries, economic and financial developments are influenced by the price and revenues from oil exports. Based on this basis, an increase in oil prices leads to an increase in oil revenues, stronger financial and foreign positions, and higher government expenses. In which increases the profitability of companies and stock prices and strengthens bank balance sheets, but it can also cause the formation of systemic vulnerability in the financial sector. Banks in oil-exporting countries have adequate capital, liquidity and profitability, and are in a good position to manage structural systemic risks. However, the linkages between oil and macroeconomics mean that asset quality and liquidity in the financial system may deteriorate in low oil prices and financial stress may emerge.

Before the financial crises of 2007-2008 affected the global economy, the relatively stable credit quality of debt securities was visible around the world. Since then, due to the global economic recession, there has been a sharp decline in the quality of the bank's assets. In this regard, researchers used various alternative indicators as a proxy for asset quality. non-performing loans [20], toxic assets [24], non-performing assets, illusory assets [25]. The use of these diverse approaches to examine the quality of asset credit has provided new research fields for researchers.

On the other hand, senior officials in the banking system argue that the volume of banks' overdue claims has significantly increased, leading to a situation where a substantial portion of banking resources that could be deployed for production and employment has effectively been frozen and lacks the ability to enter the economy. On the other hand, companies and the production sector are facing a lack of liquidity and working capital and they always emphasize the banks' facilities in this sector [28]. In fact, the problem of banks is the freezing of assets, and there is no mistake if we consider the problem of overdue bank claims as the most important current problem of banks. Astronomical numbers of locked bank receivables, which are estimated to be hundreds of thousands of billions of Tomans, have tied the hands of the banking system. Despite the current bank arrears, the ability to pay for the facilities will not increase significantly, because the resources available to the banks are limited and not enough to pay for the production units and the applicants for the bank facilities. So, it should be understood where the root of the problem of asset freezing in banks has originated: whether the imposed loans on the banking system are the source of arrears, or has the poor economic situation made borrowers unable to repay. In addition, what has been the role of direct investment of financial institutions in real estate and large construction projects in the occurrence of this problem and what forces have pushed financial institutions in this direction. Also, what is the composition of collaterals for overdue loans (land and real estate or assets of industrial/production companies)? The problem of the country's banks in the matter of asset freezing is a combination of these issues. While the country's banks may not have significant direct investments in financial paper instruments, they have both directly invested in assets (usually in real estate and housing) and encountered difficulties, and have also extended loans that are not repaid. In this regard, this study examines three categories: non-recoverable and non-current assets; government debts to banks; and the third category includes non-financial assets, or in other words, bank assets that have been transformed into real estate, buildings, stocks, and businesses in recent years as a representation of asset credibility in the frozen assets area. Furthermore, in line with numerous studies in the field of economics and banking, this study examines several macroeconomic variables, including Gross Domestic Product (GDP), Unemployment Rate (UR), and Interest Rate (IR), Consumer Price Index (CPI), Exchange Rate (CS), Economic Growth Rate (EGR), as well as intra-banking variables such as Capital Adequacy Ratio (CAR), Bank Size (SIZE), Return on Equity (ROE), Return on Assets (ROA), Liquidity level (Liquidity), and Bank Capital (Capital), to investigate their effects on bank asset freezing.

2.2 Past studies

Eskandaripour et al. [11], in their study, investigated the impact of the shock of macroeconomic variables on the performance of the country's banking system: an application of the computable dynamic recursive RDCGE model. This study examined the impact of exchange rate shocks, crude oil prices, the stock market index, and government budget on the performance (profitability) of the country's banking system using 12 scenarios based on the profitability response of the banking network to 2%, 5%, and 10% shocks in these variables. To this end, research data was collected from the 1390 SAM matrix of the Parliament Research Center and the 1395 balance sheet data of the Central Bank. Furthermore, for data analysis, the RDCGE model and the MathLab software were used. The results showed that the unofficial exchange rate and crude oil prices have an inverse effect, while the stock market index and the government budget have a direct impact on the profitability of the banking network; If a positive shock of 2%, 5%, and 10% is introduced to the unofficial exchange rate, the profitability of the banking network decreases by a maximum of 1.73%, 2.01%, and 2.57%, respectively. Also, if there is a positive shock of 2%, 5% and 10% to the price of crude oil, the profitability of the banking network will decrease by 1.41%, 1.63% and 2.03%, respectively. In addition, if a positive shock of 2%, 5% and 10% is introduced to the total stock index, the profitability of the banking network will increase by 0.47%, 0.97% and 1.52% respectively. Finally, if a positive shock of 2%, 5% and 10% is introduced to the government budget, the profitability of the banking network will increase by 0.38%, 0.44% and 0.61%, respectively.

Khodadadi et al. [21], in a research, evaluated the effectiveness of indirect monetary policy instruments under fractional reserve banking: DSGE approach. After determining the input values of the model and estimating the parameters using the seasonal time series data of the Iranian economy during the period 1370-1399 (Solar Hijri calendar) using the Bayesian estimation method, the results obtained from the simulation of the model variables indicate the validity of the model in describing the fluctuations of the Iranian economy. Examining the dynamics of the pattern shows that both the momentum to reduce the legal reserve and the repurchase of bonds reduce inflation, but the boom in production from the channel of the increasing coefficient is more than the monetary base. In addition, the final result of reducing the legal reserve on most of the real and financial sector variables is longer and larger than the bond repurchase agreement policy. This issue calls for more attention on how to determine the legal reserve in the country.

Siah Boumi and Izadinia [14], in a research, investigated the effect of low and high quality assets on the profitability of banks (an empirical study of Iranian banks). In this article, the impact of the four classes of bank claims under the title of current class as high-quality assets, past due, deferred and doubtful classes as low-quality assets on the bank's revenues and costs and their components is investigated. The statistical population of this research includes all the banks of the country's banking network and the obtained sample consists of 21 banks. The research period was from 2011 to 2019 (Solar Hijri calendar) and the hypotheses were tested using a multivariate regression model. The research results confirm part of the existing theoretical literature and experts' opinion; In this way, the positive impact of the current class on the total income and the questionable class on the total cost are confirmed, but low quality assets have an unexpected effect on profitability and its components.

Samanipour et al. [33] in a study titled 'The requirements of macroprudential supervision and its impact on the stability of the Iranian banking system' elucidate the requirements of macroprudential supervision using macroeconomic variables such as inflation, exchange rates, gross domestic product growth, profits, shareholder equity, non-current assets, and bank lending facilities. They investigate the stability of the country's banking network using the generalized method of moments (GMM) in a dynamic panel format with data from 99 countries in the time period from 1385 to 1395. The results of the research show that banking stability in the previous period, inflation, the difference in interest rates on deposits and facilities, exchange rates, return on equity, capital-to-facility ratio and the growth rate of the world economy have a positive effect on the stability index. Also, the financial index of the stock exchange, oil price, ratio of liquidity to GDP and non-current claims have a negative effect on banking stability.

Kamminga et al. [17], conducted a study to examine the seizure of frozen assets of the Central Bank of Russia: Is third-party countermeasures allowed? This article argues that it is not possible to rely on state immunity to prevent the freezing or seizure of the foreign central bank's assets through direct executive actions, as freezing the assets of a foreign government as a third-party retaliation to halt a serious breach is permissible. And this confiscation is not admissible as a countermeasure, but may be allowed as a "legal action" to repair damages. Recent changes in Canadian law support such a permissive rule. On the other hand, the controversial actions of the United States to control the assets of the Central Bank of Afghanistan show the need for protection against abuse.

Ely et al. [10], using the system generalized moments estimator model for the years 2000 to 2014 for 45 countries, have investigated the effect of a set of 12 macro-prudential policies on banks' risk-taking. The results of the research show that the tools that aim to investigate the vulnerability caused by the connection and contagion of the financial system, such as limiting inter-bank exposures and asset concentration, have a positive effect on bank stability and reduce banking risk. Tools based on borrowers, such as loan-to-value limits, reduce banking risk through the leverage channel.

Chen and Lu [7], in their study, examined the impact of macroeconomic factors on bank efficiency: evidence from Chinese urban banks. This study uses stochastic frontier analysis to examine the impact of regional disparities on cost and profit efficiency for a sample of urban commercial banks in China from 2005 to 2014. The results show that the bank efficiency of Chinese city commercial banks has a positive correlation with GDP per capita, but it has a negative correlation with the ratio of urban population. But comparing eastern and non-eastern regions, there is a significant difference in the effect of macroeconomic factors on bank efficiency.

Sedaghat Parast et al. [34], in their study investigated bank liquidity and bank performance: looking for a non-linear nexus. The purpose of this research is to analyze the asymmetric effects of holding cash assets by commercial banks on their profitability. In parallel with the careful examination of conflicting theories and empirical evidence, we have developed an econometric model to capture the nonlinear effects of liquidity on performance. The proposed model is tested for a sample of seven Iranian commercial banks during 2006-2018 by Arellano-Bond dynamic panel-data estimation. The results indicated that, if present, the non-linear relationship is not an inverted U as suggested by Bordeleau and Graham [6]. The findings suggest a positive relationship (having more cash assets leads to increased

profitability of Iranian banks) and even an accelerating effect on liquidity, possibly due to the low level of cash assets held by Iranian banks.

3 Model estimation

In order to estimate the asset freezing model using the PVAR method, the following models are used.

$$AF_{i,t} = \alpha_1 + \alpha_2 GDP_{i,t} + \alpha_3 UR_{i,t} + \alpha_4 CPI_{i,t} + \alpha_5 IR_{i,t} \alpha_6 CS_{i,t} + \alpha_7 EGR_{i,t} + \varepsilon_{i,t} \quad (3.1)$$

$$AF_{i,t} = \alpha_1 + \alpha_2 CAR_{i,t} + \alpha_3 SIZE_{i,t} + \alpha_4 ROE_{i,t} + \alpha_5 ROA_{i,t} + \alpha_6 CAPITAL_{i,t} + \alpha_7 LIQUIDITY_{i,t} + \varepsilon_{i,t} \quad (3.2)$$

3.1 The dependent variable

Asset Freezing (AF):

In this research, asset freezing, according to the definition provided by Madanizadeh [28], consists of the following three categories of variables:

1. First category; non-collectible and non-current assets (NPL): including the Rial amount of doubtful receivables, overdue and past-due claims.
2. The second category; Government Debts (PD): The amount of government debt to the central bank in Rials.
3. The third category; non-financial assets (NFA): Riyal value of bank assets that have been converted into real estate, buildings, shares, and companies during the past year.

Also, in order to create a composite index of these three items, the principal component analysis (PCA) method was used. A principal component is a normalized linear combination of the principal predictors in the dataset. It is assumed that there is a set of predictors as $X^1, X^2, ..., X^p$. The basic components of this set of predictors can be written as follows:

$$Z = \Phi^{11} X^1 + \Phi^{21} X^2 + \Phi^{31} X^3 + ... + \Phi^{p1} X^p \quad (3.3)$$

where:

- Z is the principal component.
- Xs are the normalized predictors. The mean of the normalized forecasts is equal to zero and their standard deviation is equal to one.
- (Φ), is the load (weight) of each component.

Therefore, the first principal component is a linear combination of the principal predictors that accounts for most of the variance in the data set. This component determines the most changes in the data. The higher the range of changes in the first component, the more information in this component. No other component can have more variation range than the first fundamental component. The result of calculating the first principal component is the line that is the closest line to the data. In fact, this line minimizes the sum of squared distances between a data point and the line.

3.2 Independent variables

1. Macroeconomic variables
   (a) Gross domestic product (GDP): In this treatise, for this variable, the gross domestic product at the base price of 1390 is used.
   (b) Unemployment rate (UR): The unemployment rate is the ratio of the number of the unemployed population (10 years and older) (seeking work) to the total active population (10 years and older) (employed and unemployed) multiplied by 100.
   (c) Consumer Price Index (CPI): The total price index of consumer goods and services reports changes in the total price index.
   (d) Interest rate (IR): According to the definition of the central bank, it is equal to the average interest rate of bank facilities in different economic sectors.
   (e) Currency strength (CS): It is equal to the annual average currency strength of the market

(f) Economic Growth Rate (EGR): It is equal to the annual average economic growth rate of the country

2. Bank variables
   (a) Capital Adequacy Ratio (CAR):
   The result of dividing the basic capital into the sum of the items above the line and below the line of the balance sheet is based on the weighted risk coefficients in terms of percentage. This ratio was first introduced to the world's banks in 1988 by the Ball Committee. In that year, the Ball Committee proposed a set of minimum capital requirements for banks, which later became known as the Ball Agreement. According to the laws of the Central Bank of the Islamic Republic of Iran, the minimum capital adequacy ratio for Iranian banks is equal to 8%:

$$\text{Capital Adequacy Ratio} = \frac{\text{basic capital}}{\left(\text{Items above the line} \times \text{Risk coefficient}\right) + \left(\text{Items below the line} \times \text{Risk coefficient} \times \text{Conversion coefficient}\right)} \tag{3.4}$$

In the following, we will define the components of the capital adequacy ratio, i.e. basic capital, above-the-line items and below-the-line items:

1. Basic capital
   Basic capital in banks and credit institutions means the sum of the main capital and supplementary capital after deductions.
   The main capital items of banks and credit institutions are:
   - Paid up capital
   - Legal reserve
   - Other reserves, with the exception of the revaluation reserve of fixed capital assets and shares
   - Spending shares
   - The above items are added to the accumulated profit, and if there is an accumulated loss, they are deducted.

   The items constituting the supplementary capital of banks and credit institutions are:
   - Fixed asset revaluation reserve
   - Reserve of public doubtful receivables according to the existing restrictions announced to the banks
   - Stock revaluation reserve according to the limits announced to banks.

   Deductions related to the calculation of the basic capital
   - Investing in banks and credit institutions that are not integrated with a central bank or financial institution.
   - Investing in some banks and financial institutions at the discretion of the central bank.
   - The difference between the items below the balance sheet and the items above the balance sheet
   - The difference between the items below the balance sheet line and the items above the balance sheet line in calculating the capital adequacy ratio lies in the fact that the items below the balance sheet line are not only subject to risk-weighted coefficients for different asset classes, as will be mentioned later, but they are also subject to conversion coefficients. These conversion coefficients are necessary for harmonizing the items below the balance sheet line with the items above the balance sheet line.

2. Bank size (SIZE):
   The natural logarithm expresses the valuation of the bank's total assets at the end of the financial year [16].

$$Size = \ln(TA) \tag{3.5}$$

   $Size$: The size of the bank
   ln: natural logarithm
   TA: book value of bank assets
3. Return on Equity (ROE):
   It means dividing net profit by equity.

$$ROE = \frac{\text{net income}}{\text{shareholders equity}} \tag{3.6}$$

   ROE: return of assets of bank i in period t
   net income: net profit
   shareholders equity

4. Return on Assets
   It is the ratio of net profit to total assets of the bank at the end of the financial year.

$$ROA = \frac{NOPAT}{TA} \tag{3.7}$$

   ROA: return on bank assets, $NOPAT$: Operating profit after tax, TA: book value of bank assets.
5. Bank capital: the ratio of shareholders' equity to total assets.
6. Liquidity: the ratio of liquid assets to total assets.

The statistical population of the study includes all the banks listed on the Tehran Stock Exchange. Using systematic elimination method, the number of samples examined in the current study is equal to 132 years/bank, including banks like Eghtesad Novin Bank, Parsian Bank, Pasargad Bank, Karafarin Bank, Saman Bank, Sina Bank, Sarmayeh Bank, Dey Bank, Saderat Bank, Melli Bank, Tejarat Bank, and Iran Zamin Bank. At first, asset freezing was extracted using principal component analysis (PCA). To derive the composite index of asset freezing, three criteria, non-collectible and non-current claims (NPL), government debts (PD) and non-financial assets (NFA) have been used.

Table 1: Correlation matrix of property freezing measures

	NPL	**PD**	**NFA**
NPL	1.000000		
PD	0.697236	1.000000	
NFA	−0.753946	−0.964734	1.000000

The above table shows that there is a relatively high correlation between the aforementioned criteria. As a result, by reducing the dimensions of the variables, the asset freezing index is extracted from the principal component analysis method.

Table 2 shows that the eigenvalue of the first component is greater than one and approximately 87% of the dispersion of the data set is explained by this component, so this component is the best choice in this index.

Table 2: The result of estimating the combined asset freezing index model by PCA method

Eigenvalues: (Sum = 3, Average = 1)					
				Cumulative	**Cumulative**
Number	**Value**	**Difference**	**Proportion**	**Value**	**Proportion**
1	2.616408	2.264288	2.264288	2.616408	0.8721
2	0.352120	0.320648	0.1174	2.968528	0.9895
3	0.031472	–	0.0105	3.000000	1.0000
Eigenvectors (loadings)					
Variable	**PC 1**	**PC 2**	**PC 3**	**Variable**	**PC 1**
NPL	0.536081	0.838909	0.094067	NPL	0.536081
PD	0.590998	−0.452538	0.667780	PD	0.590998
NFA	−0.602776	0.302391	0.738391	NFA	−0.602776

The relationship between the observed variables and the basic components can be written as follows using Factor Loading:

$$\begin{aligned} NPL &= 0.53PC1 + 0.83PC2 + 0.09PC3 \\ PD &= 0.59PC1 - 0.45PC2 + 0.66PC3 \\ NFA &= -0.60PC1 + 0.30PC2 + 0.73PC3 \end{aligned}$$

And also, an estimate of basic components using Factor Score can be written as follows:

$$PC1 = 0.53NPL + 0.59PD - 0.60NFA$$

It can be said that the linear composition of the first component of PC1 for asset freezing index is as above.

Finally, using the Make Principal Component Analysis command, the combined variables related to asset freezing are extracted and used in the final research model estimated using the combined data model.

In this article, to estimate the model using the panel-var method, first, the optimal interval of the model is examined. Determining the optimal number of breaks in the VAR model is very important. Based on this, in this

study, Akaike information criterion (AIC), Hannan-Quinn information criterion (HQ), Schwarz information criterion (SC) and Finite prediction error (FPE) statistics were used to determine the optimal number of breaks for the self-explanatory model. In order to determine the optimal number of breaks in the self-explanatory model, the Schwartz Bayesian criterion is more valid. The results of the above criteria for research regressions are given in the table below.

Table 3: Determining the optimal interval length of the regression model of the first model (macroeconomic variables)

VAR Lag Order Selection Criteria **Endogenous variables: AF GDP UR CPI IR CS EGR**						
Lag interval	**LogL statistics**	**LR Maximum truthfulness**	**FPE Final prediction error**	**AIC Akaike**	**SC Schwartz Bayesian**	**HQ Hannan-Quinn**
0	449.4176	NA	6.28e-14	−10.53375	−10.33118	−10.45232
1	609.3258	59.35577*	$2.06e-15$*	−14.17442*	−11.55388*	−12.72298*
2	685.7201	125.5050	2.40e-15	−13.82667	−10.78815	−12.60521
3	730.7785	66.51479	2.80e-15	−13.73282	−9.276324	−11.94135
4	797.4263	87.27692	2.07E-15	−14.15301	−8.278534	−11.79152
∗ indicates lag order selected by the criterion ∗ indicates the optimal interval						

Table 4: Determining the optimal interval length of the regression model of the second model (banking variables)

VAR Lag Order Selection Criteria **Endogenous variables: AF CAR SIZE ROE ROA CAPITAL LIQUIDITY**						
Lag interval	**LogL statistics**	**LR Maximum truthfulness**	**FPE Final prediction error**	**AIC Akaike**	**SC Schwartz Bayesian**	**HQ Hannan-Quinn**
0	471.8897	NA	3.68e-14	−11.06880	−10.86624	−10.98737
1	620.2828	268.5207*	$3.46e-15$*	−13.43530*	−11.81476*	−12.78386*
2	659.3129	64.12097	4.49e-15	−13.19793	−10.15941	−11.97647
3	696.1754	54.41606	6.37e-15	−12.90894	−8.452441	−11.11746
4	741.0848	58.80989	7.92e-15	−12.81154	−6.937069	−10.45005
∗ indicates lag order selected by the criterion ∗ indicates the optimal interval						

Based on the results presented in the table above, in accordance with all criteria, the optimal interval duration is approved for the research models. In this study, to estimate the long-term relationship in the pattern, an explanation of the optimal interval duration will be used. Furthermore, the reliability and co-integration among the variables of the research patterns have been examined, and the results indicate the presence of a long-term equilibrium relationship between the variables of both models. (The results table is attached).

3.3 The estimation results of the first model (macroeconomic variables)

After determining the optimal interval and performing a diagnostic test and ensuring the existence of a long-term relationship between model variables, the model is estimated using the panel-var method, the result of which is given in the table below.

Table 5: The result of estimating the model using the panel-var method (macroeconomic variables model)

The explanatory variables	**Answer variable: asset freeze**		
	Impact coefficient	standard deviation	Test statistics
GDP	−12.8321	2.65392	−4.83515
UR	−0.499923	0.10341	−4.83438
CPI	0.151499	0.03576	4.23655
IR	0.15391	0.03017	5.101492
CS	−0.554525	0.09358	−5.92568
EGR	−0.687146	0.16921	−4.06091

To calculate the significance statistic or the t-test statistic, the partial regression coefficient is divided by the standard deviation of the variable. If this calculated value is in the range of -1.96 to 1.96, it shows that the initial hypothesis of the t test, which is the lack of significance of the variable, is confirmed, and otherwise, the opposite hypothesis is confirmed and thus has a significant effect.

According to the results of the PVAR model for the variable "asset freeze," it can be stated that the variable "gross domestic product" has a coefficient of (-12.8321), with a negative coefficient sign indicating a negative impact of this

variable on asset freeze. Considering the t-test statistic for this variable, which is equal to (-4.83515) and falls within the critical region, it can be concluded that the gross domestic product variable has a significant negative effect on asset freeze at a 95% confidence level.

According to the result of the PVAR model for the asset freezing response variable, it can be stated that the unemployment rate variable has a coefficient of (-0.49923) and the negative sign of the coefficient indicates the negative impact of this variable on the asset freezing and according to the t test statistic for this variable that is equal to (-4.83438) and this statistic is in the critical area, as a result, it can be stated that the unemployment rate variable has a negative and significant effect on asset freezing at the 95% confidence level.

According to the results of the PVAR model for the variable "asset freeze," it can be stated that the consumer price index variable has a coefficient of (0.151499), which is a positive coefficient indicating a direct effect of this variable on asset freeze. Considering the t-test statistic for this variable, which is equal to (4.23655) and falls within the critical region, it can be concluded that the consumer price index variable has a significant and positive impact on asset freeze at a 95% confidence level.

According to the result of the PVAR model for the asset freezing response variable, it can be stated that the interest rate variable has a coefficient of (0.15391), which is a positive sign of the direct effect of this variable on the asset freezing, and according to the t test statistic for this variable, which is equal to with (5.101492) and this statistic is in the critical area, as a result, it can be stated that the interest rate variable has a positive and significant effect on asset freezing at the 95% confidence level.

According to the result of the PVAR model for the response variable of asset freezing, it can be stated that the exchange rate variable has a coefficient of (-0.554525), which is the negative sign of the coefficient of expression of the negative effect of this variable on asset freezing, and according to the t test statistic for this variable that is equal to (-5.92568) and this statistic is in the critical area, as a result, it can be stated that the exchange rate variable has a negative and significant effect on asset freezing at the 95% confidence level.

According to the result of the PVAR model for the asset freezing response variable, it can be stated that the economic growth rate variable has a coefficient of (-6.87146) and the negative sign of the coefficient is the negative effect of this variable on the asset freezing and according to the t test statistic for this variable which is equal to (-4.06091) and this statistic is in the critical area, as a result, it can be stated that the economic growth rate variable has a negative and significant effect on asset freezing at the 95% confidence level.

3.4 Dynamic analysis of the model

IMPULSE RESPONSE function

In this test, it is checked that if a shock or a sudden change as much as a deviation is introduced on macroeconomic variables, what will be its effect on the freezing of the bank's assets and how will the response to the shock be from the area of asset freezing.

As can be seen from the above graph, the reaction of the explanatory variables on the freezing of selected banks' assets is shown.

- According to the obtained results, if a shock equivalent to one standard deviation is introduced into the gross domestic product, the response to the shock in terms of asset freeze is such that it decreases for up to two periods and then gradually diminishes over time until the shock dissipates.
- In relation to the unemployment rate variable, based on the results of sudden shock tests, it can be inferred that if a shock equivalent to one standard deviation is introduced to the unemployment rate, it leads to an upward trend in asset freeze. This increase continues for up to two periods, and then the shock becomes transitory and fades away.
- According to the IMPULSE RESPONSE results for the consumer price index and interest rate variables, it can be stated that if a shock equivalent to one standard deviation is introduced to the consumer price index and interest rate, the response to the shock in terms of asset freeze for selected banks is transitory. The incoming shock from these variables cannot lead to significant changes in the asset freeze of banks, and these shocks are somewhat neutral in their effect.
- Regarding the exchange rate variable, it can be stated as follows: according to the results of sudden shock tests, if a shock is introduced to the exchange rate variable, the response to the shock in terms of asset freeze decreases for up to two periods, and then the shock becomes transitory and stabilizes.

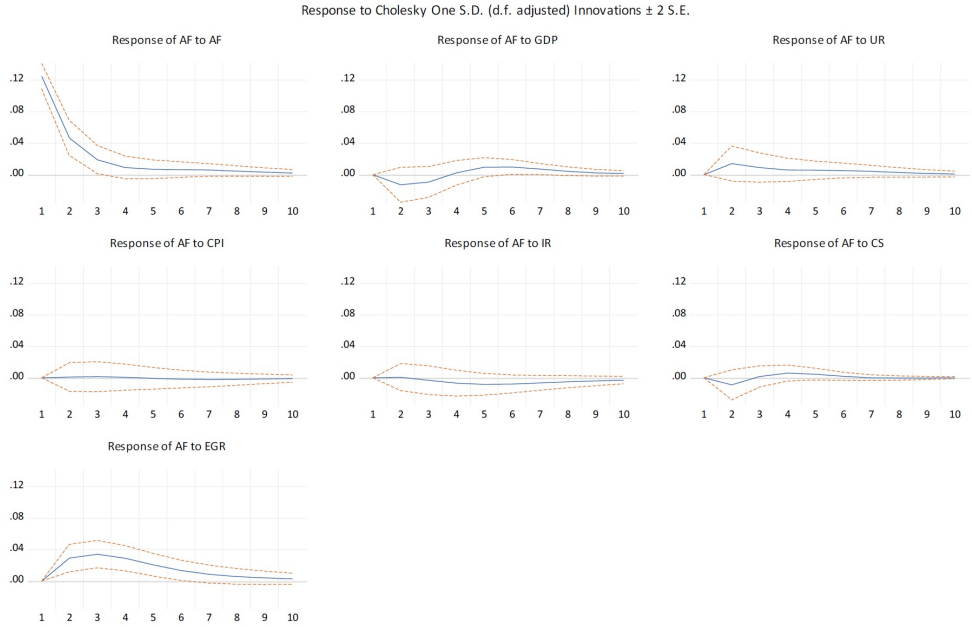

Figure 1: Reaction function of sudden shocks

- Finally, in relation to the interpretation of the shock on economic growth, it can be stated that if a shock equivalent to one standard deviation is introduced to economic growth, the response to the shock in terms of asset freeze for selected banks is initially increasing for up to three periods. Afterward, it starts to decrease and by the sixth period, the shock loses its effect and becomes transitory and neutral.

Analysis of variance

The following table shows the analysis of variance for the asset freezing variable of selected banks. Variance analyzes are defined in such a way that in the first period (short term), usually the fluctuations of each variable are explained by the impulses related to that variable itself. But in more distant time horizons, the contribution of other variables in predicting the behavior of a variable increases according to their importance.

Table 6: Analyzing the variance of asset freezing in the model of macroeconomic variables

Variance Decomposition of AF								
Period	**S.E.**	**AF**	**GDP**	**UR**	**CPI**	**IR**	**CS**	**EGR**
1	0.122555	100.0000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2	0.135658	86.15165	0.902016	0.190680	7.124915	2.209252	2.209252	3.234368
3	0.145071	75.87656	2.568069	0.410472	6.340933	2.012389	2.304616	10.48696
4	0.150278	71.11326	3.539687	0.714286	5.910121	5.567470	2.379886	10.77529
5	0.152801	69.36170	4.952186	0.930204	5.958113	5.521355	2.788965	10.48747
6	0.160096	65.88805	4.727159	1.082943	6.543685	7.558090	3.112904	11.08717
7	0.165616	64.13509	5.658365	1.039298	7.978536	7.330354	2.954912	10.90344
8	0.170756	62.59974	6.484178	1.085498	8.984331	7.501175	3.021565	10.32351
9	0.173556	60.89751	7.859280	1.066660	8.967529	7.291636	2.989291	10.92809
10	0.176398	60.54471	8.638952	1.187341	8.724607	7.105859	3.195376	10.60316

In this section, based on the estimated model, a variance analysis of the model variables has been performed, and the results can be observed in Table 6. In this table, the S.E column shows the prediction error of the relevant variables during different periods. Since this error is calculated every year based on the previous year's error and the source of this error is the change in current values and future impulses, it increases over time. The results of the table show that the prediction error in the first period for the selected banks was 0.12255 and in the second period it was 0.135658 and it increased over time. The next columns show the percentage of variance caused by a specific sudden change or impulse.

The second column indicates that, although in the first period, 100% of the changes in asset freeze were due to the variable itself, in the second period, 86.15% of the changes were attributable to the variable itself. However, in

the third period, 75.87% of the changes in this index are attributed to the variable itself, 2.56% to the gross domestic product shock, 6.34% to the consumer price index shock, and 10.48% to the exchange rate shock. Other variables have a negligible effect on explaining the asset freeze of selected banks in the third period.

However, in the tenth period, which is the long term, the explanatory power of variables in the variance analysis of the asset freeze variable has increased as follows: 8.63% of the fluctuations in asset freeze are attributed to gross domestic product, 87.2% to the consumer price index, 7.10% to the interest rate, and 10.60% to economic growth rate. This indicates that in the long term, the explanatory power of the economic growth rate is higher than that of other variables, and the lowest explanatory power of asset freeze fluctuations in the long term is related to the unemployment rate.

Finally, to ensure the stability of the model, the stability of the regression model has been investigated using the circle unit root test method, and the result of this test is attached.

3.5 The estimation results of the second model (banking variables)

In the second model, where bank variables affect asset freezing, after determining the optimal interval and performing a diagnostic test and ensuring the existence of a long-term relationship between the variables of the regression models, the model is estimated using the panel-var method, the result of which is shown in the table below.

Table 7: The result of estimation of the model with the panel-var method of the second model (banking variables)

The explanatory variables	**Answer variable: asset freeze**		
	Impact coefficient	standard deviation	Test statistics
CAR	−3.13183	0.53058	−5.90265
SIZE	−2.133603	0.33166	−6.4331
ROE	−2.49068	0.39216	−6.35118
ROA	−0.278063	0.07685	−3.61826
CAPITAL	−0.255534	0.07395	−3.4555
LIQUIDITY	−1.550174	0.25257	−6.1376

According to the results of the PVAR model for the asset freeze variable, it can be stated that the capital adequacy variable has a coefficient of (-13.13183), which is a negative coefficient indicating a negative impact of this variable on asset freeze. Considering the t-test statistic for this variable, which is equal to (-5.90265) and falls within the critical region, it can be concluded that the capital adequacy variable has a significant and negative impact on asset freeze at a 95% confidence level.

According to the results of the PVAR model for the asset freeze variable, it can be stated that the bank size variable has a coefficient of (-2.1333603), which is a negative coefficient indicating a negative impact of this variable on asset freeze. Considering the t-test statistic for this variable, which is equal to (-6.4331) and falls within the critical region, it can be concluded that the bank size variable has a significant and negative impact on asset freeze at a 95% confidence level.

According to the results of the PVAR model for the asset freeze variable, it can be stated that the variable "return on equity of shareholders" has a coefficient of (-2.49068), which is a negative coefficient indicating a negative impact of this variable on asset freeze. Considering the t-test statistic for this variable, which is equal to (-6.35118) and falls within the critical region, it can be concluded that the "return on equity of shareholders" variable has a significant and negative impact on asset freeze at a 95% confidence level.

According to the results of the PVAR model for the asset freeze variable, it can be stated that the "asset return" variable has a coefficient of (-0.278063), which is a negative coefficient indicating a negative impact of this variable on asset freeze. Considering the t-test statistic for this variable, which is equal to -3.61826 and falls within the critical region, it can be concluded that the "asset return" variable has a significant and negative impact on asset freeze at a 95% confidence level.

According to the results of the PVAR model for the asset freeze variable, it can be stated that the "bank capital" variable has a coefficient of (-2.55534), which is a negative coefficient indicating a negative impact of this variable on asset freeze. Considering the t-test statistic for this variable, which is equal to -3.4555 and falls within the critical region, it can be concluded that the "bank capital" variable has a significant and negative impact on asset freeze at a 95% confidence level.

According to the results of the PVAR model for the asset freeze variable, it can be stated that the "liquidity level" variable has a coefficient of (-1.550174), which is a negative coefficient indicating a negative impact of this variable

on asset freeze. Considering the t-test statistic for this variable, which is equal to -6.1376 and falls within the critical region, it can be concluded that the "liquidity level" variable has a significant and negative impact on asset freeze at a 95% confidence level.

IMPULSE RESPONSE function

The result of the sudden shocks test for the asset freezing model in the banking variables model is as follows.

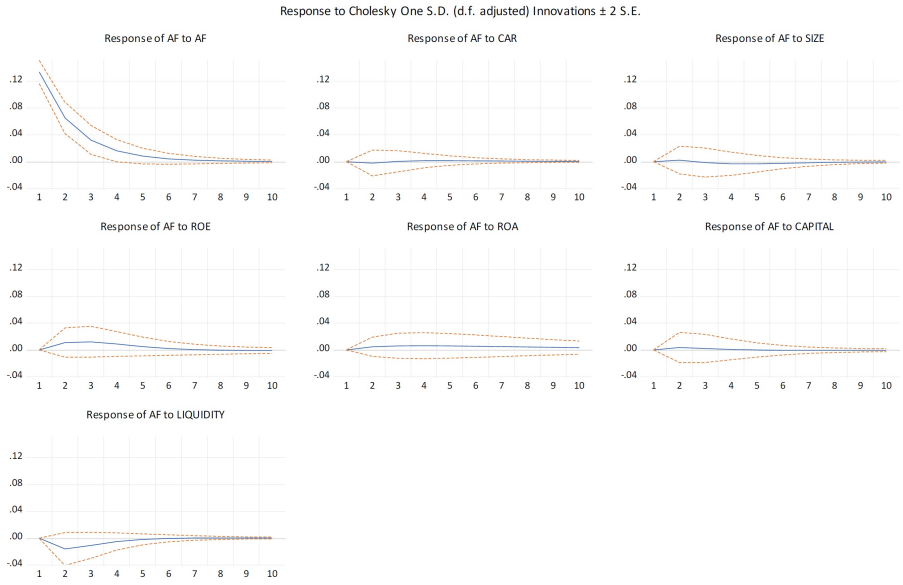

Figure 2: Reaction function of sudden shocks

As can be seen from the above graph, the reaction of the explanatory variables on the freezing of selected banks' assets is shown.

- According to the obtained results, if a shock equivalent to one standard deviation is introduced to the return on equity of shareholders, the response to the shock in terms of asset freeze increases for up to two periods, and then gradually diminishes over time until the shock dissipates.
- In relation to the asset return variable, according to the results of sudden shock tests, it can be inferred that if a shock equivalent to one standard deviation is introduced to asset returns, it leads to an upward trend in asset freeze. This increase continues for up to one period, and then the shock becomes transitory and fades away.
- According to the results of the IMPULSE RESPONSE for the variables of capital adequacy, bank size, and liquidity level, it can be stated that if a shock equivalent to one standard deviation is introduced to these variables, the response to the shock in terms of asset freeze for selected banks is transitory. The incoming shock from these variables cannot lead to significant changes in the asset freeze of banks, and these shocks are somewhat neutral in their effect.
- Regarding the liquidity level variable, it can be stated as follows: according to the results of sudden shock tests, if a shock is introduced to the liquidity level variable, the response to the shock in terms of asset freeze decreases for up to two periods, and then the shock becomes transitory and stabilizes.

Analysis of variance

The result of the analysis of variance for the asset freezing variable in the banking variable model is shown in the following table.

In this part, according to the estimated pattern, the variance analysis of the model variables has been done, the results of which can be seen in Table 8. In this table, the S.E column shows the prediction error of the relevant variables during different periods. Since this error is calculated annually based on the error from the previous year, and its source is the changes in current values and future shocks, it increases over time. The results in the table indicate that the prediction error in the first period for selected banks was 0.126266, and in the second period, it was

Table 8: Analyzing the variance of asset freezing in the model of macroeconomic variables

Variance Decomposition of AF								
Period	**S.E.**	**AF**	**CAR**	**SIZE**	**ROE**	**ROA**	**CAPITAL**	**LIQUIDITY**
1	0.126266	100.0000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2	0.140369	85.65366	2.117538	0.030936	3.160711	6.725413	0.138458	2.173287
3	0.152375	73.76210	7.954335	0.075240	9.278157	6.580133	0.428652	1.921383
4	0.161496	65.90971	9.030775	0.114040	15.16722	6.128291	1.920730	1.729233
5	0.169280	60.68471	8.733779	0.985510	19.14456	6.905931	1.955964	1.589554
6	0.178193	54.89478	7.981269	4.091781	21.16511	7.111792	2.365324	2.389941
7	0.184917	51.52631	8.101417	5.733078	21.02146	7.996488	2.379052	3.242190
8	0.189005	49.55693	8.254934	5.968796	20.80803	9.542075	2.354864	3.514372
9	0.192506	48.65889	8.219892	6.199267	20.14968	10.94238	2.302534	3.527346
10	0.195818	47.50175	8.149027	6.074669	19.88800	12.21608	2.374326	3.796146

0.140369, and it has increased over time. The next columns show the percentage of variance attributed to sudden changes or shocks.

The second column shows that although in the first period, 100% of the changes in asset freeze were due to the variable itself, in the second period, 85.65% of the changes were attributable to the variable itself. However, in the third period, 73.76% of the changes in this index are attributed to the variable itself, 7.95% to the capital adequacy shock, 9.27% to the return on equity shock, and 6.58% to the asset return shock. Other variables have a negligible effect on explaining the asset freeze of selected banks in the third period.

However, in the tenth period, which is the long term, the explanatory power of variables in the variance decomposition of the asset freeze variable has increased as follows: 8.14% of the fluctuations in asset freeze are attributed to capital adequacy, 6.07% to bank size, 19.8% to return on equity, and 12.21% to asset return. This indicates that in the long term, the explanatory power of return on equity is higher than that of other variables, and the lowest explanatory power of asset freeze fluctuations in the long term is related to bank capital.

4 Conclusion and recommendations

The freezing of assets of the banking system is affected by three categories and its volume is increasing every day. The first category is non-collectible and non-current assets, the second category is government debt, bank arrears, and the third category is non-financial assets (property) of the bank that have been converted into estate, buildings, etc. over the past years. Also, high levels of asset freezes are a sign of banking crises. In fact, the share of frozen assets is considered as an indicator of credit risk, and macroeconomic and bank conditions play a key role in their dynamics. In fact, as the literature has well shown (such as: [9, 13]), there is a vicious circle between the real economy and the factors that create frozen assets. On the one hand (from the real economy to frozen assets), lower output leads to a decrease in income and thus a decrease in the ability to repay debt. On the other hand (from frozen assets to the real economy), it will affect the financing channel. For example, increasing uncertainty about bank capital (access to financial matters) will increase the required risk-taking and this will increase the interest rate. This can lead to a credit crisis.

Comparing the results of other studies with the present study, Chen and Lu [7] showed that the efficiency of commercial banks in China has a positive correlation with GDP per capita, but it has a negative correlation with the ratio of urban population. However, in comparing the eastern and non-eastern regions, there is a significant difference in the impact of macroeconomic factors on bank efficiency. Consistent with this study and Samanipour et al. [33], the results indicate that the stability of the previous period, inflation, the difference in deposit and lending interest rates, exchange rates, return on equity, the capital-to-loan ratio, and the global economic growth rate have a positive effect on the stability index. Furthermore, the stock market's financial index, oil prices, the liquidity-to-GDP ratio, and non-current liabilities have a negative effect on banking stability.

Therefore, the positive correlation between economic conditions will worsen the frozen asset level, acting simultaneously on three other financial agents: banks, households, and firms. The results of this research are in complete agreement with such dynamic relationship between economic and internal bank conditions with asset freezing. This research has also provided evidence of the relationship between frozen assets and macroeconomics. Therefore, the use of meta-heuristic models in better understanding the aforementioned factors can prevent the increase in credit risk caused by frozen assets and thus reduce the negative feedback between Iran's banking sector and the macro economy.

The research results indicate that despite the costs incurred by banks for reserving doubtful and overdue claims, these claims in the past-due and overdue categories have a positive impact on bank income. In other words, the transfer

of some current claims to past-due and overdue categories will not be a cause for concern at a high level. Because, on one hand, the income generated for these categories will cover the incurred costs, and on the other hand, if the bank's credit policy is based on only providing facilities that fall into the current category, it must overlook to not disbursing a significant number of its facilities that will ultimately be recovered. This implies losing a significant share of its income and market share. According to the research results, the only category that incurs costs and has no positive impact on income is the category of doubtful claims. However, it should be noted that the doubtful claims category also results from lending operations, and the complete removal of this category leads to the elimination of the repayment of loans that will ultimately be recovered. Therefore, the doubtful claims category will only be costly if it is written off and not recovered. If it is possible to identify and set aside loans that are granted through misrepresentation and with the intention of non-repayment, the impact of the remaining facilities in the doubtful claims category is more significant due to their return to other categories or full recovery, leading to higher income. Therefore, it is recommended that bank management should aim to maintain and improve capital adequacy ratios and bank risk while paying as much as possible in loans and facilities that will ultimately be recovered. Even if they enter the overdue and past-due category or even enter the doubtful claims category. because they will generate income for the bank; Therefore, it is suggested that the focus of bank credit managers should be on the facilities that will be bad debts in the end. Finally, it can be said that even though bank delinquencies are not entirely "white", they should not be viewed as entirely "black" either. The management of bank delinquencies should be approached similarly to the management of receivables, as it can lead to profitability for the bank and wealth creation for its shareholders.

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