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RESEARCH PAPER

Does Credit Risk across Different Sizes of Banking Industry Matter for the Stability of Banks in Iran: A Panel Threshold Regression Approach

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Abstract

This paper explores the association between credit risk and different types of bank stability based on Z-score across various bank size regimes by employing a panel threshold regression and an extensive dataset of 20 banking industries in Iran's economy over the 2005–2020 period, although the choice of the starting and ending dates was based on the availability of data. The core finding is that in many cases, under all three measures of bank stability, credit risk at different threshold levels of bank scales has a positive impact on the z-score for all banks. In addition, we observed that the coefficients of other control variables including bank size, rate of return, liquidity risk, and funding risk on banking stability were based on our expectations. Moreover, the results revealed that the correlation between credit risk and bank stability was not homogenous, depending on whether the bank was state or private. Besides these, we found that for the state banking system in Iran, a concentration-stability view could be proved in the sense that larger banks may enhance profits. Based on the empirical evidence obtained, the findings offer some important implications for Iran's policymakers.

Keywords: Bank Size, Credit Risk, Iran, Panel Threshold Regression, Z-Score.
JEL Classification: G01, G21, O53, C24.

1. Introduction

Today, economists believe that a stable financial system is a prerequisite for sustainable economic growth; on the other hand, the prerequisite for the stability of the financial system is the adjustment and regulation of the banking system by reducing the probability of bank bankruptcy. In other words, this can lead to improving the financial stability of the banking system (Tankoyeva et al., 2018). In developing countries, including Iran, which do not have developed financial markets, the banking sector is usually the only institution capable of financial intermediation, which can facilitate trade and commercial exchanges by organizing and directing receipts and payments, as well as utilizing optimal resource utilization. This can lead to the expansion of markets, growth, and prosperity of the economy. Therefore, banking stability is considered a main characteristic of financial stability, which, in turn, leads to the improvement of financial efficiency in Iran's economy.

During the recent global financial crisis, which was accompanied by severe financial instability in the international arena, special attention was paid to large banks, both at the international level and in the field of domestic economy; this is because these banks, in the case of bankruptcy, have significant effects, not only on the global economy but also on the domestic economy (Shahchera and Norbakhs, 2016). Therefore, when the world came out of the crisis, there was much discussion regarding the effects of bank size, types of risks, and other bank-specific indicators on the degree of banking stability (Adusei, 2015; Ghenimi et al., 2017; Pham et al., 2021; Ali and Puah, 2018). According to deHaan and Poghosyan (2012), there is a non-linear relationship between volatility in returns and bank size. When bank size exceeds its threshold, the relationship between bank size and return volatility is positive. These arguments have led to a debate among policymakers on whether there should be some regulatory limits on the size of banks to reduce the impact of the financial crisis (Ali and Puah, 2018). In this context, Altaee et al. (2013), Laeven et al. (2014) and Chai et al. (2022) have highlighted that bank size has a negative impact on bank stability; meanwhile, Kakes and Nijskens (2018) found that banking sector size could be correlated positively with some indicators of financial crisis damage.

On the other hand, bank sectors in the economy are exposed to several financial risks, including 1- credit risk, based on which borrowers do not repay their loans on time, 2- liquidity risk, based on which depositors withdraw their deposits suddenly, 3- interest rate risk, which includes successive changes in interest rate, and 4- operational risk, which includes the failure of bank computer systems, or the failure and fire of their buildings (Cecchetti and Schoenholtz, 2011). Among these, credit risk is considered one of the most important risks affecting the stability or failure of banks, especially in developing countries including Iran. The increasing expansion of credit risk in the form of non-performing claims has reduced the financial ability of banks in granting facilities and profitability; with the spread of these effects from banking sectors to various economic parts, monetary and financial crises can even be witnessed (Kordmonjiri et al., 2019). According to the statistics published by the Central Bank of Iran (CBI), in the last decade, the ratio of non-performing loans to the total facilities of the banking network has experienced significant growth, reaching a figure of more than 11% in 2019; in the same year, the growth of non-performing loans, compared to the previous year ,also reached more than 54% (CBI, 2021). This indicates the locking of a significant part of bank resources; moreover, the allocation of bank credits to non-productive and speculative activities that lack productive interest for the economy is also one of the factors indicating the failure of the banking network in the optimal allocation of resources.

In light of all these facts, the purpose of this article is to examine how the credit risk and size of banks can affect the stability of Iran's state and non-state banking sectors concerning bank size at different threshold levels, along with some control variables. Compared to other papers, this article contributes to the discussion focused on the determinants of banking stability in several ways. First of all, unlike studies such as Pham et al. (2021), Ghenimi et al. (2017), and Ali and Puah (2018) that investigated the linear relationship between bank-specific variables on bank stability, here we employ a non-linear regression model with the threshold effects; so, the effects of credit risk on Z-score index may follow a nonlinear pattern; Here, we attempt to test whether credit risks at different threshold levels of bank size could lead to more instability in the banking sectors under the *Z*-score model of the Iranian economy. Additionally, while previous studies related to the Iranian economy, including Shahchera and Nourbakhsh (2017) and Isavi et al. (2017), considered the correlation between banking stability and other destabilizing factors for all banks, here we will analyze these effects separately for the time series data of private and state banks; finally, to further analyze the sensitivity in the extracted coefficients, we compare the results of the threshold panel model with the panel-GMM estimator.

The remainder of this study is organized as follows. Section 2 explains the literature review, while the data and estimation strategy are discussed in section 3. In section 4, we present empirical results. Finally, the conclusion and presentation of suggestions are reviewed in section 5.

2. Literature review

During the past two decades, the banking system has undergone significant changes in its operating environment all over the world, and several external and internal factors have influenced the stability index and performance of the banking system. However, despite all the changes, the banking system is still the main field of financing economic activities in many countries, especially developing countries, playing the main role in transferring resources from savers to investment units. Hoffmann (2011) reveals that a healthy and profitable banking system can better withstand shocks and plays a stronger role in the stability of the financial system. Therefore, it is clear that the explanation of the factors affecting the financial performance of the banking system, as well as the stability of the financial systems, could be one of the major priorities for researchers (Athanasoglou et al., 2005). In recent years, several studies have investigated the factors that guarantee banking stability or lead to instability in banking sectors and identified a range of related factors at the bank and macroeconomic levels (Zaghdoudi, 2019; Pham et al., 2021; Tian, 2021; Shabir et al., 2021; Al Shboul et al., 2020; Valencia, 2016; Dagher et al., 2020).

Based on the "*concentration-stability perspective*" vision, in centralized banking systems, larger banks may increase profits and hence, reduce financial fragility by providing a higher "capital buffer" that protects them from external liquidity and macroeconomic shocks (Boyd et al., 2004; Uhde and Heimeshoff, 2009). In contrast, Meshkin (1999) argues that according to the "*fragility-concentration view*", larger banks are often more likely to receive public guarantees or subsidies, discussed as the "*too big to fail*" doctrine. Hence, the problem of moral hazard is exacerbated for the managers of larger banks when they make risky investments under the government's safety net. In related work, Laeven et al. (2014) have strongly confirmed that the increase in bank systematic risk is positively related to the bank size, supporting the view that large banks have too much systemic risk. According to the "*hypothesis of unstable banking*", as proposed by Shleifer and Vishny (2010) and Boot and Ratnovski (2012), large banks are more willing to participate in risky activities and are financed more with short-term debt; this leads to these banks being more vulnerable to general liquidity shocks and market failures. Kohler (2014) also considered the effect of banks' business models by the share of non-interest income on the total operating income and the share of non-deposit funding in total liabilities on the stability of banks in the EU. He found that the retail-oriented banks (smaller banks), rather than investment ones (larger banks), could be more stable if they produced a larger share of their income from non-traditional activities. Regarding the size of the bank, the impact of bank-size-stability and fund-risk-stability relationship in both Islamic and conventional banks of Pakistan has been considered by Ali and Puah (2018). They found that bank size could have a negative impact on stability under *Z*-score estimation, while funding risk has a positive correlation with the stability of the bank. Moreover, Adusei (2015), for the case of the banking industry in Ghana, explained that increasing the size of a rural bank could lead to increasing its stability. The findings, thus, show that bank stability is usually supported by bank size, as measured by the natural logarithm of total assets or deposits. This suggests that the purpose of expanding bank size about confidence stability in the financial market should be followed.

Another factor affecting the stability of banking sectors is credit risk. Credit risk refers to the risk of losses caused by non-repayment or late repayment by the customer. In other words, credit risk is a risk based on which the borrower will not be able to pay the principal and form of the loan according to the conditions specified in the contract. In connection with the relationship between credit risk and banking stability, several academic studies have been investigated in recent years (Djebali and Zaghdoudi, 2020; DeYoung & Karen, 2016). In general, Ng and

Roychowdhury (2011), Cole & White (2012), and DeYoung and Torna (2013), focusing on bank failures during the recent financial crisis, have shown that credit risk plays a vital role in the overall stability of a bank. Djebali and Zaghdoudi, (2020) using a panel smooth threshold regression model, also investigated the non-linear relationship between credit risks, liquidity risk, and bank stability for 75 conventional banks from the MENA zone during 1999 and 2017. Their empirical result revealed that below the threshold value, credit risk represented a positive and significant effect on bank stability; meanwhile, above it, a negative effect could be confirmed. On the contrary, some studies have found no significant influence of the risk of credit on the stability of banking sectors (Zaghdoudi, 2019). In a pioneering study done by Imbierowicz and Rauch (2014), for all US commercial banks during the 1998–2010 period, both credit risk and liquid risk could separately increase the banks' probabilities of default, while the effect of their interaction depended on the overall level of bank risk.

Nevertheless, the determinants of a bank's stability in an emerging country over the years from 2010 to 2018 have been investigated by Pham et al (2021). Applying the generalized method of moments (GMM) technique, they found that equity-to-asset ratio, bank size, loans-to-assets ratio, and revenue diversification had a positive impact on bank stability. For 49 banks in Tunisia over the period 2006-2015, Amara and Mabrouki (2019) considered the impact of credit risk and liquidity risk on Z-score, which could be regarded as a measure of bank stability bank stability. They found that both risks could separately affect bank stability, while their interaction contributed to bank instability. Vazquez and Federico (2015) also investigated the correlation between liquidity structure and leverage applied by banks and its effect on their stability during the financial crisis for 11,000 banks in the United States and Europe, finding that banks with low liquidity structure and high financial leverage had the highest risk of bankruptcy before the crisis.

Regarding the Iranian economy, using the dynamic panel data technique, Shahchera and Nourbakhsh (2015) analyzed the relationship between bank size and stability of banking performance in 17 public and private banks in Iran. They found that there was a two-way relationship between bank size and banking stability in the country's banking network. The effect of liquidity and credit risk on the banking stability of Iran's economy during the 2005 to 2015 period for 18 state and non-state banks was investigated by Asadi et al. (2020). Their findings showed that liquidity and credit risk significantly led to a decrease in banking stability and increasing the capital ratio improved the degree of banking stability. Additionally, Poustin Chi et al. (2016) analyzed the effect of competition in the banking industry on the stability of banks in the Iranian economy. They showed that there was a negative and significant relationship between the degree of competition and Z-score. Moreover, Nikomaram et al (2013) examined the effects of asset return (ROA) and banking stability and found that ROA had a positive and significant effect on bank stability, while the liquid banks were more solvent. Finally, Kouhileilan et al. (2021) examined the factors affecting banking stability in 15 selected countries of the MENA region between 2006 and 2018 within the framework of the Panel Smooth Transition Regression (PSTR) model. Their results show that in this group of countries, in the first and linear regime before the threshold limit, credit risk, facilities, and inflation have a negative and significant effect on banking stability, while in the second and non-linear regime, liquidity risk, credit risk, and asset returns have a positive and significant correlation with the banking system.

3. Data and Estimation Strategy

3.1 Methodology

In this section, to investigate the impacts of bank-specific indices on bank stability and also, to better address the nonlinear problem between bank size, credit risk, and Z-score, we utilize the fixed effect panel threshold regression method proposed by Hansen (1999, 2000), which is widely used in some studies (Akram and Rath, 2020; Urom et al., 2020; Shrawan and Dubey, 2021; Chattopadhyay et al., 2021; Djebali and Zaghdoudi, 2020). According to Wang and Wang (2021), the purpose of the panel threshold regression method is to identify a certain threshold value as an unknown variable in the regression, constructing a piecewise function, and estimating the corresponding threshold value, as well as analyzing the threshold effects.

Here, we specify the simplest form of panel threshold regression, which consists of a single threshold with two extreme regimes, as represented in the following equation:

$$y_{it} = \eta_i + \theta' x_{it} + z_{it} I(q_{it} \leq \tau)\varphi_1 + z_{it} I(q_{it} > \tau)\varphi_2 + \varepsilon_{it} \quad (1)$$

where i and t represent the cross-section and time dimensions of the panel, respectively, y_{it} is the explained variables of different types of Z-score, and x_{it} indicates the vector of regime independent explanatory variables including liquid risk, funding risk, return on asset and capital adequacy rate; also, q_{it} is the threshold variable of bank size and τ is the threshold parameter that divides the equation into two regimes with coefficients φ_1 and φ_2; z_{it} is the explanatory variables of credit risk allowed to change with the threshold variable. Further, η_i implies the individual fixed effects, I (.) is an indicator function showing the regime specified by the threshold variable and ε_{it} is the random interference term. Equation (1) can be rewritten in a simpler form as represented below:

$$y_{it} = \eta_i + \theta' x_{it} + z_{it}(q_{it}, \tau)\varphi + \varepsilon_{it} \quad (2)$$

where

$$z_{it}(q_{it},\tau)=\begin{cases}z_{it}I(q_{it}\leq\tau)\\z_{it}I(q_{it}>\tau)\end{cases} \qquad (3)$$

Since we tend to control for problems arising from the presence of endogeneity and heterogeneity when estimating the threshold effect, we have utilized the dynamic panel threshold regression proposed by Kremer et al. (2013), instead of the static cross-sectional threshold model extended by Caner and Hansen (2004), as can be seen below:

$$y_{it}=\eta_i+\partial y_{it-1}+\theta' x_{it}+z_{it}I(q_{it}\leq\tau)\varphi_1+z_{it}I(q_{it}>\tau)\varphi_2+\varepsilon_{it} \qquad (4)$$

where the lagged value of the dependent variable (y_{it-1}) is considered endogenous in Equation (4) and contains the dynamic information in the model. This view is based on the assumption that the structure and levels of banking stability in the banking sectors of an economy are not completely independent of previous periods. Therefore, the levels of banking stability in the previous period are reflected in the following periods. In the Hansen threshold regression criterion, the threshold is determined based on the minimization of the residual sum of squares, and the significance of the threshold is confirmed.

Further, to analyze the sensitivity and compare coefficients, we employed the panel-GMM (generalized method of moments) model proposed by Arellano and Bover (1995) and Blundell & Bond (1998), which is used significantly in studies. According to Dias and Tebaldi (2012), endogeneity and heterogeneity can best be addressed through a GMM panel data model, where differences between cross-sections are observed across and over time. Moreover, similar to our study, the GMM method also provides robust outcomes for series with time dimensions smaller than the number of cross-sections (Balcilar et al., 2020).

3.2 Data

This study employed an annual panel dataset consisting of 20 state and non-state banking sectors in Iran, covering a period from 2005 to 2020. Data was collected from multiple sources; for instance, bank-specific variables were extracted from the yearly reports of the Central Bank of Iran (CBI) and Iran Banking Institute (IBI), while macroeconomic variables were obtained from the Statistical Centre of Iran (SCI).

In line with earlier studies (Boyd and Graham, 1988; Demirgüc-Kunt and Huizinga, 2010; Stiroh and Rumble, 2006), we define the Z-score value as a main proxy for bank stability, which measures a bank's distance to insolvency, and it is inversely related to the probability of bank insolvency. In other words, a higher (lower) Z-score means a lower (higher) probability of failure or bankruptcy risk for the bank and thus, more (lower) financial stability at the bank level (Boyd and Runkle, 1993; Al Shboul et al., 2020). As argued by Nguyen (2021), the Z-score better shows the overall level of bank risk-taking. Therefore, we calculate the Z-score as follows:

$$Z - score\ (BSTA1) = \left[\frac{ROA_{i,t} + \frac{EQ_{i,t}}{AS_{i,t}}}{\rho\left(ROA_{i,t}\right)}\right] \quad (5)$$

where, i, t represents bank i in year t, $ROA_{i,t}$ is the return on the assets ratio, and $\frac{EQ_{i,t}}{AS_{i,t}}$ is the ratio of total equity ($EQ_{i,t}$) over the total assets ($AS_{i,t}$) of banking sectors and ρ indicates the standard deviation of ROA as a proxy for the volatility of returns. Following the study of Köhler (2015) and Adusei (2015), we have divided the Z-score value into two components as dependent variables to gain more insight into the relationship between the Z-score index and other independent variables. In the same direction as in Ali and Puah (2018), we call the names of these two indicators risk-adjusted ROA and risk-adjusted E/A ratio, which are represented by symbols $BSTA2$ and $BSTA3$, respectively, as follows:

$$Z - score\ (BSTA2) = \left[\frac{ROA_{i,t}}{\rho\left(ROA_{i,t}\right)}\right] \quad (6)$$

$$Z - score\ (BSTA3) = \left[\frac{\frac{EQ_{i,t}}{AS_{i,t}}}{\rho\left(ROA_{i,t}\right)}\right] \quad (7)$$

Additionally, we adopt two categories of explanatory variables in our panel data model. These include Bank-specific variables and the other macroeconomic exogenous variables affecting bank stability. According to Ghenimi et al. (2017), Djebali and Zaghdoudi (2020), Nguyen (2021), and Adusei (2015), the set of banking sector factors includes credit risk, funding risk, bank size, liquid risk, capital adequacy ratio, and ROA. Bank size is measured as the natural log of total assets and utilized to control for bank size effects; Credit risk is measured as non-performing loans to total loans; liquidity risk is computed by due balances and cash held at the other depository bank to the asset ratio. The capital adequacy ratio is measured as the total equity to total assets for measuring capitalization and is ROA defined as the ratio of the net income to total assets. Moreover, in line with Adusei (2015), bank funding risk, which is measured by a Z-score and implies the possibility of loss due to the decrease in the performance of the bank's deposit equipment, is defined as follows:

$$FUND = \left[\frac{\frac{SAV_{i,t}}{AS_{i,t}} + \frac{EQ_{i,t}}{AS_{i,t}}}{\rho\left(\frac{SAV_{i,t}}{AS_{i,t}}\right)}\right] \quad (8)$$

where i and t represent bank i in year t, $\frac{SAV_{i,t}}{AS_{i,t}}$ is the ratio of deposit to total asset, $\frac{EQ_{i,t}}{AS_{i,t}}$ is the ratio of equity ($EQ_{i,t}$) to total assets ($AS_{i,t}$), and ρ is the standard deviation of deposit to asset ratio. Therefore, it is argued that with an increase in the funding risk *Z*-score index, the financial resources of the bank will become more stable.

Also, inflation and GDP are considered macroeconomic explanatory time series data wan ith impact on banking stability. We apply inflation as the growth rate and the consumer price index as the proxy for monetary instability, so that an unstable monetary environment can be incompatible with the ability of banks to allocate resources effectively (Beck et al., 2006). In addition, GDP at constant prices is used as a proxy for the development of the whole economy. However, definitions, sources, and symbols related to all the variables under study in this article are shown in Table (1).

Table 1. Definitions and Sources of Variables

Variable	Definition	Measures	Source
Dependent Variables			
BSTA1	Bank stability	Calculated by Equation (5)	CBI and IBI and the Author's calculations
BSTA2	Bank stability as risk-adjusted ROA	Calculated by Equation (6)	CBI and IBI and the Author's calculations
BSTA3	Bank stability as risk-adjusted E/A	Calculated by Equation (7)	CBI and IBI and the Author's calculations
Independent Variables			
SIZE	Size of bank	The logarithm of total Assets	CBI and IBI and the Author's calculations
CRED	Credit Risk	Non-performing loans to Total loans	CBI and IBI and the Author's calculations
CAP	Capital Adequacy Ratio	Total Equity to Total Assets	CBI and IBI and the Author's calculations
FUND	Funding risk	Calculated by Equation (8)	CBI and IBI and the Author's calculations
LIQU	Liquidity Risk	Liquid Assets to Total Assets	CBI and IBI and the Author's calculations
ROA	return on asset	Net Income to Total Assets	CBI and IBI and the Author's calculations
INF	Inflation Rate	The growth rate of the consumer price index	SCI
GDP	Gross Domestic Product	GDP at constant prices	SCI

Source: Research finding.

Table 2. Descriptive Statistic

	Descriptive Statistic										
	$BSTA1$	$BSTA2$	$BSTA3$	$SIZE$	$CRED$	CAP	$FUND$	$LIQU$	ROA	INF	GDP
Mean	11.1	0.66	10.3	5.32	0.16	0.09	4.99	0.07	0.08	20.9	1.72
Median	7.44	0.42	6.39	5.35	0.13	0.06	4.64	0.03	0.00	16.9	3.13
Max	90.6	4.43	89.9	6.87	1.17	0.96	51.8	0.86	24.8	53.8	12.5
Min	-16.9	-3.64	-14.2	3.52	-0.04	-2.13	-88.5	0.00	-0.44	7.24	-7.71
Std. Dev	13.3	1.30	13.0	0.68	0.16	0.23	7.92	0.10	1.40	12.72	5.15
Skewness	2.5	-0.09	2.82	-0.32	2.67	-3.18	-5.21	4.05	17.6	1.15	-0.11
Kurtosis	11.9	4.13	13.2	2.58	12.4	47.4	72.7	24.5	313.3	3.53	2.69
Obs	316	316	316	316	316	316	316	316	316	316	316

Source: Research finding.

Table 3. Correlation Matrix

	Correlation Matrix										
	$BSTA1$	$BSTA2$	$BSTA3$	$SIZE$	$CRED$	CAP	$FUND$	$LIQU$	ROA	INF	GDP
$BSTA1$	1.00										
$BSTA2$	0.24	1.00									
$BSTA3$	0.99	0.16	1.00								
$SIZE$	-0.19	-0.31	-0.17	1.00							
$CRED$	-0.08	-0.17	-0.06	-0.05	1.00						
CAP	0.46	0.35	0.44	-0.32	-0.36	1.00					
$FUND$	0.33	0.28	0.31	-0.08	-0.37	0.78	1.00				
$LIQU$	0.07	0.06	0.07	-0.09	-0.16	0.34	0.001	1.00			
ROA	-0.02	0.16	-0.03	0.007	-0.05	-0.001	0.01	0.01	1.00		
INF	-0.04	0.07	-0.06	0.29	-0.01	-0.14	-0.12	0.03	0.14	1.00	
GDP	0.09	0.06	0.08	-0.18	-0.04	0.08	0.07	-0.03	0.02	-0.40	1.00

Source: Research finding.

Table 5. Panel Unit Root Tests

	IPS		ADF		PP	
	Level	First difference	Level	First difference	Level	First difference
***BSTA*1**	-5.54	-4.03*	52.3***	87.4*	92.7*	194.7*
	(0.29)	(0.00)	(0.09)	(0.00)	(0.00)	(0.00)
***BSTA*2**	-0.13	-4.27*	46.6	94.2*	67.9*	225.7*
	(0.44)	(0.00)	(0.21)	(0.00)	(0.00)	(0.00)
***BSTA*3**	-1.13***	-6.12*	62.0**	111.8*	132.6*	205.0*
	(0.09)	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)
SIZE	1.04	-2.53*	38.2	68.8*	68.7*	154.3*
	(0.85)	(0.00)	(0.54)	(0.00)	(0.00)	(0.00)
CRED	0.36	-3.40*	31.7	73.6*	61.0**	193.7*
	(0.64)	(0.00)	(0.81)	(0.00)	(0.01)	(0.00)
CAP	-1.18	-5.36*	61.5**	111.1*	130.2*	203.1*
	(0.11)	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)
FUND	-0.20	-4.82*	48.3	93.1*	75.8*	210.4*
	(0.41)	(0.00)	(0.17)	(0.00)	(0.00)	(0.00)
LIQU	-0.29	-3.70*	49.6	82.8*	63.1*	231.6*
	(0.38)	(0.00)	(0.14)	(0.00)	(0.01)	(0.00)
ROA	-0.28	-1.96**	47.8	74.5*	72.8*	200.4*
	(0.38)	(0.02)	(0.18)	(0.00)	(0.00)	(0.00)
INF	-1.48***	-3.00*	37.8	61.2**	7.67	61.2**
	(0.06)	(0.00)	(0.56)	(0.01)	(1.00)	(0.01)
GDP	-6.40*	-8.7*	111.0**	147.0*	184.3*	314.7*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)

Source: Researcher finding.

Note: (1) *, ** and *** indicate significance at 1, 5 and 10 percent levels, respectively. (2) p-value is in parenthesis. (3) Model estimated by Newey-West automatic bandwidth selection and Bartlett kernel.

The descriptive statistics of variables of all banks in the sample are presented in Table (2). Here we report the values of the mean, median, maximum, minimum, standard deviation, skewness and kurtosis. Starting with the bank stability index, for all banks, we observed that the mean and median of $BSTA1$ were more than those of $BSTA2$ and $BSTA3$. Also, the mean value for $SIZE$, $CRED$, CAP and $FUND$ was 5.32, 0.16, 0.09 and 4.99, respectively. Further, the standard deviation for all variables is shown to be positive. This positive value for $BSTA1$ was slightly more than that of $BSTA3$ and much more than that of $BSTA3$.

Table (3) presents the correlation coefficient among all variables under investigation in this research. We found that there was a strong positive correlation between $BSTA1$ and $BSTA3$, while no strict correlation could be observed with $BSTA2$. The table also indicates that $SIZE$ and $CRED$ are negatively correlated with all z-score measures, while this correlation for CAP and $FUND$ is positive.

Moreover, to check the presence of collinearity between variables, we utilize variance inflation factors (VIF), which is popular in the literature, providing a measure of multicollinearity among the independent variables in a multiple regression model. Table (4) indicates that the mean value of VIF is 2.12 and less than 10, so there is no the multicollinearity.

Table 4. Variance Inflation Factors

	VIF	1/VIF
$\boldsymbol{SIZE}$	1.37	0.73
$\boldsymbol{CRED}$	1.24	0.80
$\boldsymbol{CAP}$	5.04	0.19
$\boldsymbol{FUND}$	3.70	0.27
$\boldsymbol{LIQU}$	2.04	0.49
$\boldsymbol{ROA}$	1.04	0.96
$\boldsymbol{INF}$	1.34	0.74
$\boldsymbol{GDP}$	1.23	0.81
Mean VIF	2.12	

Source: Research finding.

4. Empirical Results

4.1 Panel Unit Root and Cointegration Results

In the first step, before applying the dynamic panel threshold regression model, we must make sure that the variables involved in the empirical analysis are stationary to avoid the spurious regression problem. For this purpose, we employed panel individual unit root tests established by Fisher type tests and Choi (2001) using ADF and PP tests (Phillips–Perron type); also, we applied IPS (Im, Pesaran and Shin), which are widely used in panel analysis. From Table (5), we could confirm that all variables under investigation are stationary as the first difference and the null hypothesis of non-stationary is rejected. We could, thus, certify that none of the series is integrated at the second order or $I(2)$.

Then, we proceed to confirm the long-run relationship among the variables via the Kao test based on Engle-Granger's (1987) two-step (residual-based) cointegration tests, which allow for cross-section-specific intercepts and homogeneous coefficients on the regressors. From Table (6), we observed that the Kao residual cointegration test confirmed the long-run relationship between variables in the three-baseline model, and the null hypothesis of no cointegration could be rejected.

Table 6. Kao Residual Cointegration Test

	ADF	
Dependent variable	t-statistic	prob
$\boldsymbol{BSTA1}$	-3.15*	0.00
$\boldsymbol{BSTA2}$	-3.41*	0.00
$\boldsymbol{BSTA3}$	-2.17**	0.01

Source: Research finding.
Note: *, **, and *** indicate significance at 1, 5, and 10 percent levels, respectively.

4.2 Baseline Panel Threshold Regression Results

In the next stage, to implement the panel threshold regression analysis, we apply bank size as the threshold parameter and use the non-linearity test, as suggested by Hansen (1996; 1999). As stated by Shrawan and Dubey (2021), Hansen's sup-LR test is used to test the null hypothesis of a linear specification against the alternative hypothesis of a non-linear threshold regression model. As presented in Table (7), for $BSTA1$ and $BSTA3$ models, the F-statistic confirmed that double thresholds were optimum. For both regressions, we found that F-statistics were higher than the critical value at a 1% level and the null hypothesis of a single threshold against a double threshold could be rejected. For $BSTA2$ equation, when $SIZE$ is defined as a threshold variable, F statistics and p-value obtained by the bootstrap method confirmed only the single threshold at 5% significant level.

Table 7. The Estimates of the Thresholds for Different Bank Stability Groups

	Threshold model				
	Number of Thresholds	F-statistic (prob)	Critical value 10%	5%	1%
$BSTA1$	Double	148.2* (0.00)	21.2	30.6	65.0
$BSTA2$	Single	13.1** (0.03)	10.4	12.3	20.7
$BSTA3$	Double	145.3* (0.00)	20.1	28.6	53.5

Source: Research finding.
Note: (1) *, **, and *** indicate significance at 1, 5, and 10 percent levels, respectively.

Table 8. Estimated Threshold Variables

Threshold variables	**Estimated thresholds**	**95% confidence interval**
$BSTA1$	3.89	[3.81, 3.95]
	5.75	[5.74, 5.77]
$BSTA2$	6.53	[6.48, 6.57]
$BSTA3$	3.88	[3.83, 3.95]
	5.75	[5.74, 5.77]

Source: Research finding.

Further, the point estimates of the thresholds and their asymptotic 95% confidence intervals for all three equations are presented in Table (8). The first threshold value of bank size for $BSTA1$ and $BSTA2$ regressions was 3.89 and 3.88 respectively, and the second one was 5.75 for both of them. This value for $BSTA2$ was 6.53.

To simplify the comparison in the panel threshold model, this current study utilized the panel GMM method to examine the impact of bank-specific control variables on the stability of banking sectors in Iran. Table (9) presents the result estimated by employing PTR and GMM regression from 2005 to 2020, in which $BSTA1$ has been defined as a dependent variable. In the threshold regression model, the coefficient of lagged bank stability is 0.36 and significant at a 1% level, in line with expectations, thus confirming the existence of the dynamic adjustment process in the Z-score. This positive correlation can also be seen in the GMM method. The bank size, as the threshold variable, also has weak negative impacts on bank stability, which is consistent with the previous research (Ali and Puah, 2018; Ghenimi et al., 2017, Nguyen et al., 2012), in which banks with large scale declined stability. This, thus, suggests that larger risk banks are more likely to fail and the view of *fragility-concentration* for overall banks in Iran can be proved. On the contrary, this relationship is insignificant in system GMM.

In addition, the results revealed that when the bank scale was lower than 3.89, credit risk had a significant negative effect on bank stability. The coefficient was 7.57, and it was significant at the 5% confidence level. Also, when the bank size exceeded 5.75, the credit risk increased significantly stability under the Z-score mode at 1% level, so that 1% increase in the risk of credit could lead to an increase of 19.2% in the stability of all private and state banks in Iran. The result in low regimes is consistent with Djebali and Zaghdoudi (2020), stating that below the threshold value, credit risk has a positive effect on stability since profitability and risks are tightly linked. It has also been revealed that in a larger scale banking system, rather than a small one, credit risk has stronger positive effects on the degree of overall stability proxied by the Z-score in Iran. However, this proves the risk-return hypothesis argued by Ćurak et al. (2012), based on which a higher loan-to-asset ratio is in line with higher credit risk exposure, which requires proportional compensation in the form of higher returns and improved profitability (Adusei, 2015). Moreover, a 1% increase in the credit risk leads to an increase of 2.19% in BSTA1 when the bank size is between 3.89% and 5.75%, but the beta is insignificant.

Regarding the capital adequacy ratio, it can be stated that the contribution of capital to assets ratio to stability under a Z-score model in PTR and GMM techniques is positive and statistically significant at a 1% level. These results, thus, confirm the finding of Shabir et al. (2021), indicating that better-capitalized banks usually face less risk. Also, this outcome is consistent with Mirzaei et al. (2013), who argued that well-capitalized banks face lower external financing costs, resulting in higher profitability. In such conditions, bank capital reacts as a safety net in the event of destabilizing developments in the economy.

Liquidity risk reflects the maturity mismatch that naturally exists in the banks' business model (Tian et al., 2021) and refers to whether the bank can meet the demand for liquidity promptly at a reasonable cost. However, the regression results, as can be seen from Table (9), indicate that in the baseline model, liquidity risk exerted a statistically significant negative effect, so that %1 increase in $LIQU$ led to a 15.9% decrease in the bank stability of Iran's banking sectors. These negative and significant results could also be confirmed in the system GMM model. This outcome was in line with those of Imbierowicz and Rauch (2014) and Ali and Puah (2018), implying that liquidity risk is negatively associated with the stability of the bank and more liquidity indicates less profitability and vice versa. The existence of liquidity risk and uncertainty about the future makes banks, face such risk, inevitably increasing assets with high liquidity and no return. This affects the return on assets and equity and leads to the instability of the bank by reducing profitability.

In addition, the bank funding risk affects stability under the Z-score negatively in Iran's banking sectors since the estimator is significantly negative at the 1% level. However, these coefficients are also proved in the GMM method. However, these findings are not consistent with those of Köhler (2015) and Adusei (2015), who illustrated that funding risk had a positive impact on bank stability, thus suggesting that the effective and efficient mobilization of deposits increases the financial stability of banks. Table (9) further shows that in both regressions, the role of the rate of return in overall banks' stability becomes insignificant in Iran, despite carrying the positive sign, as expected. From the macroeconomic perspective, the panel threshold regression shows that there is a strong significant positive relationship between GDP and the stability of Iran's banking industry and this positive relationship could also be confirmed in the GMM model. In line with general expectations, we found a strong significant positive relationship between inflation and Z-score, thus confirming the study of Srairi (2013). For instance, statistically, a 1% increase in Iran's inflation led to a 0.1% increase in financial stability in both techniques.

Notably, the Sargan test statistics show that we cannot reject the validity of the instruments and the instrument variables used in the GMM system estimation are suitable. On the other hand, the overall effectiveness of the instrumental variables in GMM has been considered by the Hansen test. Also, the P values of the Hansen statistic test confirmed that the overall instrumental variables were effective. Hence, the results of the diagnostic test illustrated that the model had preferred econometric properties. In addition, Figure (A1) in the appendix indicates the confidence interval construction for a two-threshold of the BSTA1 model.

Table 9. Threshold and GMM Results in Baseline Model for $BSTA1$

Variables	Threshold results		System GMM results	
	Coefficient	**t-statistic**	**Coefficient**	**t-statistic**
$\boldsymbol{BSTA1(-1)}$	0.36*	7.86 (0.00)	0.70*	13.8 (0.00)
$\boldsymbol{SIZE}$	-1.99***	-1.74 (0.08)	0.95	1.15 (0.25)
$\boldsymbol{CRED}$			4.36	1.45 (0.14)
$\boldsymbol{CRED}$ **(**$\boldsymbol{SIZE < 3.89}$)	7.57**	2.02(0.04)		
$\boldsymbol{CRED}$ **(3.89<** $\boldsymbol{SIZE < 5.75}$)	2.19	0.27 (0.74)		
$\boldsymbol{CRED}$ **(**$\boldsymbol{SIZE > 5.75}$)	19.2*	3.04 (0.00)		
$\boldsymbol{CAP}$	39.7*	6.90 (0.00)	22.7*	4.92 (0.00)
$\boldsymbol{FUND}$	-0.73*	-4.66 (0.00)	-0.31*	-3.15 (0.00)
$\boldsymbol{LIQU}$	-15.9*	-2.65 (0.00)	-16.9*	-3.77 (0.00)
$\boldsymbol{ROA}$	0.24	0.94 (0.34)	0.01	0.28 (0.78)
$\boldsymbol{INF}$	0.10*	3.21(0.00)	0.10*	2.77 (0.00)
$\boldsymbol{GDP}$	0.15**	2.04 (0.04)	0.12**	2.09 (0.03)
$\boldsymbol{Constant}$	14.0**	2.32 (0.02)	-4.96	-1.03 (0.30)
Number of obs	300			
Number of groups	20			
F-test	27.7 (0.00)			
$\boldsymbol{R^2}$ **_Overall**	0.58			
Number of obs			300	
Number of groups			20	
Wald Chi (2)			(0.00)	
Sargent test,			(0.07)	
Difference-in-Hansen test			(1.00)	
Arellano-Bond test for AR(1)			(0.21)	
Arellano-Bond test for AR(2)			(0.30)	

Source: Research finding.

Note: (1) *, **, and *** indicate significance at 1, 5, and 10 percent levels, respectively. (2) The p-value is in parenthesis.

Table 10. Threshold and GMM Results in Baseline Model for BSTA2

Variables	Threshold results		System GMM results	
	Coefficient	**t-statistic**	**Coefficient**	**t-statistic**
$BSTA2(-1)$	0.31*	5.61 (0.00)	0.68*	13.01 (0.00)
$SIZE$	-0.78*	-5.79 (0.00)	-0.25**	-1.96 (0.05)
$CRED$			-0.22	-0.66 (0.50)
$CRED\ (SIZE < 6.53)$	0.05	0.12 (0.90)		
$CRED\ (SIZE > 6.53)$	11.46*	3.55 (0.00)		
CAP	1.50**	2.15 (0.03)	0.07	0.17 (0.86)
$FUND$	-0.01	-0.69 (0.49)	0.01	1.36 (0.17)
$LIQU$	-1.39***	-1.81 (0.07)	0.42	0.72 (0.47)
ROA	0.17*	5.53 (0.00)	0.13*	18.6 (0.00)
INF	0.02*	5.47 (0.00)	0.02*	4.61 (0.00)
GDP	0.007	0.85 (0.39)	0.009	1.19 (0.23)
$Constant$	4.14*	5.74 (0.00)	1.00	1.39 (0.16)
Number of obs	300			
Number of group	20			
F-test	28.6 (0.00)			
R^2 **_Overall**	0.46			
Number of obs			300	
Number of groups			20	
Wald Chi (2)			(0.00)	
Sargent test,			(0.78)	
Difference-in-Hansen test			(1.00)	
Arellano-Bond test for AR (1)			(0.00)	
Arellano-Bond test for AR (2)			(0.19)	

Source: Research finding.

Note: (1) *, **, and *** indicate significance at 1, 5, and 10 percent levels, respectively. (2) The p-value is in parenthesis.

Table 11. Threshold and GMM Results in Baseline Model for BSTA3

Variables	Threshold results		System GMM results	
	Coefficient	t-statistic	Coefficient	t-statistic
$BSTA3(-1)$	0.36*	7.46 (0.00)	0.69*	14.5(0.00)
$SIZE$	-1.63	-1.40 (0.16)	1.04	1.35 (0.17)
$CRED$			4.83***	1.64 (0.09)
$CRED\ (SIZE < 3.88)$	7.60*	1.98 (0.04)		
$CRED\ (3.88 < SIZE < 5.75)$	3.61	0.44 (0.66)		
$CRED\ (SIZE > 5.75)$	20.6*	3.20 (0.00)		
CAP	37.3*	6.35 (0.00)	22.7*	4.59 (0.00)
$FUND$	-0.70*	-4.36 (0.00)	-0.33*	-3.14 (0.00)
$LIQU$	-14.4**	-2.34 (0.02)	-17.1*	-3.57 (0.00)
ROA	0.11	0.44 (0.66)	-0.09*	-2.73 (0.00)
INF	0.06***	1.86 (0.06)	0.06*	3.01 (0.00)
GDP	0.11	1.45 (0.14)	0.08**	2.06 (0.04)
$Constant$	12.5**	2.04 (0.04)	-4.56	-1.11 (0.26)
Number of obs	300			
Number of group	20			
F-test	22.7 (0.00)			
R^2 **_Overall**	0.57			
Number of obs			300	
Number of groups			20	
Wald Chi (2)			(0.00)	
Sargent test,			(0.13)	
Difference-in-Hansen test			(0.04)	
Arellano-Bond test for AR (1)			(0.23)	
Arellano-Bond test for AR (2)			(0.31)	

Source: Research finding.

Note: (1) *, **, and *** indicate significance at 1, 5, and 10 percent levels, respectively. (2) The p-value is in parenthesis.

However, in the risk-adjusted return on assets regression, one threshold could be confirmed to divide bank size into two intervals. Here, the most coefficient of bank-specific variables have the expected signs. From Table (10), we found that in a low regime (bank size lower than threshold value of 6.53), the impact of credit risk on risk-adjusted ROA was insignificant; meanwhile, in a high bank scale regime, we could confirm a significant positive relationship between credit risk and $BSTA2$ at 1% level, which was consistent with what was extracted in $BSTA1$ equation. Further, as expected, the results, as reported in Table (10), revealed that the size of the bank negatively and significantly affected stability when risk-adjusted ROA was used to measure bank stability in both PTR and GMM models, with a greater impact for the threshold model. The argument is in line with Altaee et al. (2013) and $BSTA1$ model, implying that large-scale banks have an adverse effect on the stability of the bank.

Generally, Table (10) indicates the results concerning the effects of other control variables. Our findings revealed that the stability of the bank had been positively influenced by an increase in the capital adequacy ratio. More precisely, a 1% rise in CAP caused risk-adjusted return on assets to increase by 1.50%. However, in the GMM model, this relationship was insignificant. Through our expectations, the coefficient of a general rate of return was positive and statistically significant at a 1% significance level in both models. More precisely, a 1% rise in ROA caused BSTA2 to accelerate by 0.17% and 0.13% in the threshold and GMM methods, respectively. This result was in line with the literature, such as Al-Shboul et al. (2020) and Shim (2019), suggesting that higher profitability and well-diversified loan portfolios are more stable. Notably, we found that the bank stability was inversely related to the liquid risk only in the threshold model. On the other hand, compared to the previous regression, the funding risk had an insignificant relationship with bank stability in the two types of models.

We could also prove that under the risk-adjusted ROA measures of bank stability, there was a strong statistically significant positive effect of inflation on bank stability, thus implying that an increase in inflation results in higher bank stability. Concerning GDP, we have not found any significant correlation between panel threshold and GMM estimations. Additionally, we found that the Hansen's J tests could not reject the null hypothesis of the joint validity of instruments.

Moreover, Table (11) presents the estimated threshold value of bank size for banking sectors when we apply the risk-adjusted E/A ratio as the proxy for bank stability as the dependent variable. We found that in the lower regime of bank size (<3.88), the impact of credit risk on risk-adjusted equity-to-assets ratio was positive and statistically significant, while in the median regime (3.88<size<5.75), we did not observe any significant relationship. Similarly, the positive effect of credit risk on the stability of the banking industry, when the bank scale was high, was statistically significant and the value of the coefficient was 20.6%. According to these outcomes, it could be clearly stated that under all three measures of bank stability, credit risk enhanced the degree of bank stability in many bank size regimes, especially in the upper and lower thresholds, thus suggesting that credit risk is a significant predictor of bank stability in Iran.

Turning to the covariates, the same as previous models, we found that the sign of inflation and the ratio of total equity over the total assets of the bank on the stability of Iran's banking systems, when risk-adjusted E/A ratio was used to measure stability, was statistically positive, while liquid risk and funding rate had a negative and significant effect on bank stability in both techniques. However, in threshold and GMM models, the coefficient of the first lag of bank stability was positive and statistically significant, thus implying that an increase in previous period bank stability could have a significant positive effect on the overall stability of banks in the current year. Also, the likelihood ratio function diagram plotted in Figure (A3) in the appendix can be used to derive thresholds and form a confidence interval process.

4.3 Robustness

In this section, to extract more reliable results and conduct further sensitivity analysis of the coefficients, banks were divided into two sectors: private (non-state) and state banks; then we examined the effects of threshold and control time series data on all three bank stability factors. The statistical description for the included variables, over the study period related to 8 state and 12 private banks, can be seen in the appendix. Table (A1) clearly shows that the mean value of bank stability under the main Z-score and risk-adjusted E/A ratio in state banks are more than those in the non-state ones; meanwhile, the size of private banks is bigger than Iran’s government banking industry. In addition, the appendix reveals that the mean value of VIF for state and non-state commercial banks is 1.57 and 3.13, respectively, which is less than 10, so rejecting the existence of multicollinearity in the two banking sectors. Regarding the stationary specification, from the appendix, the panel unit root test indicates that the null hypotheses of unit root presence in all state and non-state banking industry data can be rejected at the first-order difference of variables based on the high probability values of test statistics. Moreover, the Kao residual cointegration test established a long-run relationship between all bank stability factors and control variables as formalized in the baseline model and the null hypothesis of no cointegration could be rejected (See the Appendix).

As in the previous section, in the next step, we performed a threshold test in which F-statistics were obtained with bootstrap p-values by bootstrap approximation. As shown in Table (12), for state banking systems, the F-statistics of panel threshold effect tests indicated the presence of double optimum threshold in $BSTAB1$ and $BSTAB3$ models; meanwhile, for $BSTAB2$, we found single threshold effects. However, for $BSTA2$ and $BSTA3$ regressions in a non-state bank, F-statistic confirmed that double thresholds were optimum, while for $BSTA1$, we observed the single optimum threshold.

Table 12. The Number of Thresholds and Estimated Threshold Variables for State and Non-State Banking Sectors

Threshold variables	Number of Thresholds	Estimated thresholds	95% confidence interval
		State banks	
$\boldsymbol{BSTA1}$	Double	5.71	[5.70, 5.78]
		5.78	[5.75, 5.79]
$\boldsymbol{BSTA2}$	Single	6.33	[6.32, 6.39]
$\boldsymbol{BSTA3}$	Double	5.71	[5.70, 5.78]
		5.78	[5.75, 5.79]
		Nonstate banks	
$\boldsymbol{BSTA1}$	Single	5.81	[5.54, 5.82]
$\boldsymbol{BSTA2}$	Double	5.21	[5.16, 5.21]
		5.25	[5.24, 5.25]
$\boldsymbol{BSTA3}$	Double	5.64	[5.26, 5.73]
		5.66	[5.45, 5.67]

Source: Research finding.

As expected, the results, as reported in Table (13) for the main basic model, clearly showed that in two state and non-state bank estimations, the lagged dependent variable was positive and significant at a 1% level, thus confirming a high degree of persistence in Z-score as an indicator of bank stability. By running separate regressions for each group, the coefficient of size was positive in state banks estimation, while it was not significant for the non-state banks samples. Contrary to the previous section, we could confirm the hypothesis of *concentration-stability* as proposed by Boyd et al. (2004) for the state banking system in Iran, in the sense that larger banks may enhance profits and thus, reduce financial fragility by providing a higher "capital buffer" that protects them from external liquidity. However, in the non-state bank model, the impact of credit risk on bank stability was statistically significant (at a 10% level) only in the high-bank size regime and this coefficient was negative. Meanwhile, in the low-bank size regime (size<5.81), we did not find any significant relationship. In connection with the state banking model, we could observe that in high and low-bank size regimes (size<5.78 and size>5.81), the impact of credit risk on $BSTAB1$ was insignificant, but the estimated credit risk coefficient in the median-bank scale regime was strongly positive and significant at 1% level, thus suggesting that increase in credit risk strengthens stability. The results also revealed that there was a strong significant positive relationship between capital to assets ratio and measurement of capitalization and banks' stability in state and private regressions, as expected, thus indicating that banks more focused on capital adequacy rate are more stable. For instance, statistically, a 1% increase in CAP led to an 83% and 29% increase of $BSTA1$ in the state and non-state equations, respectively. Furthermore, our empirical results revealed some other interesting findings regarding the control variables. As shown in Table (13), the funding risk had a negative and significant effect on BSTA1 in only the non-state model. As in the previous section, the rate of return was found to be a significant and positive determinant of bank stability of non-state banks; however, in the state model, we observed an insignificant relationship. Related to the macroeconomic control variable, regression indicated that only in the state sample, there was a statistically significant positive relationship between GDP and Z-score at the 10% level, while the correlation between inflation and stability was insignificant in both banking industry models. This, thus, suggests that inflation by itself is not a significant predictor of banking stability in Iran.

Table 13. Threshold Results in Baseline Model for BSTA1

Variables	State bank		Non-state bank	
	Coefficient	t-statistic	Coefficient	t-statistic
$\boldsymbol{BSTA1(-1)}$	0.25*	3.86 (0.00)	0.21*	6.02 (0.00)
$\boldsymbol{SIZE}$	6.16**	2.11 (0.03)	-0.64	-1.38 (0.16)
$\boldsymbol{CRED\ (SIZE < 5.71)}$	0.88	0.11 (0.91)	-	-
$\boldsymbol{CRED\ (5.71 < SIZE < 5.78)}$	104.3*	5.04 (0.00)	-	-
$\boldsymbol{CRED\ (SIZE > 5.78)}$	18.4	1.35 (0.17)	-	-
$\boldsymbol{CRED\ (SIZE < 5.81)}$	-	-	1.12	0.70 (0.48)
$\boldsymbol{CRED\ (SIZE > 5.81)}$	-	-	-5.32***	-1.90 (0.06)
$\boldsymbol{CAP}$	83.3*	6.56 (0.00)	29.4*	11.07 (0.00)
$\boldsymbol{FUND}$	0.73	1.56 (0.12)	-0.65*	-8.54 (0.00)
$\boldsymbol{LIQU}$	-23.0	-1.32 (0.19)	-3.13	-1.20 (0.23)
$\boldsymbol{ROA}$	0.06	0.23 (0.81)	17.8*	2.87 (0.00)
$\boldsymbol{INF}$	0.01	0.32 (0.74)	0.07*	4.56 (0.00)
$\boldsymbol{GDP}$	0.22***	1.71 (0.09)	-0.01	-0.51 (0.61)
$\boldsymbol{Constant}$	-37.3**	-2.28 (0.02)	8.89*	3.65 (0.00)
Number of obs	120		180	
Number of groups	8		12	
F-test	26.3 (0.00)		62.3 (0.00)	
$\boldsymbol{R^2}$ **_Overall**	0.67		0.72	

Source: Research finding.

Note: (1) *, **, and *** indicate significance at 1, 5, and 10 percent levels, respectively. (2) The p-value is in parenthesis.

Contrary to the baseline estimation results, when we put risk-adjusted ROA as a dependent variable, in state banking system regression, credit risk could have negative effects on bank stability in only high bank size regimes at a 1% significant level (see, table 14). In the non-state model, we found that in a high regime (bank size above the threshold value of 5.22), the impact of credit risk on the second measure of banking stability was negative and significant; meanwhile, in a low bank size regime, we could confirm an insignificant correlation. On the other hand, when bank size was between 5.21 and 5.25 threshold point, the impact of credit risk on $BSTAB2$ was positive and significant, so a 1% increase in credit risk led to a 3.71% increase in $BSTAB2$ as a proxy for bank stability.

As expected, according to Table (14), the capital-to-assets ratio was positive and significantly connected with bank stability in the private bank model, suggesting that banks with sufficient capital usually face less risk. Also, the results represented the significant positive relationship between profitability and bank stability in two regression models. However, our empirical results presented an insignificant nexus between liquidity risk and $BSTAB2$. Based on the previous literature, we found that the coefficient sign of GDP and inflation as macroeconomic control variables were as expected in both equations.

Table 14. Threshold Results In Baseline Model for BSTA2

Variables	State bank		Non-state bank	
	Coefficient	t-statistic	Coefficient	t-statistic
$\boldsymbol{BSTA2(-1)}$	0.04	0.42 (0.67)	0.31*	5.01 (0.00)
$\boldsymbol{SIZE}$	-0.93*	-2.95 (0.00)	-0.40*	-3.06 (0.00)
$\boldsymbol{CRED\ (SIZE < 6.33)}$	1.28	1.48 (0.14)	-	-
$\boldsymbol{CRED\ (SIZE > 6.33)}$	-27.9*	-3.56 (0.00)	-	-
$\boldsymbol{CRED\ (SIZE < 5.21)}$	-	-	0.28	0.56 (0.57)
$\boldsymbol{CRED\ (5.21 < SIZE < 5.25)}$	-	-	3.71*	4.15 (0.00)
$\boldsymbol{CRED\ (SIZE > 5.25)}$	-	-	-1.75*	-3.05 (0.00)
$\boldsymbol{CAP}$	0.37	0.27 (0.78)	1.47**	1.94 (0.05)
$\boldsymbol{FUND}$	-0.02	-0.46 (0.64)	-0.09*	-3.98 (0.00)
$\boldsymbol{LIQU}$	-1.27	-0.67 (0.50)	-1.02	-1.23 (0.22)
$\boldsymbol{ROA}$	0.18*	5.61 (0.00)	18.7*	7.00 (0.00)
$\boldsymbol{INF}$	0.01**	2.42 (0.01)	0.02*	5.09 (0.00)
$\boldsymbol{GDP}$	0.03**	2.42 (0.01)	0.005	0.53 (0.59)
$\boldsymbol{Constant}$	4.56**	2.57 (0.01)	2.74*	3.88 (0.00)
Number of obs	120		180	
Number of groups	8		12	
F-test	11.9 (0.00)		28.0 (0.00)	
$\boldsymbol{R^2}$ **_Overall**	0.40		0.58	

Source: Research finding.

Note: (1) *, **, and *** indicate significance at 1, 5, and 10 percent levels, respectively. (2) The p-value is in parenthesis.

In the final stage, a similar analysis was repeated when we defined the risk-adjusted E/A ratio as a dependent sample to consider the impact of control variables on stability in two types of the banking industry. From Table (15), we observed the significant negative relationship between the proportion of total equity over total assets and the degree of bank stability held across two state and private bank regressions. Furthermore, the results revealed a significant nexus between the first lag of risk-adjusted E/A ratio and bank stability in the two types of banks. However, only in the state bank model, the bank scale was significantly positive in the regression for the Z-score at a 5 percent significant level, thus indicating that banks with higher size are more stable. Table (15) further shows that the effect of liquid risk and GDP on Z- score becomes insignificant in the two regressions, while the impact of inflation is positive and significant only in the non-state bank model.

In the state bank model, we found that only in the median regime (5.71<size<5.78), did the relationship between credit risk and stability become positive and significant, while for non-state banks, we observed that these positive correlations could be confirmed in both lower and median high scale regime.

Table 15. Threshold Results in Baseline Model for BSTA3

Variables	**State bank**		**Non-state bank**	
	Coefficient	t-statistic	Coefficient	t-statistic
$\boldsymbol{BSTA3(-1)}$	0.23*	3.32 (0.00)	0.21*	6.14 (0.00)
$\boldsymbol{SIZE}$	6.28**	2.02 (0.04)	-0.22	-0.53 (0.59)
$\boldsymbol{CRED\ (SIZE < 5.71)}$	-0.25	-0.03 (0.97)	-	-
$\boldsymbol{CRED\ (5.71 < SIZE < 5.78)}$	104.5*	4.77 (0.00)	-	-
$\boldsymbol{CRED\ (SIZE > 5.71)}$	17.8	1.23 (0.22)	-	-
$\boldsymbol{CRED\ (SIZE < 5.64)}$	-	-	2.57***	1.71 (0.08)
$\boldsymbol{CRED\ (5.64 < SIZE < 5.66)}$	-	-	105.8*	3.37 (0.00)
$\boldsymbol{CRED\ (SIZE > 5.66)}$	-	-	-2.42	-0.79 (0.44)
$\boldsymbol{CAP}$	84.3*	6.21 (0.00)	25.8*	11.09 (0.00)
$\boldsymbol{FUND}$	0.74***	1.64 (0.09)	-0.55*	-8.15 (0.00)
$\boldsymbol{LIQU}$	-19.7	-1.07 (0.28)	-0.26	-0.11 (0.91)
$\boldsymbol{ROA}$	-0.002	-0.01 (0.99)	11.1**	2.00 (0.04)
$\boldsymbol{INF}$	-0.05	-0.78 (0.43)	0.04*	3.55 (0.00)
$\boldsymbol{GDP}$	0.11	0.82 (0.41)	-0.004	-0.15 (0.87)
$\boldsymbol{Constant}$	-35.9**	-2.08 (0.04)	5.69*	2.64 (0.00)
Number of obs	120		180	
Number of groups	8		12	
F-test	21.9 (0.00)		56.5 (0.00)	
$\boldsymbol{R^2}$ **_Overall**	0.65		0.73	

Source: Research finding.

Note: (1) *, **, and *** indicate significance at 1, 5, and 10 percent levels, respectively. (2) The p-value is in parenthesis.

5. Conclusion

Financial markets in developing countries are important in terms of financing production projects due to the lack of resources and infrastructure; in the meantime, due to the lack of development of capital markets in countries, the money market has become doubly important. On the other hand, the existence of various financial risks in the banking system, especially credit risks, along with the difference in banking scales, makes banks' performance and stability difficult. In addition, the evaluation of factors affecting instability is considered one of the most important issues of the banking system of any country for the growth of that country's economy. Bank stability as the basic capital of the bank can help in compensating financial losses; as a factor in reducing shock transmission, it can make the bank's lending process easier and smoother. Also, the increase in the cost of providing financial resources has led to a decrease in the profitability of banks and as a result, their capital is reduced.

Hence, the innovation of the paper, compared to other studies, is that we have considered the impact of the credit risk and size of banks on the stability of Iran's state and non-state banking sectors concerning bank size at different threshold levels along with some control variables. To examine the potential correlation between bank stability and credit risk at different bank size levels, this study has built and estimated a dynamic panel threshold as well as panel GMM regressions. Here we define three proxies for bank stability namely, the main Z-score ($BSTA1$ model), risk-adjusted ROA ($BSTA2$ model), and risk-adjusted E/A ratio ($BSTA3$ model). We found that for $BSTA1$ and $BSTA3$ models, F-statistic confirmed that double thresholds were optimum, while when $SIZE$ is defined as a threshold variable, F statistics and p-value obtained by the bootstrap method confirmed only the single threshold. Our findings suggested that under different types of bank stability for 20 banking industries in Iran over the 2005–2020 period, the size of bank negatively affects bank stability all over Iran, confirming Ali and Puah (2018) and Ghenimi et al. (2017) in which banks with large scale declined stability. Whereas for separate public and private banks, these coefficients are somewhat heterogeneous. According to the findings obtained from this study, in a low and high bank size regime, the impact of credit risk on z-score was positive and significant and this result is consistent with Ćurak et al. (2012), confirming that credit risk could lead to improving the stability of the entire banking network of Iran's economy and higher loan-to-asset ratio is in line with higher credit risk exposure, which requires proportional compensation in the form of higher returns and improved profitability. Moreover, for the state banking system, a concentration-stability view could be proved in the sense that larger banks may enhance profits. In addition, as expected, higher levels of capital ratio and rate of return can help to enhance three proxies of bank stability in many models.

In terms of policy implications, our outcomes shed some light on the importance of appropriate mechanisms to promote the level of stability of banks. In the first stage, banks should make a double effort to allocate their resources and prevent the creation of outstanding claims. Also, by optimal management of costs and improvement of performance indicators in banks, they can have a suitable size for the respective bank. The size of the bank should be such that they can provide a variety of banking services based on market needs and manage risk by managing new methods. Considering the positive effects of credit risk on banking stability, credit risk management should be considered first to formulate strategies to reduce instability in the country's banking system.

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Appendix:

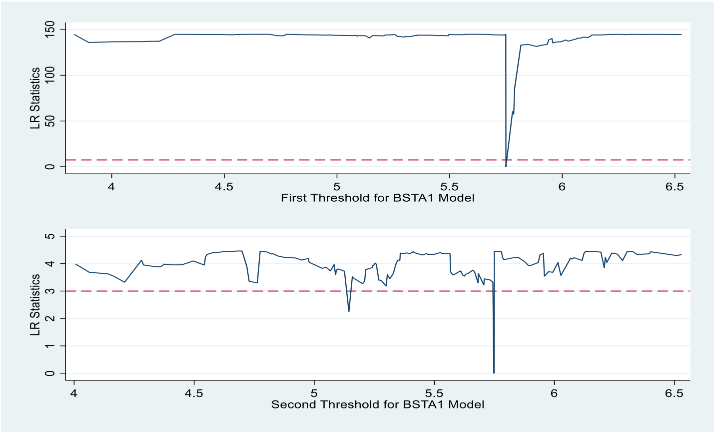

Figure A1. LR Statistic of Two thresholds in BSTA1 Model

Source: Research finding.

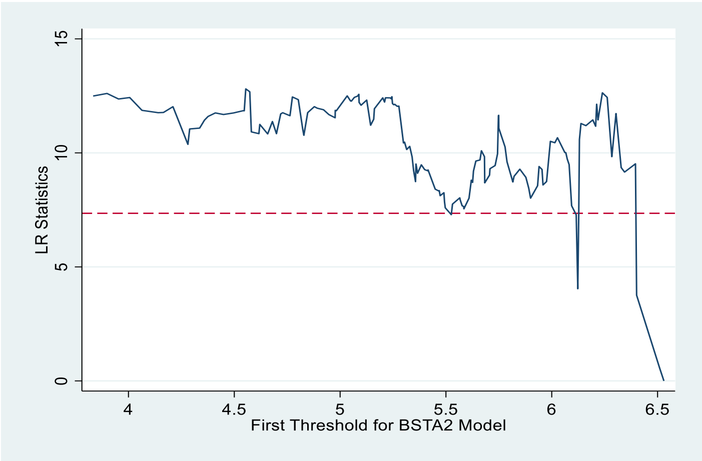

Figure A2. LR Statistic of Single Thresholds in BSTA2 Model

Source: Research finding.

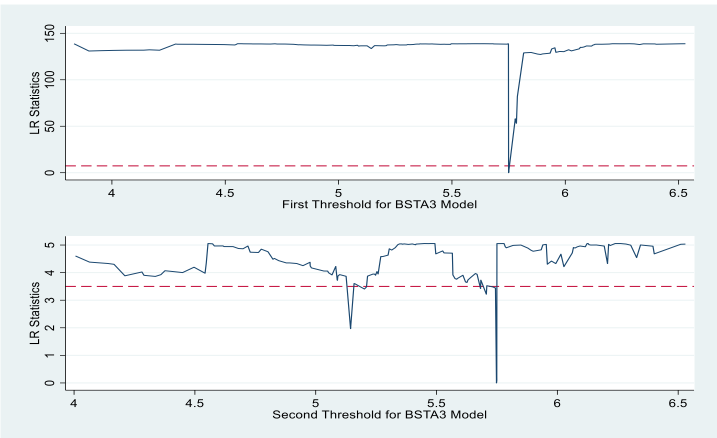

Figure A3. LR Statistic of Two Thresholds in BSTA3 Model

Source: Research finding.

Table A1. Descriptive Statistic for State and Non-State Banking Sectors

	$BSTA1$	$BSTA2$	$BSTA3$	$SIZE$	$CRED$	CAP	$FUND$	$LIQU$	ROA
State bank									
$Mean$	15.0	0.04	14.8	5.31	0.15	0.11	5.45	0.04	0.19
$Median$	7.49	0.06	7.41	5.35	0.12	0.06	4.76	0.02	0.00
Max	90.6	4.13	89.9	6.79	0.81	0.56	20.7	0.32	24.8
Min	-9.93	-3.64	-6.31	3.52	-0.04	-0.06	0.002	0.00	-0.03
$Std.Dev$	18.2	1.08	17.9	0.72	0.11	0.13	3.35	0.05	2.19
$Skewness$	1.67	-0.43	1.78	-0.38	2.37	1.50	2.14	2.40	11.1
$Kurtosis$	6.00	7.11	6.41	2.44	12.4	4.54	8.99	11.07	126.0
Non state bank									
$Mean$	8.32	1.07	7.25	5.33	0.18	0.08	4.66	0.08	0.008
$Median$	7.43	0.83	6.12	5.35	0.13	0.06	4.42	0.05	0.01
Max	62.7	4.43	59.2	6.87	1.17	0.96	51.8	0.86	0.09
Min	-16.9	-2.86	-14.2	3.56	0.00	-2.31	-88.5	0.001	-0.44
$Std.Dev$	7.42	1.27	6.65	0.66	0.19	0.27	9.84	0.12	0.05
$Skewness$	2.43	-0.21	3.11	-0.26	2.42	-3.66	-4.50	3.47	-6.67
$Kurtosis$	19.2	3.67	23.8	2.66	10.02	37.3	50.3	17.68	52.9

Source: Research finding.

Table A2. Variance Inflation Factors For State and Non-State Banking Sectors

	State bank		Non state bank	
	VIF	1/VIF	VIF	1/VIF
$SIZE$	1.80	0.55	1.18	0.84
$CRED$	1.42	0.70	1.49	0.66
CAP	2.55	0.39	9.60	0.10
$FUND$	1.69	0.59	5.06	0.19
$LIQU$	1.35	0.74	3.46	0.28
ROA	1.11	0.90	3.26	0.30
INF	1.42	0.70	1.35	0.74
GDP	1.26	0.79	1.22	0.81
Mean VIF	1.57		3.33	

Source: Research finding.

Table A3. Panel Unit Root Tests for State Bank

	State bank					
	IPS		ADF		PP	
	Level	First difference	Level	First difference	Level	First difference
$BSTA1$	-0.80 (0.21)	-5.78* (0.00)	17.9 (0.32)	66.8* (0.00)	20.6 (0.19)	110.9* (0.00)
$BSTA2$	-0.26 (0.39)	-4.25* (0.00)	17.5 (0.34)	52.5* (0.00)	26.0** (0.05)	119.7* (0.00)
$BSTA3$	-1.47*** (0.06)	-7.38* (0.00)	23.3 (0.10)	78.11* (0.00)	33.5* (0.00)	105.9* (0.00)
$SIZE$	1.38 (0.91)	-3.23* (0.00)	11.8 (0.75)	39.4* (0.00)	20.2 (0.21)	83.6* (0.00)
$CRED$	-1.16 (0.43)	-3.52* (0.00)	14.8 (0.53)	39.6* (0.00)	32.6* (0.00)	82.0* (0.00)

CAP	-1.43*** (0.07)	-7.41* (0.00)	22.9 (0.11)	78.3* (0.00)	33.1* (0.00)	103.7* (0.00)
FUND	-0.13 (0.44)	-5.17* (0.00)	14.2 (0.50)	56.7* (0.00)	21.3 (0.16)	120.3* (0.00)
LIQU	2.64 (0.99)	-1.73** (0.04)	3.81 (0.99)	25.0*** (0.06)	8.75 (0.92)	80.3* (0.00)
ROA	-0.20 (0.41)	-4.16* (0.00)	17.4 (0.35)	51.7* (0.00)	25.0*** (0.06)	117.6* (0.00)
INF	-1.18 (0.11)	-3.63* (0.00)	18.7 (0.28)	38.8* (0.00)	6.33 (0.98)	38.8* (0.00)
GDP	-5.74* (0.00)	-8.27* (0.00)	61.8* (0.00)	87.6* (0.00)	75.3* (0.00)	158.5* (0.00)

Source: Research finding.

Note: (1) *, **, and *** indicate significance at 1, 5, and 10 percent levels, respectively. (2) The p-value is in parenthesis. (3) The Model estimated by Newey-West automatic bandwidth selection and Bartlett kernel.

Table A4. Panel Unit Root Tests Non-State Bank

	non-state bank					
	IPS		ADF		PP	
	Level	First difference	Level	First difference	Level	First difference
BSTA1	0.11 (0.54)	-4.00* (0.00)	23.3 (0.50)	57.2* (0.00)	57.8* (0.00)	138.4* (0.00)
BSTA2	-0.42 (0.22)	-2.04** (0.02)	25.4 (0.38)	41.6** (0.01)	25.5 (0.37)	106.0* (0.00)
BSTA3	-0.71 (0.23)	-5.17* (0.00)	31.6 (0.13)	71.0* (0.00)	73.4* (0.00)	148.6* (0.00)
SIZE	6.01 (1.00)	-2.50* (0.00)	8.13 (0.99)	44.2* (0.00)	29.7 (0.19)	92.3* (0.00)
CRED	-1.29*** (0.09)	-3.57* (0.00)	32.0 (0.12)	52.9* (0.00)	35.3** (0.06)	129.7* (0.00)
CAP	-0.72 (0.23)	-5.13* (0.00)	32.6 (0.11)	71.9* (0.00)	87.8* (0.00)	142.8* (0.00)
FUND	-0.70 (0.23)	-4.45* (0.00)	28.2 (0.25)	62.6* (0.00)	51.5* (0.00)	109.9* (0.00)
LIQU	0.01 (0.50)	-6.89* (0.00)	33.0 (0.10)	93.6* (0.00)	39.1** (0.02)	172.7* (0.00)
ROA	-0.60 (0.27)	-2.72* (0.00)	25.8 (0.35)	49.7* (0.00)	27.2 (0.29)	125.7* (0.00)
INF	-1.44*** (0.07)	-4.45* (0.00)	28.0 (0.25)	58.2* (0.00)	9.49 (0.99)	58.2* (0.00)
GDP	-7.04* (0.00)	-10.1* (0.00)	92.8* (0.00)	131.5* (0.00)	112.9* (0.00)	237.7* (0.00)

Source: Research finding.

Note: (1) *, **, and *** indicate significance at 1, 5, and 10 percent levels, respectively. (2) The p-value is in parenthesis. (3) The Model estimated by Newey-West automatic bandwidth selection and Bartlett kernel.

Table A5. Kao Residual Cointegration Test for State and Non-State Banking Sectors

	ADF	
	State bank	Non state bank
Dependent variable		
$BSTA1$	-2.51*	-4.79*
	(0.00)	(0.00)
$BSTA2$	-3.82*	-3.11*
	(0.00)	(0.00)
$BSTA3$	-1.95*	-4.97*
	(0.00)	(0.00)

Source: Research finding.
Note: (1) *, **, and *** indicate significance at 1, 5, and 10 percent levels, respectively. (2) The p-value is in parenthesis.

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