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Application of panel data analysis to determine the role of macroeconomic variables on banks' risks

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Abstract

Investment in and allocating investment resources to business activities is done through the financial market and the banking credit market is part of this market. The most role of banks in the financial market is to give credit to customers. In this matter the capital adequacy assessment and credit risk are important and their control is considered as one of the key effective factors in bank operation and plays a major role in banks and financial institutes' stability. So, the aim is to determine the effect of macroeconomic variables (GDP, liquidity, inflation rate and exchange rate) on Capital adequacy, liquidity risk and credit risk. The results showed that macroeconomic variables have a significant effect on banking risks.

Keywords: capital adequacy ratio, credit risk, gross domestic product (GDP), panel data, econometrics
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1 Introduction

The changes in macroeconomic factors are the consequences of external affairs (such as changes in commercial conditions or world interest rate fluctuations) most of the time, but sometimes it is because of political reasons. It is generally emphasized on 5 indices of inflation rate, exchange rate, interest rate, financial status of the government and payment balance status in defining a stable macroeconomic environment [6].

Successful banks in the world develop their appropriate credit portfolio management systems. Such systems help bank managers to make better credit decisions. Decisions are based on qualitative and quantitative evaluations of individual facilities and the bank's credit portfolio. In this matter, it has been focused on simultaneously applying different factors to determine macroeconomic status by Fischer [6] and Sahay and Goyal [18]; as every single variable contains just a part of information separately, so the hybrid index could be more proper. The inflation is a good index for the monetary and financial situation, but it could be affected by price control. When inflation is kept down by price

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control, the uncertainty and lack of trust in financial policies shall crush the exchange rate. The pressures on exchange rates may be not revealed under a stable exchange rate system, but the policymakers try that the foreign currency stability is exposed in the form of changes in international reserves. Reducing and controlling risk is considered as one of the effective factors in improving the process of granting credit and as a result in the performance of banks, and it plays an essential role in the continuation of providing facilities and the profitability and survival of banks and financial institutions. Equipping and allocating investment resources to economic activities is done through the financial market, and the bank credit market is a part of this market. This is done as the main bank in the financial market by providing credit and facilities to customers. Therefore, one of the important issues in this field is the review and management of credit risk (probability of default in repaying the facilities granted by customers). But the main part of the business is the financial inputs of lending, in addition, institutions must pay back in order to earn more profit. Complete their loan from successful customers, or in other words, their credit risk is low. In case of not paying attention to credit risk and reducing it, behavioral risk may occur [17].

Therefore, the aim is to determine the effect of macroeconomic variables (GDP, liquidity, inflation rate and exchange rate) on Capital adequacy, liquidity risk and credit risk.

Banking Risks

Greuning et al. [8] recommended another classification for risk in research by World Bank. Notwithstanding this classification has been considered especially for banking risk assessment, but it could be applied for other commercial institutes and enterprises in terms of topics and contents. In this model, Greuning has mentioned exposure risk which means positive and negative changes in future interest and divided into 4 classifications of financial risk, operation risk, business risk and exposure risk.

Financial risks are those risks which are highly dependent on each other and increase the general banking risk in total [2] as well as divided into two groups of certain risk and market risk. The certain risk includes cash risk, credit risk and capital structure risk and market risk include interest rate fluctuation risk, currency risk and price risk [20].

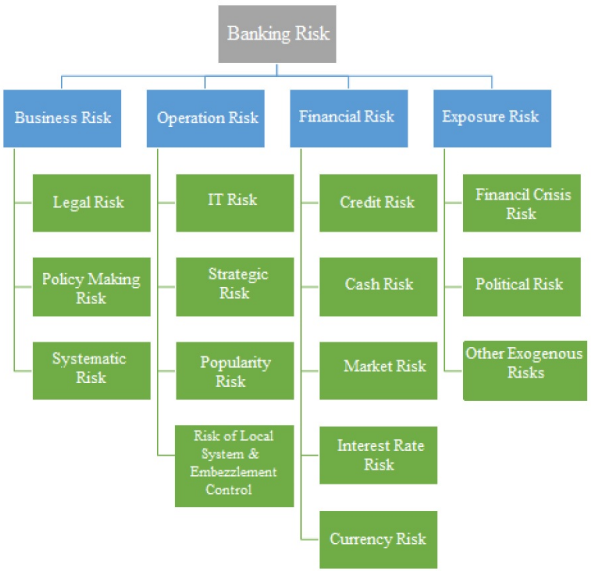

Figure 1: Banking Risks [8]

1.1 Credit risk

Consists of overdue receivables, outstanding receivables and bad debts divided to the whole credit balance and the result show the banking risk rate [10].

$$\frac{(\text{overdue receivables} + \text{outstanding receivables+bad debts}) \times 100}{\text{Credit balance} - \text{interest of further year}}$$

The standard credit risk for banks is 5 but it is so much higher in Iran because of different reasons.

1.2 Capital adequacy ratio

The bank could stand against lost resulted from nonpayment of loans, market unfavorable conditions and some operational bottlenecks by relying on their capital. However, even in best conditions it is possible for a bank with proper capital to be collapsed by disasters, but many researchers such as Grier and Grier [9] consider reviews which showed that banking crisis has been limited in those banks with more proper capital. Because a bank with sufficient investment has more time to investigate the problems and properly fight them.

1.3 The impact of macroeconomic variables on banking risks

The current literature shows that the main effective factor on credit risk is macroeconomic factors. For example, Keeton and Morris [11] showed by research on 2400 commercial banks that the economic conditions are the main effective variable on blocking facilities in banking systems. Also, Mueller [15], Anderson and Sandaresan [1] and Goldstein and Turner [7] revealed that there is a direct relation between increasing credit risk level and deterioration of macroeconomic terms.

The capital adequacy is not just affected by interbank indices but also state economic conditions. Also, two components of GDP growth rate and inflation could affect banking circular function against economic changes [13].

From one point of view, inflation is caused by the factors resulting from demand pressure and the high demand of the whole society compared to the total supply, and one of the important factors that causes the increase in demand is liquidity. Inflation caused by the increase in the amount of money will decrease the value of money. Inflation reduces the purchasing power of money, and society members are forced to increase their nominal money reserves and give up other expenses in order to neutralize inflation [19].

Exchange rate is the price at which the national currency can be exchanged with the money of other countries. In other words, the exchange rate represents the value of the domestic currency in relation to the foreign currency. In some cases, the exchange rate is defined as the units needed to own a domestic currency. In this case, an increase in the exchange rate means an increase in the value of the domestic currency against the foreign currency in the foreign exchange market [5].

2 Method

Levin, Lin and Chu [12] t test for stability, which is one of the most important and common tests for this aim, was used to determine the stability of the model. Since combining time series statistics with cross-sectional statistics can provide useful information for estimating econometric models, therefore, according to the data and the nature of the model, the panel data method has been used to estimate the model. In the following, because when pooled data is used, various tests must be performed to determine the appropriate estimation method, the most common of which are the Chow test and the Hausman test to select one of the panel or POOL models and the fixed effect or random effect model, so before estimating the model has been used to determine the appropriate estimation method from these tests. Also, Eviews12 and Excel 2021 software were used to analyze the model [16].

2.1 Data

In this research, 12 Iranian commercial banks' data during the years 1396 to 1401 have been used.

2.2 Panel data analysis

Panel data refers to a set of data based on which observations are examined by a large number of cross-sectional variables (N), which are often randomly selected, during a specific time period (T). In this case, $N \times T$ statistical data are called panel data or cross-sectional time-series data. Panel data models examine group effects, time effects, or both effects together. Panel data methods can be split into two broad categories: Homogeneous (or pooled) panel data models assume that the model parameters are common across individuals. Heterogeneous models allow for any or all of the model parameters to vary across individuals. Fixed effects and random effects models are both examples of heterogeneous panel data models.

Estimating equations in the panel data mode depends on the assumptions that are applied to the coefficients, the width of the origins, and the error term. Of course, this assumption is different from the classical assumption because first it is assumed that $u_{it} \sim N(0, \sigma^2)$ is random and the rest of the assumptions are valid. This new assumption that has been applied is an addition to the classic assumption [16].

Five modes can be considered, which are:

1. assume that the width of the origins and coefficients are the same between sections and periods, so the error sentences are different during periods and between errors. This is the simplest approach that can be estimated with ordinary least square (OLS). This situation is like the number of sections multiplied by the number of periods, i.e., N.T. (The first assumption is also true for the next four cases).
2. The second case: the coefficients of the slopes are constant, but the widths of the origins are different between different sections. The framework and infrastructure of integrated data models are as follows:

$$y_{it} = \alpha_i + \beta' X_{it} + u_{it} \tag{2.1}$$

in this model, there is k explanatory variable without including the intercept in X_{it}. The difference between the cross-sections was shown α_i to be constant over time. One way to account for the nature of cross-sectional units is to have different widths from the origins, that is, each segment has a width from the origin for itself, so the coefficients are the same, which is known as the fixed effects model in econometrics literature. To consider the width from different sources, the dummy variable method can be used:

$$\begin{pmatrix} y_{1t} \\ y_{2t} \\ \vdots \\ y_{Nt} \end{pmatrix} = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & \cdots & 0 \\ 0 & 1 & 0 & 0 & 0 & \cdots & 0 \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ 0 & 0 & 0 & 0 & 0 & \cdots & 1 \end{pmatrix} \begin{pmatrix} \alpha_1 \\ \alpha_2 \\ \vdots \\ \alpha_N \end{pmatrix} + \begin{pmatrix} X_{1t} \\ X_{2t} \\ \vdots \\ X_{Nt} \end{pmatrix} \beta + \begin{pmatrix} U_{1t} \\ U_{2t} \\ \vdots \\ U_{Nt} \end{pmatrix} \tag{2.2}$$

the above model is known as Least squares dummy variable (LSDV) estimation (LSDV)

3. the coefficients of the slopes are constant, but intercepts between cross-sections and periods are different between sections and periods. Again, using the dummy variable method, it can be written as follows:

$$\begin{pmatrix} y_{1t} \\ y_{2t} \\ \vdots \\ y_{Nt} \end{pmatrix} = \begin{pmatrix} I & 0 & 0 & 0 & 0 & \cdots & 0 \\ 0 & I & 0 & 0 & 0 & \cdots & 0 \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ 0 & 0 & 0 & 0 & 0 & \cdots & I \end{pmatrix} \begin{pmatrix} \alpha_1 \\ \alpha_2 \\ \vdots \\ \alpha_N \end{pmatrix} + \begin{pmatrix} X_{1t} \\ X_{2t} \\ \vdots \\ X_{Nt} \end{pmatrix} \beta + \begin{pmatrix} U_{1t} \\ U_{2t} \\ \vdots \\ U_{Nt} \end{pmatrix} \tag{2.3}$$

in which the α_is are $T \times 1$ vectors and I is a $T \times 1$ vector. Now, if we define matrix D as a horizontal matrix with dimensions $NT \times N$, we will have:

$$D = [d_1, d_2, ..., d_N] \tag{2.4}$$

$$y = D\alpha + X\beta + u \tag{2.5}$$

the above model can be estimated by ordinally least square (OLS) method.

4. all the coefficients are different between different sections.
This state indicates that each section has its own function and these functions are different from each other, just like estimating the equation for each section separately. If the fourth state is meaningfully confirmed, it indicates that they are not pooling.
5. The intercept and slopes should be different for different sections and periods.

In order to determine the type of model used in consolidated data, various tests have been designed. If the goal is to choose a suitable model from two models of fixed effects and random effects, a test called Hausman's test can be used. Chow test is usually used in choosing between pooled regression model and fixed effect model. At the same time, in order to choose the appropriate model from among the two random effect models and the pooled regression model, the test used will be the LM test.

A. Chow test: The assumptions of the test are as follows:

H_0: Pooled Model

H_1: Fixed Effect Model

The Chow test statistic is based on the sum of squared errors of the constrained and unconstrained model as follows [3].

$$Chow = \frac{\frac{RRSS - URSS}{(N-1)}}{\frac{URSS}{(Nt-N-K)}} \sim F_{N-1,N(T-1)-k} \tag{2.6}$$

the above statistic has F distribution or $NT-N-K, N-1$ degrees of freedom. In the above relationship, N represents the number of cross-sections, K means the estimators (except for the fictitious variable), T is the number of time periods, NT is the total number of observations, $RRSS$ is the sum of the residual squares of the restricted regression and $URSS$ is the sum of the residual squares of the unrestricted regression.

In order to determine which of the two integrated models (OLS) or fixed effect (LSDV) is more suitable for estimating the regression model, it is necessary to test assumptions in this field. The null hypothesis is based on the concept that all dummy variables, with the exception of one, are equal to zero.

$$H_0 = \alpha_1 = \alpha_2 = \cdots = \alpha_{n-1} = 0$$
$$H_1 = \alpha_i \neq 0 \quad \exists_i \in 1, ..., n-1$$

The appropriate statistic for testing the above hypothesis is the F test. The F statistic can be expressed in terms of R^2 determination coefficient as follows:

$$F_{pooled-effect} = \frac{\frac{(R^2_{fem} - R^2_{Pooled})}{(n-1)}}{\frac{(1-R^2_{lsdv})}{(nt-n-k)}} \sim F(n-1, nT-n-k) \tag{2.7}$$

in the above relationship, R_{fem} indicates the sum of squared error of the fixed effect model, R^2_{Pooled} indicates the sum of squared error of pooled models. R^2_{lsdv} is the sum of squared error of the fixed effect model with dummy variable. If the null hypothesis is rejected, it can be concluded that the fixed effect model is better than the pooled OLS model.

B. Hausman's test: Hausman's test is the most common test in the process of choosing between random effects models and fixed effects models. This test is designed based on the existence of correlation between independent variables and individual effects, and the null hypothesis and the alternative hypothesis can be presented as follows [4].

$$H_0 = COV[\alpha_i, x_i] = 0$$
$$H_1 = COV[\alpha_i, x_i] \neq 0$$

If the random error component (individual effect) is correlated with the explanatory variables (H_0 hypothesis is rejected), then the random effect model is skewed and the assumptions of Gauss-Markov's theorem will be incomplete. In this case, the fixed effect model will be used [4].

C. Lagrange Multiplier (LM) test: In order to choose the optimal model from the random effect model and the panel data model, the LM test can be used. The null hypothesis in the above test states that the variance of the cross-sectional effect is equal to zero:

$$H_0 : \sigma^2_\alpha = 0$$

If the null hypothesis is not rejected, then the pooled regression model can be a suitable model. The LM statistic, which follows the chi-square distribution with one degree of freedom, can be presented as follows:

$$LM = \frac{nT}{2(T-1)} \left[\frac{\sum(\sum e_{it})^2}{\sum\sum e^2_{it}} - 1 \right]^2 = \frac{nT}{2(T-1)} \left[\frac{\sum(T_{\bar{e}_{i0}})^2}{\sum\sum e^2_{it}} - 1 \right]^2 \sim x^2_1 \tag{2.8}$$

in the above relationship, e_{it} is the estimation error of the integrated model, $\bar{e}_{i0}$ is the average error in the first period, T is the number of the time period and nT is the total number of observations.

3 Result

To analyze the research hypotheses, tests have been done on the research variables, which are briefly described below.

$$\text{Model 01} : \text{Capital Adequacy}_{it} = \alpha_0 + \alpha_1 * \text{Liquidity}_{it} + \alpha_2 * \text{Oil Income}_{it} + \alpha_3 * \text{GDP} + \alpha_4 * \text{Inflation Rate}_{it} + \alpha_5 * \text{Exchange Rate}_{it} + \varepsilon_i$$

$$\text{Model 02} : \text{Liquidity Risk}_{it} = \beta_0 + \beta_1 * \text{Liquidity}_{it} + \beta_2 * \text{Oil Income}_{it} + \beta_3 * \text{GDP} + \beta_4 * \text{Inflation Rate}_{it} + \beta_5 * \text{Exchange Rate}_{it} + \varepsilon_i$$

$$\text{Model 03} : \text{Liquidity Risk}_{it} = \gamma_0 + \gamma_1 * \text{Liquidity}_{it} + \gamma_2 * \text{Oil Income}_{it} + \gamma_3 * \text{GDP} + \gamma_4 * \text{Inflation Rate}_{it} + \gamma_5 * \text{Exchange Rate}_{it} + \varepsilon_i$$

3.1 The results of stability tests for model variables

In order to provide correct inferences about time series variables, the stability of these variables over time should be ensured first. Neglecting this important may lead to providing wrong conclusions about the critical quantities of the model and obtaining false regression. Therefore, in this research, at first, with the help of Levin, Lin and Chu [12] t test, the stability of the used variables was tested, the results of which are summarized in Table 1. Null: Unit root (assumes common unit root process)

Table 1: Levin, Lin and Chu [12] t test for stability

	Level		**1st differences**	
Variable	**Statistic**	**Prob.****	**Statistic**	**Prob.****
Capital Adequacy	−1.367	0.047	–	–
Liquidity Risk	−103.0	0.00	–	–
Credit Risk	−5.073	0.00	–	–
Liquidity	28.756	1.00	−7.513	0.00
Oil Income	−7.712	0.00	–	–
GDP	−2.180	0.017	–	–
Inflation Rate	−0.770	0.314	−2.893	0.00
Exchange Rate	70.361	1.00	3.841	0.00

As the results of Levin, Lin and Chu [12] t test show, the variables of capital adequacy, liquidity risk, credit risk and static oil income are of zero degree $I(0)$ and do not need to be differentiated. But the variables of GDP, liquidity, inflation and stable exchange rate are not zero and therefore need to be differentiated. Therefore, according to this issue, Levin's test was performed with one time difference on these variables. The results of this test are shown in the table below. As can be seen in the mentioned table, these variables have been determined by one-time differentiation. Therefore, GDP, liquidity, inflation and stable exchange rate are of the first degree $I(1)$ and are stable with one time difference.

3.2 Choosing the appropriate model

In order to determine the type of model used in panel data, Hausman and Chow tests were used.

Table 2: Chow's and Hausman's tests results

Models	**Effects Test**	**statistic**	**P-Value**
Model 01	Chow's Cross-section F	44.037	0.00
	Chow's Cross-section Chi-square	148.124	0.00
	Hausman's Cross-section random	26.614	0.00
Model 02	Chow's Cross-section F	2.008	0.06
	Chow's Cross-section Chi-square	24259	0.01
	Hausman's Cross-section random	16.967	0.00
Model 03	Chow's Cross-section F	4.870	0.00
	Chow's Cross-section Chi-square	35.400	0.00
	Hausman's Cross-section random	8.829	0.00

Considering that the test statistic is greater than the critical point. As a result, the Null hypothesis, based on the use of Pool, has been rejected. Therefore, the panel data method has been used to estimate the model.

Due to the fact that the test statistic is greater than the critical point and the P-Value value is less than 0.05, as a result, the hypothesis based on the same width from the origins is rejected. Therefore, the fixed effects method has been used to estimate the model.

3.3 Estimating the models

In the following, according to the tests that have been done specifically for each of the models, the model has been done according to the dependent variables of capital adequacy, liquidity risk and credit risk. The results of these estimates are given below.

The results of the estimation of the model in the case of fixed effects in sections and using the weighted least squares method.

Table 3: weighted least squares method

Dependent variable	**Capital Adequacy**			**Liquidity Risk**			**Credit Risk**		
Independent Variables	Model 01			Model 02			Model 03		
	Coefficient	t-Statistic	P-Value	Coefficient	t-Statistic	P-Value	Coefficient	t-Statistic	P-Value
C	8670.700	3220.0	0.00	2457.900	7290.0	0.00	1563.900	7980.0	0.00
D(GDP)	0.119	996.0	0.00	−0.187	−9870.0	0.00	−0.043	−4230.0	0.00
Oil Income	0.004	139.0	0.00	0.033	7920.0	0.00	0.003	1520.0	0.00
D(Liquidity)	−0.013	−1030.0	0.00	0.016	7520.0	0.00	0.006	5310.0	0.00
D (Exchange Rate)	1.090	1120.0	0.00	−1.300	−8710.0	0.00	−0.402	−4930.0	0.00
D (Inflation Rate)	−13586.200	−8470.0	0.00	10199.900	43800.0	0.00	5607.000	42900.0	0.00

	Model 01	**Model 02**	**Model 03**
R-squared	0.92	0.706	0.481
Adjusted R-squared	0.89	0.615	0.319
F-statistic	34.88	7.723	2.977
Prob (F-statistic)	0.00	0.00	0.003
Durbin-Watson stat	1.55	1.998	1.552

According to the regression coefficient table, for model 01 the value of R^2 in the investigated model is equal to 0.92 and the Adjusted R-squared value is estimated to be equal to 0.88, which shows the high explanatory power of the model. According to the F statistic which is equal to 34.88 and the significance level value (P-Value) of this statistic which is equal to 0.00, it can be said that the whole model is statistically significant. In addition, Durbin-Watson's statistic also shows that there is no autocorrelation in the above model. The results for models two and three are the same.

4 Discussion and conclusion

In absence of extended capital market, banks play a key role in financing enterprises. On the other word, banks are assumed as the engine of economic growth and development and any inefficiency and disorders resulted from bad economic conditions could directly or indirectly affect their functions. During last years, the cash growth and other effective variables on monetary base caused increasing in inflation rate and unfavorable effects on economics and consequently on banking system. On the other word, in Iran economy, as per the money market mechanism, the increased cash caused increased requests for stock jobbery in a certain level of income. The high fluctuations of gold and currency markets of last year is the perfect example of increasing requests of stock jobbery. By increased inflation, the operational and non-operational expenses of the banks are simultaneously increased while applicants for loans will also suffer from unrequested expenses, as by increasing bank operation expenses, the new loans shall be paid to the applicants with higher interest rate to maintain their profit margin. About increasing operation expenses, it could be argued that when the interest rate of deposit accounts is less than inflation rate, the depositors are not intended to invest in banks, as the inflation causes less purchasing power and decease money value. So, if the accrued interest to banking deposit account is lower than inflation rate, the money value of the depositors will be practically decreased and because of higher return rate and attraction of other markets such as real estate, currency or gold, the cash shall be exited from banking system and flows to those markets. It should be mentioned that the duration of keeping money in hands is limited and the money shall be eventually returned to banking network. So, inflation has not so much effects on increasing or decreasing bank resources independently and just resulted to changes in combination and contribution of investment deposits. In this matter, perhaps the rate of long-term investment deposit could be decreased and current and short-term deposits could be increased. In this matter, decreased long-term investment deposits in favor of current and short-term deposits shows the decreased capability to gather capital, as the effect of long-term deposits grows on investment is more significant than call deposit accounts growth and banks could offer long-term loans for financing investment projects from the place of long-term deposits.

Iran economy has recently faced high cash rate growth which is resulted from increasing net external assets of central bank, increasing net debts of public sector, governmental budget deficit, economic rely on petroleum incomes, dependency of central bank and expansionary monetary and financial policy. Also, the idea that the economic issues of the country such as inflation, unemployment and other issues could be solved by using credits and pressure on banking network is of important and effective factors in growth of cash rate and made some issues for banking network.

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