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Original Research Article

The Resilience of the Iranian Banking System to Macro Shocks with an Emphasis on Credit Risk

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In this paper, we present the macro stress test with a credit risk approach for banking system of Iran during the period 2004Q1-2019Q4. The goal is to evaluate the vulnerability of the banking system through credit risk to the country economic shocks. In this regard, the developed method of Wilson (1997) Credit Portfolio View model including macroeconomic variables and default rate has been used. The results of the applied analysis show that the nominal exchange rate has a significant and positive effect on default rate or credit risk and the variables of the inflation rate, economic growth, loan growth, and liquidity rate have a less negative effect and considering that the economic recession during the studied period, the unemployment rate has had the most positive and destructive effect on the credit risk. Using Mont Carlo simulation and calculating the risk value and expected losses for each of the economic variables, the capital required by banks to cover losses is obtained. The results of the credit risk stress test show that an adverse scenario due to nominal exchange rate shock with a standard deviation has the greatest impact on the amount of capital required to cover unexpected losses compared to the baseline scenario and banks need less capital to cover their losses. But to cover the losses caused by the shocks of other variables, it is necessary to increase their capital. In general, according to the obtained results from the simulation and checking the distribution of credit losses, the banking system except for the nominal exchange rate variable is not resilient to cover losses due to shocks from other variables.

Keywords: Macro Stress Test, Loss Distribution, Credit Risk, Vector Auto Regression.
JEL Classification*:* C53, G28, G21, M41

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1 Introduction

Financial stability refers to the stability of financial markets and the payment system against shocks and crises. Today, the banking industry has faced challenges due to changes in financial operations in theory and practice, which has led to an increase in credit risk. Due to its high share in the financing of various economic sectors, the banking industry faces various risks, including credit risk. Therefore, the stability of the financial system is achieved when it is governed by standard risk management. One of the important tools of risk, both at the micro and macro levels, is the stress test for measuring risk (Nili et al. 2012).

In Iran, considering that the banking system as the largest financial provider of various economic sectors are affected by economic policies, any shock in macroeconomic and financial variables can affect the real sector of the economy and financial risks including risk Increase credit. Therefore, evaluating the resistance and resilience of the banking system against changes in adverse economic conditions is of particular importance to determine the amount of economic capital required to cover unexpected losses (Heidari and Sabrian, 2013).

Since default probability is the first step in assessing credit risk, the basis of this paper focuses on simulating default probability in future periods as a variable for determining expected and unexpected losses and the capital required to cover losses in critical situations. Been considered and the basis of Wilson (1997), Boss (2002), and Virolainen (2004) model is the default rate as a dependent and influential variable in calculating the credit loss distribution. The probabilities of default under the baseline and stress scenarios are simulated over a one-year time horizon and then the credit loss distribution values are calculated based on it.

In definition, stress testing refers to a variety of techniques used to assess the vulnerability and resilience of a banking portfolio against "exceptional but acceptable" macroeconomic shocks. According to the Basel Committee on Banking Supervision, to assess vulnerability, the adverse shock used in the stress test must be "extreme and exceptional" but "acceptable" (Moshiri, & Abdoshah, 2017). Stress testing was an important and vital part of the Financial Sector Assessment Program (FSAP) developed by the International Monetary Fund and the World Bank in the 1990s, and is an integral part of policymakers' decision-making tools in the area of financial stability and banking supervision. The purpose of macro stress testing is to help the supervisory body define the sensitivity of the system to stressed events which

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might lead to the system break-down (Basurto, 2006). The stress testing process involves several stages, as shown in Figure 1.

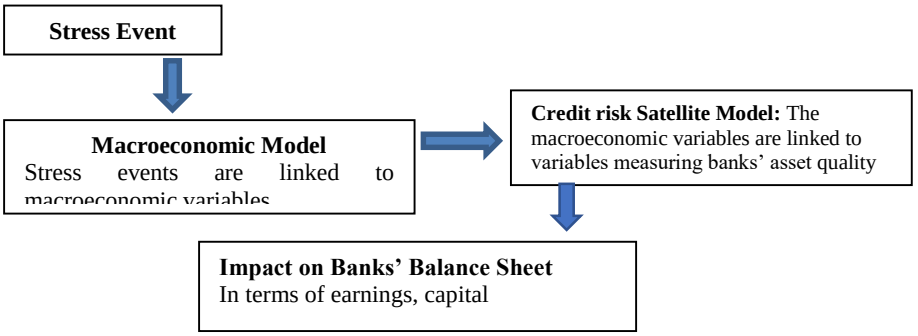

Figure 1. Macrostress test process.
Source: Cihak (2007)

First stage - evaluation and identification of an event from exogenous factors. These events may be under the pressure of a shock that will affect the macro economy of the country, which is big enough and possible. The effect of this scenario under pressure on macroeconomic conditions and variables is measured and calculated with structural evaluative economics model, vector autoregression method, and/or pure statistical analysis (Foglia, 2008). The next step is to model the relationship between credit (default rate) and other macroeconomic and financial variables derived in step 1. The third step (last step) is to evaluate the effects on the bank's loan portfolio and evaluate the capacity of the bank against stressful events. This means that the loss of the bank should be compared with the appropriate benchmark. In this study, by assessing the impact of macroeconomic shocks on the default rate of the Iranian banking system during the period 2004:1-2019:3 and seasonally, based on Wilson (1997), Boss (2002), and Virolainen (2004) model and using technique of VAR[1] and Monte Carlo simulation, the macro stress test is performed. The basis of different scenarios was examined for the degree of

[1] Vector Auto-Regression

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resilience of banks against those shocks. Based on this method, the amount of expected and unexpected losses of the banking system is calculated and the measure of economic capital required to cover the losses is obtained. The purpose of this study is to use a stress test to assess the resilience of the Iranian banking system against macroeconomic shocks with emphasis on credit risk and whether the banking system is resilient to these stresses or not, and how much capital is needed to cover the losses incurred.

The required capital of the bank is divided into first and second-degree sections. Tier 1 capital includes shareholders' cash inflows plus accumulated profits, and Tier 2 capital and reserves include legal and capital reserves.

Relatively many theoretical and empirical studies have been conducted in developed countries on the macro stress test of the banking system, but in Iran, this test has not received enough attention in practice. This article has two innovations compared to previous work: First, in addition. This article has two innovations compared to the previous work: first, in addition to macroeconomic variables, the financial variable, ie the variable of loans paid by the banking system, has also been used, and second, the resilience of the banking system against macroeconomic shocks has been examined and analyzed quarterly.

The structure of this article is as follows: after the introduction, the literature review is reviewed, the third part is dedicated to research methodology and data, the fourth part is dedicated to estimating the model and results of the macro stress test, and the fifth part is dedicated to concluding.

2 Literature Review

Recently, macroeconomic variables are used as a model for the stress testing method. The macroeconomic stress test method was introduced by Wilson (1997a; 1997b) to evaluate the resilience of the financial system against macroeconomic shocks. Wilson, based on its studies (CPV)[1], introduced its model for measuring systematic risk, in which the defamation rates link the various parts of the economy to macroeconomic variables. Wilson 1997 In order to develop models that measure systematic risk, using business cycle theory, introduces a model that derives from four facts (Vaez et al. 2012): 1. Diversification helps reduce uncertainty about losses. 2. By diversifying and creating a diversified asset portfolio, not all portfolio risks can be eliminated. 3. The systematic risk of the portfolio depends largely on the health of the macroeconomy, as the default rate is expected to increase in times of crisis. 4.

[1] Credit Portfolio View

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Different sectors of the economy react differently to macro shocks. In fact, when the economy is booming, better credit conditions and default rates on financial institutions decrease, and when the economy is in recession, the default rate increases. In fact, the credit cycle (default rate) depends on the business cycle, and this model provides a way that a significant relationship can be established between macroeconomic variables and the default rate. In fact, the study framework of this paper is based on the Wilson model and the results of the relationship between macroeconomic variables and the default rate are largely consistent.

After Wilson's studies, many researchers used this model to evaluate the relationship between default rates and macroeconomic variables in different countries. In addition to Wilson's approach, Merton's (1974) approach has also been developed and used in many studies. This approach is based on the Black-Scholes pricing theory. Merton's approach models the effect of macroeconomic changes on stock prices and then relates these changes to default probabilities. In this model, the default process of the company is determined by the value of its assets, and therefore the risk of default is associated with changes in the value of the company's assets and the difference between the value of assets and the value of liabilities. Accordingly, default occurs when the market value of a company's assets is less than the value of its liabilities. Merton's method has been developed by many researchers in different countries.

Kalirai and Scheicher (2002) build a credit risk model for Australia using 9 selected variables between 1990 and 2001. A credit loss simulation and stress test are implemented for the Australian Banking System. They found acceptable levels of capital ratios when compared to the current level of capital ratio rates.

Boss (2002) studies a model including the default rates of the Australian economy between 1965 and 2001. A Credit Portfolio View (CPV) model is used to define the default rates by selecting 8 macroeconomic variables which are chosen among 31 different variables. In this model, the probability of default is modeled as a function of macroeconomic variables, and then using simulation, a path of the probability of default in the future is obtained to determine the distribution of losses. Simulation of credit losses and stress test have been emphasized and used in this model, and finally it comes to the conclusion that the Australian banking system has a higher risk endurance capacity than the required ratios.

Virolainen (2004) build a macroeconomic credit risk model to determine the default rates of Finland’s corporate sector between 1986 and 2003. Based on

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this, the obtained default rates are modeled using the logistic function of the apparently unrelated regression model (SURE), which was used to determine the effect of macroeconomic variables on default rates. There is a significant relationship between default rates and important macroeconomic variables such as GDP, interest rates and corporate debt. The obtained model aims to show the effect of credit conditions of companies on some macroeconomic variables. In addition, the intended study included examples of macroeconomic stress test modeling, such as analyzing the effect of negative and adverse macroeconomic shocks on the credit risk of the Finnish banking sector. The findings of the research show that the credit risks of the corporate sector are quite limited in the current macroeconomic conditions.

Hoggarth and Whiteley (2003) presented another method using the VAR technique to measure the resilience of the UK banking system to adverse macroeconomic shocks. In this research, the effects of some macroeconomic shocks on the losses of the banking system have been investigated. The ratio of non-performing loans to total loans is used to measure the vulnerability of banks. The results indicate a significant relationship between the ratio of non-performing loans and the output gap, and adverse macroeconomic shocks increase the ratio of non-performing loans.

Wong et al. (2006) modeled macroeconomic stress testing under the framework of credit loss and adverse macroeconomic shocks using quarterly data from the Hong Kong banking system during 1994-2006. The shocks of this research are used in the analysis similar to the situation of the Asian Financial Crisis in 1997. The framework is such that first an experimental model with a system of credit risk equations and macroeconomic variables is considered. Then, using Monte Carlo simulation, the distribution of default rates (as a representative of the loss due to lending) is obtained. The estimated model for Hong Kong banks shows there is a significant relationship between the default rate and important macroeconomic variables. The results show that if the GDP growth and asset prices decrease and the interest rate increases, the default rate of bank loans will increase. It has been found that even in the worst case scenario, the banking system continues to be profitable and credit risk is normal at various levels.

Jakubik and Schmieder (2008) developed an extended credit risk model comparing the German and Czech economies. This study included Czech data between 1998-2006 and German data between 1994-2006. The analysis of this research is done at both sectoral and individual levels. The result of this research shows that the macroeconomic shock has a twice as strong impact on the economy of the Czech Republic than on the German economy.

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Vazquez et al. (2012) in their research developed a credit risk model that used scenario analysis as a baseline to test the Brazilian banking sector. Data have been selected at the bank level between the periods of 2001-2009. In this study, two macro and micro models are used and instead of distributing the probability of default, the non-current loan distribution is used. The macro model examines the relationship between macro variables and macroeconomic scenarios in the framework of a vector autoregression (VAR) model it simulates. Research results supported a credit risk quality moving with the conjuncture.

Oanh T.K.Vu et al (2017) using the VAR technique, while investigating the relationship between economic variables, including inflation, loan interest rates, real currency rates, real gross, and default rate in Vietnam during the period 2015-1994, tested stress under low, medium and high scenarios tested put and the results show that high and medium scenarios when capital adequacy is over 9% can cover losses from macroeconomic shocks.

Vaez et al. (2012) Based on the CPV Wilson model, the relationship between Iran's macroeconomic variables in the season and the default rate during the period of 2000-2009 estimates the system of equations, and the results show that the effects of production variables, nominal exchange rate, loan interest rate and oil price on the default rate of banks are significant.

In this research, the optimal basket for banking system facilities has been used to minimize value at risk of bank equity rates. This shows well that the variables affecting the default rate affect the number of unexpected losses or the capital required by banks.

Moshiri and Abdul Shah (2017), using the information on macroeconomic variables and Iran's banking system during the period 2002-2016, estimated the losses of credit risk by using a stress test. In addition to estimating the probability equation based on the Wilson model, they also used multiple regressions. And the results indicate that the distribution of losses for all scenarios is to the right. This is the only study in Iran that has worked on the subject of macro stress tests with emphasis on credit risk and the results show that unemployment rate and inflation rate shocks have the highest and lowest effect on credit risk, respectively. This article is very similar to this recent study, with the difference that the above authors, in addition to changing some macroeconomic variables, have used the quantile regression method in estimating the model.

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3 Model and Data

In order to macro stress test in the Iran banking system, we first adopt the framework proposed by Wilson (1997), Boss (2002), and Virolainen (2004). Then estimate the relationship between credit risks and macroeconomic variables changes. Thereafter, we proceed with scenario, adverse credit scenarios, and expansionary scenarios. The advantage of this model that distinguishes it from other models is that it is a multi-factor model, i.e. the default rate is related to more than one explanatory variable. In fact, the Wilson model is a model that simulates the conditional distribution of default probabilities for different groups in different industries of each country.

Step 1: At this stage, for each economic sector, the default process that relates macroeconomic variables to the probability of loan default is modeled by the logistic function, which shows that the default rates are estimated within the range of 1 and 0% and their relationship is not linear with macro variables.

$$P_{j,t} = \frac{1}{1+\exp(y_{j,t})} \quad (1)$$

Where P (j, t) default rate in section j at time t and y (j, t) is the macroeconomic index of a given sector, the value of the macroeconomic index is an inverse function of the default rate. That is, the improvement of the economic situation is accompanied by a reduction in the default rate in economic sectors and vice versa.

The above relationship can be written with the following changes:

$$\boldsymbol{y_{j,t}} = \ln\left(\frac{1-P_{j,t}}{P_{j,t}}\right) \quad (2)$$

In order to examine the relationship between this variable and macroeconomic variables, it is assumed that the converted default rate (ie macro index) is determined by a number of macroeconomic variables, as shown in Equation (3) or the Wilson model.

$$y_{j,t} = \beta_{j,0} + \beta_{j,1}x_{1,t} + \beta_{j,2}x_{2,t} + \cdots + \beta_{j,n}x_{n,t} + v_{j,t} \quad (3)$$
$$\beta_j = (\beta_{j,0}, \beta_{j,1}, \ldots, \beta_{j,n})$$
$$x_t = (x_{1,t}, x_{2,t}, \ldots x_{n,t})$$

Step 2: Changes and evolution of macroeconomic variables are modeled using their time series. It is assumed that each of the macro variables is a function of their own regression. At this stage, based on the theory of Wilson

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(1997) as well as Boss (2002) and Virolainen (2004), an auto-regression process (VAR) is used, which is shown in Equation (4).

$$x_{i,t} = k_{i,0} + k_{i,1}x_{i,t-1} + k_{i,2}x_{i,t-2} + \cdots + \varepsilon_{i,t} \quad (4)$$

That k_i is a set of estimated regression coefficients for the macroeconomic factor iμ and ε (i, t) is a random error sentence that is assumed to be independent and has a normal distribution.

Step 3: In this step, the correlation structure of the model is created. Shows macro variables. In this system, a 1 * (j + i) vector of error statements is called E and the matrix (j + i) * (j + i) variance-covariance of error statements (∑) is defined as follows:

$$E = \binom{v}{\varepsilon} \sim N(0\,,\varepsilon) \quad , \quad \sum = \begin{bmatrix} \sum_v & \sum_{v,\varepsilon} \\ \sum_{\varepsilon,v} & \sum_{\varepsilon} \end{bmatrix} \quad (5)$$

Step 4: In this step, by simulating default rates using Monte Carlo simulation, future routes and distribution of credit portfolio losses are obtained by Monte Carlo simulation method. First, the error statements are generated using the covariance structure estimated in the previous step, and then the macro variables and future default rates are calculated. Finally, using the default loss values (LGD)[1] and default value (EAD)[2], the portfolio loss distribution is obtained. In addition, it will be possible to analyze macroeconomic stress scenarios with the model.

Data: Default rate referred to as NPL and macroeconomic variables in this research are extracted from CBI[1] database of default rates. Model data covers from Q1 in the year 2004 to Q4 in 2019.

Dependent Variable: Credit risk refers to the potential possibility that bank borrowers will not fulfill their obligations and bank loans will default. NPL is one of the important indicators to evaluate the portfolio situation in a banking system. As the NPL rate increases, the bank accepts more risk to get loans. Therefore, the NPL rate can logically indicate the default risk of the Iranian banking system. Here, according to the Wilson model, we use the logit rate of the default rate(Y) as a dependent variable.

Independent Variable: The selection of explanatory variables based on methodology was selected by Boss (2002) and Virolainen (2004) according to Table 1.

[1] Loss Given Default
[2] Exposure At Default

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Table 1
Definition of variables

Variable	Abbreviations	Expected impact on dependent variables
Real GDP Growth	GDPG	-
Unemployment Rate	UR	+
Nominal Exchange Rate	NER	+/_
Inflation	INF	+/_
Loan Growth	LG	-
Liquidity Growth	M2G	-

Source: Research Findings

The survey of the status of non performing loan (NPL) in Iran during the study period shows that in most years the ratio of NPL has been in double digits. As shown in Figure 2, this ratio is based on quarterly data, and evidence of increasing upward growth from the first quarter of 2004 to the fourth quarter of 2009 (except for the fourth quarter of 2006) is largely due to the poor credit rating of customers and Also, the interest rate of commercial loans is suppressed by the monetary authorities. But, after 2009, with the increase in the volume of commercial loans and the corrective and regulatory measures of the banking system in customer credit, this ratio decreased. In general, comparing the NPL rate of the Iranian banking system with the global average rate indicates a relatively high rate in this country.

Studies have shown that the payment of loans without customer validation and at non-expert levels, as well as the suppression of interest rates in this period, is one of the important factors in increasing the default rate in the Iranian banking system.

Other factors of creating non performing loan (NPL) include the slowness of the receivables collection process, the lack of effective management of asset items, the poor quality of the process and the steps of examining loans paid, the lack of a system for targeting the bank's obligations and the low rate of delay damages compared to the cost. The acquisition of money in the informal market, the politicization of banks and installment loans, the absence of an integrated financial information system for borrowers, the occurrence of unexpected events, the conditions governing the country's economy (economic recession), the difference in interest rates on deposits and bank loans, interest rates, and inflation named.

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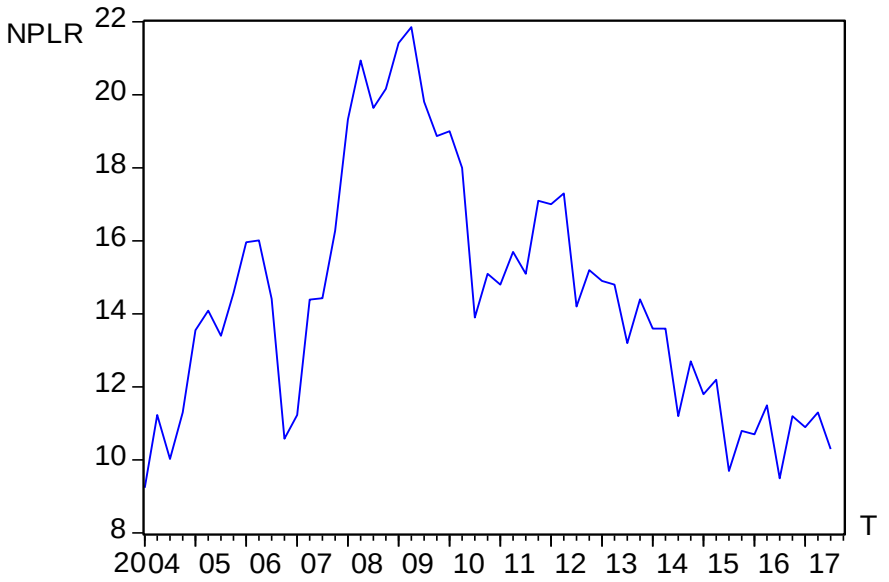

Figure 2. Default rates graph seasonally in the studied period.
Source: Research Findings

Factors affecting default rate

GDP[1] growth: According to the business cycle models, with the decline in economic growth, ie when the economy is in a recession cycle, the default rate increases, and this can be due to the decline in household income and the recession in the business of individuals in society. It leads to non-timely payment of its debt to the banking system and this debt is transferred to the classes of non-performing loans and vice versa in the boom cycle stage, total income and production and household income increase and this causes borrowers Commitments and payment of their debts at the maturity of the loan.

Unemployment rate: Examining the relationship between the unemployment rate and default rate, indicates that the direction of change of this variable is in the same direction as the default rate, that is, with an increasing unemployment rate, the default rate increases and vice versa. In fact, despite high unemployment in the country, it will limit the current and

[1] Gross Domestic Product

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future purchasing power of households and will negatively affect the cash flows of individuals, and the ability to repay the debts of bank borrowers will be reduced, leading to an increase in non-performing loans.

Inflation: An examination of historical data on inflation in Iran shows that as inflation increases, the default rate also increases, ie with increasing inflation, the real value of individuals' debts to banks decreases and borrowers try to repay their debts as much as possible in the face of inflation. Delay.

Liquidity growth: The relationship between liquidity growth and the default rate is negative, ie with increasing liquidity at the community level, people's income increases as a result of non-performing loans of banks also decrease, and with decreasing liquidity, people's income decreases, and consequently non-performing loans increase.

Nominal exchange rate: An increase in the nominal exchange rate has a dual effect: on the one hand, this increase reduces the value of the domestic currency, which means that borrowers have to pay less than what they have borrowed, and thus reduces the default rate, and on the other hand increases nominal exchange rate increases the price imported goods and as a result inflation increases and the default rate increases.

Loan growth: With the increase in loan payments, we expect the ratio of non-performing loans to loans to increase, and in fact, the default rate will decrease, and with the decrease in loan payments, this ratio will decrease and the default rate will increase.

According to Figure 3, with the increase in economic growth and the improvement of the economic situation, in most of the years under review, the default rate decreases, and with the decrease in economic growth, the default rate increases.

As can be seen in Figure 3, the changes in the unemployment rate and the inflation rate are in the same direction as the default rate, that is, with the increase of these economic variables, the default rate increases and vice versa. The changes in the economy's liquidity growth and the default rate show the inverse relationship between these two variables, that is, with the increase in liquidity growth, the default rate decreases and with the decrease in liquidity, this rate also increases.

Examining the relationship between the ratio of non-current receivables and the growth of facilities in the studied period based on Figure 3 shows that when the loan growth rate decreases, the ratio non performing loan or the default rate increases, and vice versa, with the increase in the loan growth rate, the default rate increases is reduced.

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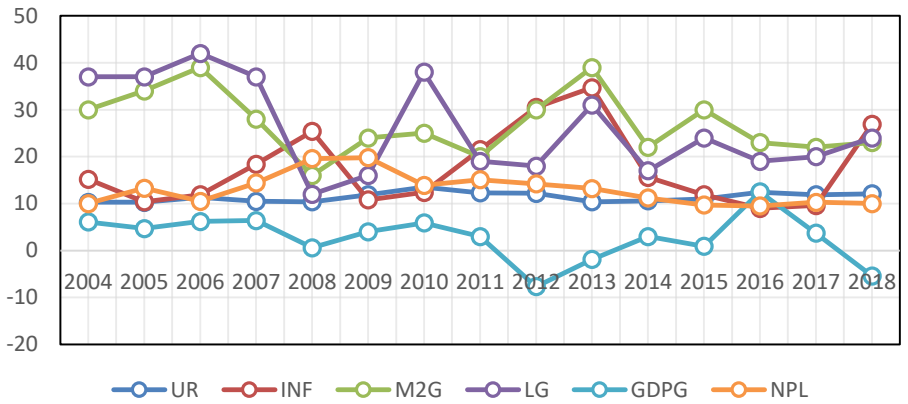

Figure 3. Comparative chart of variables in the studied period.
Source: Research Findings

According to Table 2, it can be seen that the amount of non performing loan always increases with the increase in the number of loans. From 2004 to 2007, the growth of non-current claims was more than the growth of facilities, and after that, this trend was reversed and the growth of loans was higher than the growth of non performing loan, which could be due to the review of the control and reduction of bank claims by applying Control and monitoring policies such as validating credit customers and obtaining documents with high liquidity, etc.

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Table2
Comparison of loans paid and non performing loan rates in the period of 2004-2017

Year	Non performing loan **(billion rials)**	Loan **(billion rials)**	Loan Rate (percentage)	NPL Rate (percentage)
2004	61023.22	608407	27	45
2005	111599.4	832831	36	82
2006	169997.9	1179722	41	52
2007	233158.6	1615791	37	37
2008	356122.3	1813250	12	53
2009	416785.8	2103916	16	17
2010	403584	2903482	38	-3
2011	521951.6	3456633	19	29
2012	577597.8	4067590	18	11
2013	705925.2	5347918	31	22
2014	698985.7	6240944	17	-1
2015	707324	7292000	17	1
2016	864595	9101000	25	22
2017	1038446	10082000	11	20

Source: Research Findings

According to Table 3, the characteristics and values of descriptive statistics of dependent and explanatory variables are shown quarterly. All the variables affecting default except the exchange rate are growth rates. Due to the high exchange rate, the rial value of this variable is divided by one thousand to be in the same range as other variables. The mean probability of default during the study period was almost symmetrically distributed. Among the macro variables, the unemployment rate is relatively stable, but inflation, exchange rates, facility rates, liquidity growth, and economic growth have fluctuated sharply.

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Table 3
Deterministic properties of the series (seasonally)

	UR	INF	M2G	LG	NER	GDPG	NPL
Mean	11/35	4/02	14/47	5/79	20382/67	0/68	14/3
Median	11/20	3/30	14/39	5/53	11531	0/58	14/2
Max	14/60	11/60	21/85	14/28	45280	15/54	21/8
Min	9/50	-1/30	9/50	0/09	8734	-11/45	9/2
Std.Dev.	1/08	2/41	3/272	3/35	12455/64	4/20	3/3
Skewness	0/49	0/94	0/53	0/46	0/44	0/84	0/5
Quartz	3/13	4/34	2/41	2/37	1/43	7/81	2/4
Prob.	0/31	0/002	0/18	0/23	0/024	0.000000	0/1
Sum. Squ.	63/69	314/07	578/37	608/76	8/38E+09	956/31	

Source: Research Findings

4 Empirical Result

First, before ordinary least squares (OLS) estimation, a stationarity test will be applied to the indicator time series. The results of the Dickey-Fuller and Phillips-Peron tests show that the series is not at a constant level, but when we consider the first difference in this test, the result is stable.
According to equation (3), we associate all macroeconomic variables with the equation and make conduct linear regression. According to Equation 3, the dependent variable is Y, which according to Equation 2 is inversely related to the default rate.

Table 4
Credit Risk Satellite Model Result

	C	NER	INF	UR	GDPG	LG	M2G	R Squre	Ad Squre	R F
Coefficient	2.19***	-./013***	./054	-./05*	./022*	./0231*	./052*	./61	./55	15.97

Note: "*", "**", "***" indicate significance at the 10%, 5%, and 1% levels respectively.
Source: Research Findings

According to the regression coefficients in table 4, and on the other hand, the relationship between the deficiency of the logit default rate variable (Y), and the symptoms of coefficients are matched with the expected symptoms. The results of Table 4 show that the nominal exchange rate is significant at the level of 1% and has a negative effect on the logit of the default rate, ie with increasing the nominal exchange rate, the dependent variable decreases or the default rate increases. The unemployment rate is significant at the level of

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10% and has a negative effect on the logit variable of the default rate, ie with an increasing unemployment rate, the default rate of default increases. The results show that the variables of loan growth, GDP growth and liquidity growth were all significant at the 10% level and had a positive effect on the dependent variable of the default rate, that is, with the increase of these last three variables, the default rate decreases. Although the inflation rate is not significant, as expected, it has a negative and unfavorable effect on the default rate.

As can be seen from Table (4), in Wilson's model, the economic growth rate has a positive effect on the logit rate of the default rate and since the default rate is inversely related to its logit, the growth rate will have an inverse effect on the default rate. Economically, the income of the people of the society will increase and as a result, the rate of default will decrease and this is in line with expectations. As expected, the growth of liquidity has a negative effect on the default rate, so with the increase of liquidity in the society, the income of more people and the default of loans will be less. The effect of the nominal exchange rate on the default rate is positive. , The probability of defaulting the loans will increase. In fact, with the increase in the nominal exchange rate, the price of imported goods has risen, causing inflation and a decrease in production and income, and the default rate can be expected to increase. The growth of loans, as expected, is inversely related to the default rate, ie with the increase in the number of facilities, the ratio of receivables to bank loans decreases. The inflation rate in Wilson model is not significant and its expected sign is negative with the default rate. In fact, rising inflation reduces the real price of bank debt and increases the value of individuals' assets, and this can reduce the default rate.

Here is a model that combines macroeconomic variables in the context of vector autoregression (VAR). This framework allows all system variables to interact. The optimal interval was used to select the optimal interrupts using statistics and based on Akaik and Schwarz tests, which is the optimal interval of two.

Simulation Scenario Analysis

In this part, the simulation results of the joint distribution of potential credit losses of the bank in the future and the change in the minimum required capital are presented. Second, we also present the results of IRBA[1] stress test credit losses and capital requirements with deterministic scenarios. Following Sorge and Virolainen (2006), our

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simulation at a given time horizon T is performed as follows: For each step of the simulation process in this model, a (j + i) × 1 vector of standard normal random variables Z_{t+1}~(0,1) is drawn. This is transformed into a vector of related innovations in macroeconomic and financial variables and banking industry default rates (logit transformed) using Cholesky decomposition. Using simulated realizations of error terms and initial values for macroeconomic and financial variables in 1:2004, i.e. the end of the estimation period, the simulated values corresponding to $x_{i,t+1}$ and subsequently for $y_{j,t+1}$ and finally for $p_{j,t+1}$, the default rate, are obtained using the system of equations (2)-(4). This method is repeated until the selected time horizon is reached and the desired number of simulated paths (10,000) is repeated from the default possibilities.

By obtaining a credit loss distribution using Monte Carlo simulation, we can calculate the minimum capital required to cover other expected shocks.

Loss distribution includes expected and unexpected losses. Expected losses (EL) that the banking system calculates based on specific procedures according to equation 6. But unexpected loss (UN) or economic capital is any deviation from expected loss and in fact, the loss is due to unpredictable shocks to credit risk, which is obtained from the difference between the distribution of losses and expected losses. In fact, unexpected losses are the economic capital that banks need in the face of shocks and vulnerability prevention. (Figure4)

$$EL_t^s = PD_t^s \times LGD_t^s \times EAD_t^s \quad (6)$$

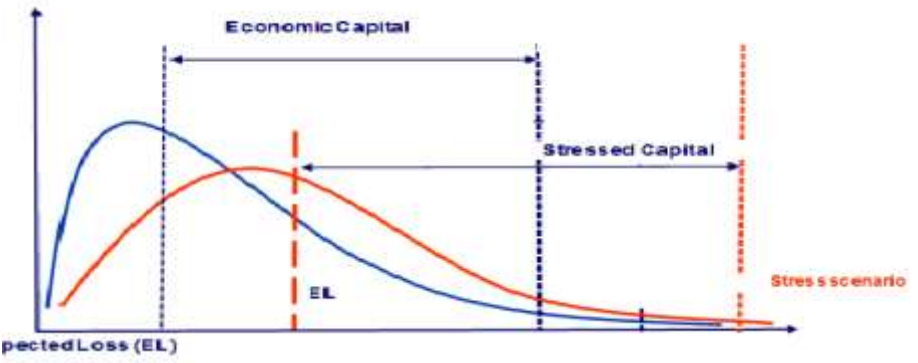

Figure 4. Expected and unexpected distribution of losses.
Source: Research Findings

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The concept of probability of default (PD) indicates the degree the probability that promised payments such as Loan principal and interest repayments will not be paid by the obligor. Also Exposure at Default (EAD) estimates the amount that the Borrower's debt in case of default. The Loss Given Default (LGD) quantifies the portion of loss the lending unite will really suffer in case of default.

The macroeconomic stress test is performed to determine expected and unexpected losses, and it is expected that in the event of a sudden event, the macroeconomic crisis situation will be reflected by a corresponding shock in one of the macroeconomic variables. The purpose is to determine the amount of expected and unexpected losses and whether it is at the time point t + 1, whether these losses are sufficiently covered by the capital of their banks or not. In this section, the macro and financial variables introduced in the previous section are placed under the baseline and unfavorable scenarios, which is the most important part of the stress test. The shock enters. And with the impact of this shock, it is possible to calculate the expected and unexpected losses and the amount of capital required to cover these losses. The losses due to credit risk in the next year are shown in Table (5).

Table (5)
Credit risk losses (shock of a standard deviation) in the next year

Credit Loss	Expected Loss	Unexpected Loss	Scenario	Variable
18.42	4.58	13.84	Baseline	
22.4	6.99	15.41	Adverse Scenario	GDPR
21.14	6.72	14.42		INF
21.54	6.87	14.67		UR
18.1	5.77	12.33		NER
21.59	6.9	14.69		M2
21.09	6.71	14.38		LR

Source: Research Findings

As shown in Table 5, the shock corresponding to each macroeconomic variable is measured by a standard deviation using Monte Carlo simulation, loss distribution, contingent loss, and unexpected loss, or the minimum capital that the banking system must maintain is obtained to be able to neutralize the effect of shocks.

By comparing the baseline scenario and the adverse scenarios in Table 5, the effect of the economic shock by a deviation increases the unexpected loss of economic capital for macroeconomic variables excluding the nominal exchange rate relative to the loss in the baseline scenario.

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5 Conclusion

The importance of the financial sector plays a decisive role in the financial stability of developing and developed countries, as well as in the stability of global markets. Because of this important role, the banking industry must be disciplined, transparent and in accordance with scientific criteria. Bank credit risk is still the dominant risk that challenges financial stability and therefore this research evaluates the potential impact of adverse macroeconomic shock scenarios on credit risk variables. Stress testing is a method used to test the stability of banks against various highly reflective scenarios. Then the macroeconomic stress test is performed to evaluate the vulnerability and resilience and exposure to the risk of the entire loan portfolio of banks. The majority of macroeconomic stress test research in different countries is based on the method proposed by Wilson (1997), Boss (2002) and Virolinen (2004), which includes modeling default probabilities as a nonlinear function of macroeconomic variables.

In this research, the stability of Iran's banking industry against the financial crisis has been tested by building a credit risk model. First, credit risk satellite models are created in order to reveal the relationship between macroeconomic and financial variables and the ratio of non-performing loans (as a proxy for the default rate). Then a macroeconomic VAR model is estimated to determine the relationship between macroeconomic variables. Using error terms the variance -covariance matrix of two steps ago, default possibilities using Monte Carlo simulation on one-year time horizon under the basic scenario and stress scenario with the effect of macroeconomic shock as a standard deviation and by calculating value at risk, Unexpected losses or the capital required to cover the losses are obtained. Regarding the selection of macroeconomic variables, we follow international and domestic models and logically select and introduce GDPR, INF, UR, NER, M2 and LR as financial and macroeconomic variables. This article identifies macro factors and NPL rate (as a proxy for default rate) of Iran's banking system from the first quarter of 2004 to the fourth quarter of 2019, a total of 58 chapters, and then uses Eviews 10 software for analysis.

The analysis suggests a significant relationship between the default rates of bank loans and key macroeconomic factors in Iran. The results of Wilson's model show that the variables of the unemployment rate and nominal exchange rate have a positive effect on the default rate, that is, with an increase in the unemployment rate and the nominal exchange rate, the default rate or credit risk increases, so that the effect of the unemployment rate on the dependent variable is greater. On the other hand, other variables including

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inflation, loan growth, economic growth, and liquidity growth will have a negative effect on the default rate, that is, with the increase of these variables, the default rate will decrease.

By using the framework of Monte Carlo method is applied to estimate the distribution of possible credit losses conditional on an artificially introduced shock. And as a result, there will be expected and unexpected losses.

The results of the macro stress test show that in adverse scenarios, the distribution of losses is larger than the baseline scenario, and consequently unexpected losses or the economic capital of banks in Iran will increase, ie the banking system will be vulnerable to macroeconomic shocks including GDPR, INF, UR, M2 and LR and is resilient only to nominal exchange rate shocks.

In fact, by comparing some of the unexpected losses or economic capital needed in Wilson model stress and basic scenarios, it is observed that the nominal exchange rate is the most effective shock for the Iranian banking industry, that is, the nominal exchange rate shock as a standard deviation, less capital is needed than other variables, even than the basic scenario, and due to the shock of GDP growth as much as a standard deviation, more capital is needed.

Finally, it is suggested that in order to deal with financial crises and macroeconomic shocks, practical measures such as increasing the capital adequacy ratio according to the guidelines of Basel committee, including increasing shareholders' equity and improving asset quality, are considered by monetary authorities also, macro stress test should be used as an important risk management tool by the managers of the banking and monetary system.

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