Iranian Journal of Economic Studies, 13(2) 2024, 543-573

Shiraz University

Iranian Journal of Economic Studies

Journal homepage: ijes.shirazu.ac.ir

Linear and Non-Linear effect of Exchange Rate on Iranian Banks's Financial Soundnes

Azam Ahmadyan*[a], Mohammad Valipourpasha[b]

a. Department of Banking and Monetary Institutions , Monetary and Banking Research Academy, Tehran, Iran.

b. Central Bank of Iran, Tehran, Iran.

Article History

Received date: 27 April 2025
Revised date: 12 July 2025
Accepted date: 03 September 2025
Available online: 02 October 2025

JEL Classification

C11
C13
C59
D13
D21
E58
G21

Keyword

ARDL
State Space Model
Ownership
Size of banks

Abstract

This study investigates the linear and non-linear effects of official and non-official exchange rates on the financial soundness of Iranian banks, with a focus on ownership type (private-owned, state-owned commercial, and state-owned specialized banks). Using advanced econometric methodologies, including the ARDL and State Space methods, the analysis covers macroeconomic and bank-level data for the period 1996–2024. The study identifies distinct responses based on owner-ship type: while state-owned commercial and specialized banks are primarily affected by official exchange rates due to their reliance on government-determined rates, private banks demonstrate greater sensitivity to non-official exchange rates due to their exposure to informal currency markets. Internal financial metrics also significantly influence bank stability. Larger banks show greater resilience due to diversified portfolios, while high liquidity ratios positively impact short-term solvency. In contrast, over-reliance on loans and interbank liabilities increases credit and liquidity risks. Macroeconomic variables such as inflation exert negative effects, while economic growth and stock market performance improve financial soundness. This analysis underscores the importance of exchange rate management, targeted policy interventions, and ownership-specific strategies to enhance banking sector resilience in emerging markets. The findings contribute to existing literature by integrating new metrics for evaluating financial soundness and examining the dual impact of Iran's exchange rate regime on banking performance.

Highlights

- The results establish that both official and non-official exchange rates exert complex, non-linear effects on the financial soundness of Iranian banks.
- There is evidence of threshold effects, where moderate increases in exchange rates improve stability before excessive volatility leads to destabilization.
- State-owned banks are more vulnerable to official exchange rate fluctuations, while private banks exhibit stronger sensitivity to non-official exchange rates due to their reliance on informal currency market activities.
- In addition to exchange rate effects, internal financial metrics such as bank size, liquidity ratios, and investment deposits significantly enhance stability, whereas high loan-to-asset ratios and interest income dependency increase risks.
- Furthermore, macroeconomic variables show inflation negatively impacts financial soundness, while GDP growth and stock market performance have positive effects.

* a.ahmadian@mbri.ac.ir

DOI: 10.22099/ijes.2025.53065.2034

1. Introduction

The relationship between exchange rates and the financial soundness of banks is complex and multifaceted, with exchange rate fluctuations exerting significant influence on various aspects of banking operations, such as profitability, liquidity, and credit risk.

Exchange rate movements directly impact bank profitability by affecting foreign exchange transactions and investments. Banks exposed to assets or liabilities denominated in foreign currencies may experience gains or losses as exchange rates fluctuate. For example, Keshtgar et al. (2020) found that exchange rate volatility negatively impacts banks' capital return ratio in Iran, while simultaneously widening the financial gap, thereby increasing credit risk.

In terms of liquidity, exchange rate volatility can create challenges in managing foreign currency reserves and meeting short-term obligations. This may lead to liquidity shortages and higher borrowing costs. For instance, Njagi & Nzai (2022) highlighted that exchange rate volatility in the East African Community posed risks to banks' profitability by influencing their return on assets (ROA).

Exchange rate fluctuations also elevate credit risk, particularly for borrowers with foreign currency-denominated loans who may struggle to meet debt obligations during volatile periods. Carolyn et al. (2016) demonstrated that exchange rate volatility contributes to both an increase in profitability and heightened credit risks, reinforcing the notion that exchange rate instability can exert mixed effects depending on context.

This study empirically evaluates the impact of exchange rate fluctuations on the financial soundness of Iranian banks, using financial soundness indicators alongside financial statement and macroeconomic data spanning 1996 to 2024. The focus on Iran is justified by two primary factors. First, exchange rate volatility plays a pivotal role in shaping banks' financial strategies and stability. The Iranian banking sector, as the main driver of economic growth, is directly influenced by these fluctuations, which affect lending, liquidity, profitability, and overall risk management practices. Seyed Kalaei et al. (2021) found that following a significant exchange rate shock, Iranian banks initially increase their credit-to-deposit ratio due to optimism about favorable economic outcomes. However, prolonged volatility leads to decreased credit growth, underscoring the negative impact of persistent exchange rate fluctuations on lending behavior.

Contrary to expectations that higher exchange rates strengthen banks' financial positions, studies have shown that excessive appreciation beyond a critical threshold (Rials 42,475) destabilizes the banking system. Banks initially tolerate moderate fluctuations but succumb to instability when exchange rates rise dramatically, leading to higher non-performing loans (NPLs) and weaker profits (Mohammadi et al., 2020). Inflation reduces credit growth by diminishing purchasing power, while GDP growth positively contributes to financial health by improving credit availability (Seyed Kalaei et al., 2021).

Second, the effect of exchange rate fluctuations on financial soundness varies significantly based on bank ownership type (state-owned, private, or semi-

private). Ownership structure determines operational resilience and risk management approaches, particularly in response to macroeconomic shocks like exchange rate volatility.

This study makes several key contributions to the literature. First, it moves beyond traditional investigations focusing on specific financial metrics such as ROA, ROE, or NPL ratios (Bani Yousef et al., 2024; Cheluget et al., 2023) by introducing a composite metric for evaluating banking sector financial soundness based on insights from IMF (2019). Second, it innovatively analyzes the separate effects of Iran's dual exchange rate system (official and unofficial rates) on banks' financial soundness, revealing distinct impacts for these two exchange rate regimes. Unlike previous studies that examined only a single exchange rate, this approach provides a nuanced understanding of exchange rate dynamics.

Third, the study incorporates ownership type into its analysis, differentiating between state-owned and private banks to assess how each responds to exchange rate volatility. Past studies failed to consider these differences, making this investigation particularly critical in understanding the relative vulnerability of these ownership structures.

Forthly, this article examines both the linear and non-linear effects of official and unofficial exchange rates on the financial health of banks. This approach is unique compared to previous studies concentrated solely on the linear impacts of exchange rates on banking performance.

Finally, the study employs advanced econometric methodologies, including the ARDL model to evaluate exchange rate dynamics and their nonlinear effects, and the state-space approach to examine temporal impacts on banks' financial soundness. The state-space method adds a temporal lens to the analysis, enabling the assessment of specific shocks at particular time intervals. These novel techniques provide deeper insights into the complex interplay between exchange rate volatility and banking stability.

The analysis contributes meaningfully to the literature by integrating macroeconomic variables with bank-specific factors to document a comprehensive relationship between exchange rate fluctuations and banking performance. Furthermore, the dual focus on official and non-official exchange rates underscores the complexity of the Iranian economic context, particularly in light of its unique financial challenges stemming from inflationary pressures and foreign trade uncertainties. The results help inform strategies for mitigating the risks posed by exchange rate volatility and enhancing the resilience of banks in emerging economies.

The structure of the paper is as follows: Section 2 provides a review of the relevant literature; Section 3 outlines the methodology and describes the data; Section 4 presents and discusses the empirical results; and Section 5 concludes with key implications and offers recommendations for policy and future research.

2. Literature Review

The banking sector plays a critical role in promoting economic growth, especially in countries with underdeveloped capital markets, by providing essential funds for investment activities. Bank performance has significance at both micro and macroeconomic levels. At the micro level, the financial soundness of banks is crucial for maintaining competitive institutions capable of offering low-cost funding. At the macro level, a robust banking sector enhances resilience to economic shocks and supports the stability of the overall financial system. Over time, financial crises have illustrated the dependence of banking sector performance on macroeconomic conditions. Economic disruptions, such as fluctuations in GDP growth, exchange rate volatility, and inflation variation, have historically contributed to banking crises and financial system instability. Conversely, changes in bank performance impact credit conditions, either amplifying or mitigating macroeconomic shocks.

Theoretical and empirical studies consistently emphasize the interconnectedness of banking performance, solvency risks, and key macroeconomic indicators such as GDP, inflation, and exchange rates. For example, the substantial costs of financial crises—alongside government interventions to stabilize banking systems, as seen during the 2008 U.S. financial crisis—highlight the importance of this relationship. During that period, government measures such as loans, guarantees, and bailouts were necessary to address liquidity and credit crunches, reinforcing the banking sector's central role in economic equilibrium.

The impact of foreign exchange rate volatility on the financial performance of banks has drawn significant attention from researchers and policymakers alike. While macroeconomic factors like GDP, inflation, and interest rates have been intensively studied in relation to banking, the effects of exchange rate exposures on banks' profitability and financial stability remain relatively underexplored. Many studies focus either on how exchange rates affect bank profitability indirectly, as part of a broader economic framework, or on the direct consequences of currency volatility on bank performance. Despite the agreement that exchange rate fluctuations influence banking, the nature and direction of this impact vary across studies.

Several studies have explored the link between exchange rate fluctuations and banking performance indicators—such as Return on Assets (ROA), Return on Equity (ROE), and Net Interest Margin (NIM)—yielding mixed evidence. Chamberlain, Howe, & Popper (1997); Ngerebo (2011); Babazadeh & Farrokhnejad (2012); Acaravci & Çalim (2013); and Issac (2015) report a positive association, noting that exchange rate volatility can create profit opportunities for banks engaged in foreign exchange operations. Conversely, research by Taiwo and Adesola (2013); Almaqtari et al. (2018); and Hasanov, Bayramli, & Al-Musehel (2018) finds a negative relationship, indicating that such volatility amplifies uncertainty and risk exposure, thereby eroding profitability.

Bank performance in these studies is typically assessed using indicators such as ROA, ROE, and NIM. ROA measures management efficiency in utilizing assets, ROE evaluates shareholder returns, and NIM reflects the profitability of interest-generating activities. These indicators are examined through various methodologies, including Ordinary Least Squares (OLS), fixed and random effects models, Error Correction Models (ECM), Generalized Method of Moments (GMM), and Autoregressive Distributed Lag Models (ARDL).

The variability in results stems from differences in the specific measures of bank performance, as well as country-specific or bank-specific factors. For instance, Kemisola et al. (2016) argue that the choice of metric strongly affects the observed relationships, while Almaqtari et al., (2018) highlight the effects of local currency depreciation. Wong et al., (2009) also note that bank size may influence the magnitude and direction of the impact. These complexities suggest that further research is needed to fully understand the relationship between exchange rate volatility and banking performance, particularly in diverse economic contexts.

Some region-specific investigations further elaborate on this dynamic. For instance, Bani Yousef et al., (2024) examined how exchange rate fluctuations impact bank profitability and risk management across 14 MENA countries, concluding that exposure to foreign exchange risk negatively correlates with financial performance. Similarly, Cheluget et al., (2023) analyzed the effects of exchange rates and inflation on Kenyan banking performance, finding that while inflation positively influences profitability, exchange rate volatility weakens it due to increased credit costs and loan defaults. In Sudan, Abbas Elhussein & Elfaki Osman (2019) noted that exchange rate fluctuations had minimal influence on banking performance, attributing this to the prolonged economic embargo and limited integration with global markets, reducing banks' exposure to foreign exchange operations.

In Iran, Keshtgar et al. (2020) found that exchange rate volatility negatively impacted profitability in a study of 14 Iranian banks between 2007 and 2017. Using GARCH methods and panel data models, the research emphasized the risks posed by currency fluctuations, including rising credit risks and widening financial gaps. These findings resonate with broader research, such as Agénor et al. (2020), which identified a destabilizing effect of currency volatility on Iranian banks' lending and credit structures.

Collectively, these studies underline the essential role of exchange rate volatility in shaping banking sector performance and underscore the need for robust risk management strategies and adaptive economic policies to mitigate these effects. Further research is encouraged to refine existing models and expand the understanding of how exchange rate fluctuations influence bank soundness.

The fundamental distinction of this article compared to the literature lies in its incorporation of both official and non-official exchange rates and its analysis of their linear and non-linear effects on the financial soundness of banks. While prior studies in the literature typically focus on only one type of exchange rate

and adopt a linear approach to evaluate its impact on the financial soundness of banks, this paper introduces a more comprehensive techniques.

Furthermore, while previous research emphasizes a single aspect of bank financial soundness, such as profitability or asset quality, this article develops a new composite measure of financial health based on CAELS methodology. This innovative approach allows for a broader and more integrated assessment of banking sector stability, setting it apart from traditional studies that rely on narrow performance indicators.

3. The Study Model

3.1 Data description

Our dataset integrates bank-level and macroeconomic data from two primary sources: bank-specific information obtained from the Iran Banking Institute and macroeconomic indicators drawn from the Central Bank's economic time-series database. The final dataset comprises 25 bank observations spanning the period 1996–2024. Building on the existing literature on banks' financial soundness, we have constructed a novel variable to measure financial stability.This measure is based on 2019 financial soundness indicators compilation guide (2019 FSIs Guide)[1]it is a composite indicator. The new financial soundness is dependent variable. The dynamic explanatory variable will be one of the official exchange rateand non − official exchange rate. To investigate the non-linear effect of the exchange rate, we have used the official exchange rate^2 and non − official exchange rate^2.The official exchange rate^2 and non-official exchange rate^2 are dynamic explanatory variables.Other dynamic explanatory variables are the liquid asset to total assets, loans to total assets, due to banks to total liabilities, investment deposit to total liabilities as asset and liability combination and so economic gorwth and stock price as macroeconomics variables.

In accordance with previous studies, we incorporate the next set of fixed explanatory variables. Since the effect of exchange rate can be different according to the different ownership, we use interaction term between official exchange rate and non- official exchange rate with ownership (official exchange rate ∗ ownership and non − official exchange rate ∗ ownership). Ownership is dummy variable so this variable is one if it is a private-owned bank and zero otherwise.

[1] International Monetary Fund, 2019. Financial Soundness Indicators Compilation Guide. International Monetary Fund, publisher.

Table 1.Variables

Symbol	definition	Reference
official exchange rate	the exchange rate that it is obtained officially by Iranian government	Economic Time Series Database, Central bank of Iran, https://cbi.ir/page/8020.aspx
non − official exchange rate	the exchange rate that it means the rate of buying and selling currency in the informal and non-governmental market.	Economic Time Series Database, Central bank of Iran, https://cbi.ir/page/8020.aspx
size	the natural logarithm of total assets	Performance report of the Iranian's banks. 1996-2024. Iran Banking Institute and researcher calculations
liquid asset to total assets	the ratio of liquid assets to total assets	Performance report of the Iranian's banks. 1996-2024. Iran Banking Institute and researcher calculations
loan to total assets	the ratio of loan to total assets	Performance report of the Iranian's banks. 1996-2024. Iran Banking Institute and researcher calculations
due to banks to total liabilities	the ratio of due to banks to total liabilities	Performance report of the Iranian's banks. 1996-2024. Iran Banking Institute and researcher calculations
investment deposit to total liabilities	the ratio of investment deposit to total liabilities	Performance report of the Iranian's banks. 1996-2024. Iran Banking Institute and researcher calculations
interest income to total incomes	the ratio of interest income to total incomes	Performance report of the Iranian's banks. 1996-2024. Iran Banking Institute and researcher calculations
inflation	the percentage changes in the CPI index	Economic Time Series Database, Central bank of Iran, https://cbi.ir/page/8020.aspx
economic growth	the annual growth rate of GDP	Economic Time Series Database, Central bank of

		Iran, https://cbi.ir/page/8020.aspx
stock price index,	which is used as a index to measure the overall performance of the stock market, is obtained by dividing the current value of the stock market at the given time by the current value of the stock market in the base year and multiplying the result by 100.	Economic Time Series Database, Central bank of Iran, https://cbi.ir/page/8020.aspx

Source: *Economic Time Series Database, Central bank of Iran and Iran Banking Institute*

3.2 Construction of new financial soundness

We construct a new financial soundness indicator. Table 2 indicates financial soundness indicators used in constructing new financial soundness.

Table 2. Financial Soundness indicators

Core	indicators
Capital Adequacy	Regulatory capital to risk-weighted assets
	Tier 1 capital to risk-weighted assets
Asset Quality	Non-performing loans to total gross loans
Earning and Profitability	Return on assets
	Return on equity
	Interest margin to gross income
Liquidity	Liquid assets to total assets
	Liquid assets to short term liabilities

Notes: We used IMF(2019) to introduce financial soundness indicators. But the indicators have been selected that can be calculated based on the data disclosed by the banks. Since the sensitivity to market risk could not be calculated using the disclosed data, it has been excluded from the financial soundness indicators.

Source: *Researcher calculations*

We use the next steps to construct of new financial soundness. First, we aggregate financial statements of total banks. Second we make each of indicators in Table 1. Third, the indicators are normalized using (1).

$$I_{ti} = \frac{X_{it} - \min(X_{it})}{\max(X_i t) - \min(X_i t)} \quad (1)$$

i, is each of financial soundness indicators. I_{ti} is normalized financial soundness indicators in Table 1. X_{it} is each of financial soundness indicators. $\min(X_{it})$ is min of financial soundness indicator during 1996-2021. $\max(X_i t)$ is max of financial soundness indicator during 1996-2021.

Fourth, new financial soundness indicator construct using (2).

$$\text{new financial soundness}_t = \frac{\sum_{t=0}^{t=t} I_{ti}}{n} \quad (2)$$

n is number of indicators that it is 8. The new financial soundness_t is between -1 and 1.If the $new\ financial\ soundness_t$ is between zero and negative one, it indicates low financial soundness, and if the $new\ financial\ soundness_t$ is between zero and one, it indicates strong financial soundness.

3.3 Descriptive statistics

Table 3 presents the summary statistics for the variables used in this study, with particular emphasis on the newly developed financial soundness variable, exchange rate measures, bank performance indicators, and key macroeconomic variables. We observe that during 1996-2024, the new financial soundness exhibits a mean of 0.51, meaning that the financial soundness of Iranian banks is at an average level. Regarding the banks performance variables, liquid assets exhibits a mean to 10.6 % of the total assets and loans exhibits a mean 66.6 % of the total assets of the Iranian banking system. This statistic shows, firstly, in time of sudden withdrawal of deposits from banks, Iranian banks cannot respond to customers due to the low liquid assets to total assets. Secondly, the share of more than 50% of loans to assets can increase the credit risk of banks in future periods. Thirdly, the share of more than 50% of the loans to total assets can have a positive effect on the profitability of Iranian banks. As can be seen, interest income constitutes 88% of the total income. This statistic shows that the income of Iranian banks is mainly focused on interest income rather than non-interest income. The reason is the non-use of modern financial tools in Iranian banking network. Investment exhibits a mean to 81.3% of the total liabilities. This statistic confirms that, first, banks have enough long-term resources to provide facilities. Second, due to the mismatch of maturity, in liquidity risk of banks increase in future periods.

Table 3. Descriptive Statistics.

	(1)	(2)	(3)	(4)	(5)	(6)
	N	mean	Std.Dev	P1	P2	P3
new financial soundness	26	0.510	0.206	-0.046	0.071	-0.469
Exchange rates:						
official exchange rate	26	16420.81	14522.23	0.296	0.407	0.189
non − official exchange rate	26	40222.31	65135.37	0.215	0.385	0.342
Banks performance variables:						
size	26	5.241	0.351	0.277	-0.279	0.291

liquid assets to total assets	26	10.676	5.590	0.442	0.214	0.053
loan to total assets	26	66.652	0.569	-0.425	-0.219	0.243
due to banks to total liabilities	26	1.586	1.789	0.168	-0.379	-0.226
investment deposit to total liabilities	26	81.394	4.819	-0.261	0.264	0.339
interest income to total incomes	26	88.686	7.094	-0.303	-0.144	0.396
Macroeconomic variables:						
inflation	26	18.707	7.748	0.186	-0.330	0.270
economic growth	26	6.088	3.889	-0.209	0.321	-0.281
stock price index	26	30324.39	26123.10	0.377	-0.244	-0.038

Notes: Table reports selected descriptive statistics for the variables included in the analysis. new financial soundness is the composite of financial soundness indicators.
Source: *Researcher calculations*

Table 4 reports descriptive statistics of the variables used in our study across banks with high and low financial soundness. We can observe that low financial soundness banks exhibit higher loan to total assets , compared to high financial soundness. This evidence highlights the importance of credit risk management for banks. In addition to this, low financial soundness banks shows higher due to banks to total liabilities, lower investment deposit to total liabilities, and lower interest income to total incomes, relative to high financial soundness banks. This result exhibit that low financial soundness banks indicate more liquidity risk and interest expense compared to high financial soundness banks. So, liquidity risk management and asset and liability management are important for low financial soundness banks.

Table 4. Descriptive statistics-subsample.

	High Soundness		Low Soundness		Deffere nce	t-stat
	Mean	Std.Dev	Mean	Std.Dev		
new financial soundness	0.366	0.391	0.136	0.169		2.075**
Exchange rates:						
official exchange rate	521.317	3484.701	892.394	5252.883		-1.189***
non − official exchange rate	1269.272	1351.77	2193.573	17405.42		-2.772**
Banks performance variables:						
size	1.980	2.473	2.184	2.565		-2.067*

liquid assets to total assets	5.234	9.004	6.190	12.12	3.059***
loan to total assets	23.352	3.094	65.190	12.125	-3.326***
due to banks to total liabilitie	23.496	6.541	24.257	6.585	-2.381**
investment deposit to total li	62.003	31.958	61.196	30.464	-2.532***
interest income to total incon	53.011	40.242	51.098	40.592	3.757***
Macroeconomic variables:					
inflation	9.327	11.214	9.845	11.196	-0.546
economic growth	1.241	3.130	1.361	3.176	0.179
stock price index	16318.43	25481.71	18391.55	26541.19	0.677

*Notes: Table 3 reports the mean, the standard deviation and the test of difference in means for variables included in the analysis and for subsample of banks with high and low financial soundness. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.*
Source: *Researcher calculations*

Table A1 presents the correlations among the study variables, revealing a negative and statistically significant relationship between the newly developed bank financial soundness variable and both the official and unofficial exchange rates.This result exhibit the importance of exchange rate management in Iran. In addition the correlation between new financial soundness and the ratio of loan to total assets is negative and significant. This evidence is due to the fact that with the increase of loans, non-performing loans increase, so increasing the ratio of loans to total assets reduces the financial soundness of banks. The correlation between new financial soundness and economic growth is negative and significant. If the economic growth increases, the demand for loans increases and the increase in demand for loans can increase non-performing loans and the credit risk of banks increases. Therefore, the financial soundness of banks decreases.

3.4 Econometric specification

To examine the effect of exchange rates (official exchange rate and non-official exchange rate) on financial soundness indicator, we propose Eq. (1):

$$\text{soundness}_t = \beta_0 \text{main dynamic explanatory variable}_t + \beta_1 0\text{ther dynamic explanatory variable}_t + \sum_{i=1}^{i=3} \beta_i \text{ Fixed explanatory variables}_t + \varepsilon_t \quad (1)$$

The main dynamic explanatory variable will be one of the official exchange rate and non official exchange rate,official exchange rate^2, nonofficial exchange rate^2. Other dynamic explanatory variables are: size, liquid asset to total assets, loan to total assets, due to banks to total liabilities, investment deposit to total liabilities, interest income to total incomes, inflation, economic growth, and stock market index. ε_t is the error term.

Also, the fixed explanatory variables in different estimations will be official exchange rateownership,and non official exchange rate ownership.

Official and non-official exchange rates will allow us to examine the direct effects of exchange rate on banks financial soundness. official exchange rate^2 and non − official exchange rate^2 represents the non-linear effect of exchange rates on banks financial soundness. We examine the indirect impact of banks financial soundness to exchange rates through the ownership of banks, with official exchange rate ∗ ownership, and non − official exchange rate ∗ ownership. These variables, show effect of the interaction term between the official and non-official exchange rate and the ownership of banks.

Consequently, we have different estimates of Eq. (1). First, the ARDL method has been used to examine the dynamics of the effect of official and non-official exchange rates on the financial soundness of banks. Second, to separate the effect of the exchange rates on the financial soundness of banks according to the type of ownership of banks (private owned, commercial state-owned and specialized state-owned banks), Eq. (1) is estimated using the State Space method for each of private owned banks, commercial state-owned banks and specialized state-owned banks.

4. Methodology and Stylized Facts

The central bank and Statistical center of Iran data were used during 1996-2024, and the ARDL and State Space method is used to estimation.

4.1 Main Results

Table A2 indicates Unitroot test . Some variables such as Liquid asst to total asset, Due to banks to total liabilities, Interest income to total income, have a unit root and become stationary after first differencing. Other variables are stationary at level.

Table B1 reports the results for the different estimation of Eq.(1). Official exchange rate and non—official exchange rate are dynamic explanatory variables in Panel A and B of Table B1. Columns (1) and (2) in Panel A examines the linear and non-linear effects of the official exchange rate on the banks' new financial soundness without control variables and with control variables respectively. Column (5) and (6) in Panel B examines the linear and non-linear effects of non-official exchange rate on the banks' new financial soundness without control variables and with control variables respectively. Results confirm inverse U shaped relationship between exchange rates and banks' new financial soundness. So an increase in the official exchange rate and non- official exchange rate up to threshold improves financial soundness, and after that, an increase in the official exchange rate reduces financial soundness. This result confirms the existence of a threshold for the official and non-official exchange rate.

Likewise, in Columns (3) and (4) in Panel A of Table B1we explore the impact of official exchange rate*ownership on banks' new financial soundness with control variables and without control variables. Also, in Column (7) and (8)

in Panel B of Table B1, we explain the impact of non-official exchange rate*ownership on banks' new financial soundness without control variables and with control variables. Official exchange rate*ownership and non-official exchange rate*ownership are fixed explanatory variables in Columns (3), (4), (7) and (8). Ownership is dummy variable that it is 1 if banks are private owned banks and other it is 0. The negative sign of the official exchange rate*ownership demonstrates an increase in the official exchange rate has a negative effect on the private owned banks' financial soundness, but an increase in the non-official exchange rate has a positive effect on the private owned banks' financial soundness. This result confirms exchange rates have different effect on the financial soundness of banks according different ownership. Also, according to the nature of activity of private banks that are focused on buying and selling foreign exchange, the profit from buying and selling non-official exchange rate is more than the profit from buying and selling official exchange rate. For this reason, the official exchange rate has a negative effect on the financial soundness of private banks and the non-official exchange rate has a positive effect on the financial soundness of private banks.

The comparison of the coefficients in all estimation shows that the effect of the exchange rate decreases with the addition of control variables. This results shows the importance of the effect of control variables on the financial soundness of banks.

Bank size exhibits a positive and significant relationship with financial soundness, indicating that larger banks are better equipped to weather exchange rate volatility due to their capital buffers and diversified portfolios.

Liquid Assets to Total Assets indicate liquidity positively contributes to financial stability across the models. Banks with higher liquidity ratios tend to manage short-term obligations better, which improves their overall financial soundness.

A negative relationship exists between the loan-to-asset ratio and financial soundness, as over-reliance on loans increases exposure to non-performing loans (NPLs), especially during periods of exchange rate volatility.

Due to Banks-to-Total Liability is negatively associated with financial soundness, emphasizing the detrimental effects of rising interbank borrowing on stability, likely due to increased refinancing costs during volatile periods.

A significant positive effect of Investment Deposits to Total Liabilities indicates that higher investment deposits boost financial stability, providing banks with stable funding sources.

Interest Income to Total Income has a negative effect, suggesting that excessive reliance on interest income can expose banks to risks, especially during economic downturns when interest margins shrink.

Inflation negatively impacts financial soundness as it raises borrowing costs and decreases credit growth. Conversely, economic growth tends to support financial stability by improving borrowers' ability to repay loans and enhancing bank profitability.

A strong positive relationship is evident between the stock price index and financial soundness, as rising stock prices improve capital buffers, investor confidence, and access to funding.

This analysis highlights the complex interplay between exchange rates, ownership structures, and other financial indicators in determining the financial soundness of banks. Both official and non-official exchange rates exert significant effects, with non-linearities indicating thresholds beyond which currency movements become destabilizing. Ownership type plays a critical moderating role, with state-owned banks showing greater resilience. Additionally, internal financial metrics such as size, liquidity, and investment deposits positively influence stability, while high loan and liability exposures increase risks. The results underscore the need for targeted policy interventions to mitigate exchange rate volatility's risks and support banking sector resilience.

4.2 State Space estimation

This section builds on our analysis by examining the robustness of the main results. We investigate the effect of official exchange rate and non-official exchange rate through the types of ownership (private owned commercial, state owned commercial and state owned specialized banks) and various years using state space method.

The effect of official exchange rate and non-official exchange rate depend on types of ownership and may be different in various years. We using state space, investigate the effect of official exchange rate and non-official exchange rate through the types of ownership (private owned commercial, state owned commercial and state owned specialized banks). We test three hypotheses. The first hypothesis is the equality test of official and non-official exchange rate coefficients for banks with various ownership. (The effect of official and non-official exchange rates are compared in private owned commercial, state owned commercial and state owned specialized banks separately). The second hypothesis is the equality test of the effect of the official exchange rate for banks through various ownerships (the effect of the official exchange rate is compared in private owned commercial, state owned commercial and state owned specialized banks) and the third hypothesis is the equality test of the effect of the non-official exchange rate for banks through different ownerships(the effect of the non-official exchange rate is compared in private owned commercial, state-owned commercial and state owned specialized banks). Table 5 reports the estimation result of Eq. (1) using the state space method.

In this study, to examine the effect of official and non-official exchange rates on the financial soundness of banks with different types of ownership, the state space model has been employed. The state equation is specified as follows:

State Equation:

$$\text{soundness}_{it} = \alpha_0 + \alpha_1 * \text{official or non official exchange rate}_t + \alpha_2 * \quad (2)$$

$$\text{official or non pfficial exchange rate}_t^2 + \gamma_i + \varepsilon_{it}$$

Where,γ_i is Bank fixed effects (by type of ownership: private, state-owned commercial, and state-owned specialized)

ε_{it} is error term

In this equation, to capture the heterogeneous effects of ownership, the coefficients are estimated separately for each type of bank. Moreover, to account for the time series dynamics and heteroscedasticity, an ARMA(1,2) process is included for the error term.

To estimate the state space model, the Kalman Filter was used. This technique allows for efficient estimation of model coefficients under dynamic time series conditions with incomplete or noisy observations.

The coefficients of the above equations were estimated using the Maximum Likelihood Estimation (MLE) approach, specifically applying the BFGS/Marquardt optimization steps to maximize the likelihood function.

The final model selection was also based on the Schwarz Bayesian Criterion (SBC/BIC), according to which the ARMA(1,2) model was selected for estimation.

All these aspects (the specification of the state and observation equations, methodology for coefficient estimation, and the model selection procedure) can be incorporated and clarified in the relevant section of the manuscript.

In summary, the steps are as follows:

- Specification of the state space model for each type of bank
- Modeling errors using ARMA(1,2)
- Coefficient estimation via Kalman Filter and MLE
- Model selection based on the Schwarz/Bayesian Information Criterion

Table5 Displays the results for the different estimation carried out Eq. (1), including separate estimations for official exchange rate (Panel A) and non-official exchange rate (Panel B), as well as their non-linear effect ($\text{official exchange rate}_t\text{^2}$ and $\text{non} - \text{official exchange rate}_t\text{^2}$) through the type of ownership of banks. For presentation purposes, the other fixed explanotary variables have been removed from Eq.(1). The Schwartz Bayesian criterion was used to select the appropriate model, and based on the Schwarz Bayesian results, the ARMA (1,2) was chosen for all estimates.

Firstly, in estimations results of state owned commercial banks and state owned specialized banks reported in Panel A of Table5, official exchange rate show a negative and statistically effect on state owned commercial banks and state owned specialized banks' soundness, so, if official exchange rate increases 1%, Soundness of state owned commercial banks and state owned specialized banks, decreases 2.64% and 8.78% respectively. The effect of official exchange $\text{rate}_t\text{^2}$ indicates a positive and statistically effect on state owned commercial banks and state owned specialized state owned commercial banks and state owned

specialized banks' soundness, 1.31% and 2.93% respectively. These results support the non-linear and U shaped effect of official exchange rate on state owned commercial banks and state owned specialized banks' soundness. In other words, when the official exchange rate increases, state owned commercial banks 'soundness and state owned specialized banks' soundness decreases to the minimum level of financial soundness, and after that level, with the increase of the official exchange rate, the financial soundness of banks increases.

But in private banks, with the increase in the official exchange rate, the financial soundness of the private banks increases, and after reaching the maximum level of financial soundness of the private banks As the official exchange rate continues to rise, the financial soundness of the banks declines(-3.81). These results confirm the non-linear and U inverse shaped effect of non-official exchange rate on private owned commercial banks' soundness. If official exchange rate increase 1%, private own banks' soundness, increases 1.65%.

Secondly, Panel B in Table4 represent estimation results of non-official exchange rate and $\text{non} - \text{official exchange rate}_t\text{^2}$ on banks' soundness through various ownership. Results of Panel B in Table4.indicate in line with the results of Panel A in Table4, non-official exchange rate exhibit non-linear and U inverse shaped effect on private owned banks' soundness. So if the non-official exchange rate increases by 1%, the financial soundness of private owned banks improves by 4.03 % and after maximum level of soundness, after the maximum level of financial soundness, the financial health of banks decreases 2.28% with the continuous increase of the non-official exchange rate. Also non-official exchange rate is related non-linear and U inverse shaped to state owned specialized banks' soundness, so this result is contrary to the result of panel A in the Table4 So, before the maximum level of the banks' financial soundness, with a 1% increase in the non-official exchange rate, the banks' financial soundness improves by 3.77%, and after the maximum level of the banks' financial soundness, with the continued increase in the non-official exchange rate, the banks' financial soundness decreases. But, Panel B in Table4 demonstrate U shaped relation between non-official exchange rate and state owned banks' soundness. This result is in line with Panel A.

Thirdly, the effect of the official exchange rate on the financial soundness of banks in Panel A is less than the effect of the non-official exchange rate in Panel B. So the official exchange rate coefficient is 1.65, -2.64, -8.76 less than the non-official exchange rate coefficient (4.03, -6.24, 3.77) in private owned, state owned commercial, and state owned specialized banks, respectively. The important reasons, is the greater stability of the official exchange rate than the non-official exchange rate. So banks expect the official exchange rate to remain stable for a longer period of time than the non-official exchange rate. Therefore, their financial soundness is less affected. This result is consistent with the results of Table3. Also, state owned specialized banks are more affected by the official exchange rate in Panel A and less affected by non-official exchange rate in Panel B than other banks. According to the nature of the specialized activity, state

owned specialized banks, which are responsible for financing specific sectors such as industry, agriculture, and housing, use more official exchange rate in their activities than other banks. Therefore, their effectiveness of the official exchange rate is more than the non-official exchange rate in other banks.

Table 5. State Space method estimation results.

		Panel A		Panel B	
Explanatory variable		Official exchange rate	Official exchange rate^2	Non-official exchange rate	Non-official exchange rate^2
Private Owned banks	(1)	1.65 (2.995) [0.0194]	-3.18 (-3.107) [0.0680]	……	……
	(2)	……	……	4.03 (2.870) [0.0342]	-2.28 (2.292) [0.0332]
State owned commercial banks	(3)	-2.64 (-2.312) [0.0546]	1.31 (3.235) [0.0142]	……	……
	(4)	……	……	-6.24 (-3.536) [0.0244]	2.82 (2.652) [0.0984]
State owned specialized banks	(5)	-8.76 (-3.347) [0.0279]	2.93 (3.536) [0.0513]	……	……
	(6)	……	……	3.77 (2.474) [0.0350]	-1.09 (-3.397) [0.0608]
Observations		26	26	26	26

Note: Table 5 Reports the estimations results for Eq.(1) applying the State Space method. Dependent variable is $soundness_{it}$ *that i is private owned banks' financial soundness, state owned commercial banks' soundness and state owned specialized banks' financial soundness. Row (1) , (3), and (5) present linear effect of official exchange rate(* $official\ exchange\ rate_t$*) and non-linear effect of of official exchange rate(*$official\ exchange\ rate_t$^2*) on private owned banks' financial soundness, state owned commercial banks' soundness and state owned specialized banks' financial soundness respectively. Row (2) , (4), and (6) demonstrate linear effect of non-official exchange rate(* $non-official\ exchange\ rate_t$*) and non-linear effect of non-official exchange rate (*$non-official\ exchange\ rate_t$^2*) on private owned banks' financial soundness, state owned commercial banks' soundness and state owned specialized banks' financial soundness respectively. T statistic is in parentheses. Prob. Is in [].*
Source: *Researcher calculations*

Now we test different hypotheses using the Wald test. The first hypothesize is the equality of the effect of official and non-official exchange rates in banks through ownership. The Table6 shows the result of the Wald test for this hypothesize. The results indicate, null hypothesis of equality effect of exchange rates is rejected and the effect of the official exchange rate is different from the effect of the non-official exchange rate in banks. This result is consistent with the Table4and Fig1 results.

Table 6. Equality effect of official and non-official exchange rate through ownership of banks

	Wald test	null hypothesis of equality effect of exchange rates
Private owned banks	1.310 (0.009)	rejected
State owned Commercial banks	1.040 (0.039)	rejected
State owned Specialized banks	1.808 (0.067)	rejected

Note:Table6 report results the equality test of official and non-official exchange rate coefficients for banks through ownership. Row (1) compares coefficients $official\ exchange\ rate_t$ and $onon-official\ exchange\ rate_t$ for private owned banks in Table5 . Row (2) compares coefficients $official\ exchange\ rate_t$ and $onon-official\ exchange\ rate_t$ for state owned commercial banks in Table5. Row (3) compares coefficients $official\ exchange\ rate_t$ and $onon-official\ exchange\ rate_t$ for state owned specialized banks in Table4. The value is Chi-square and number in () is probability.
Source: *Researcher calculations*

The second hypothesize is the equality of the effect of the official exchange rate between private owned banks and state-owned commercial banks and state-owned specialized banks, as well as the equality of the effect of the official exchange rate between state-owned commercial banks and state-owned specialized banks. For this purpose, the Wald test has been used. The Table6 shows null hypothesis of equality effect through ownership is rejected and the effect of the official exchange rate in private banks is different from state-owned commercial and state-owned specialized banks. Also, the effect of the official exchange rate in state-owned commercial banks is different from state-owned specialized banks.

Table 7. Equality effect of official exchange rate through ownership

	Wald test	null hypothesis of equality effect through ownership
Private owned banks and State owned Commercial banks	2.299 (0.012)	rejected
Private owned banks and State owned Specialized banks	2.393 (0.021)	rejected
State owned Commercial banks and State owned Specialized banks	1.022 (0.081)	rejected

Note:Table7 report results the equality test of official exchange rate coefficients for banks through ownership. Row (1) compares coefficients $official\ exchange\ rate_t$ between private owned banks and state owned commercial banks in Table6 . Row (2) compares coefficients $official\ exchange\ rate_t$ between private owned banks and state owned specialized banks in Table6. Row (3) compares coefficients $official\ exchange\ rate_t$ between state owned commercial banks and state owned specialized banks in Table4. The value is Chi-square and number in () is probability.
Source: *Researcher calculations*

The third hypothesize is the equality of the effect of the non-official exchange rate between private owned banks and state owned commercial banks and state owned specialized banks, as well as the equality of the effect of the official exchange rate in state owned commercial banks and state owned specialized banks. Table8 represents null hypothesis of equality effect through ownership is rejected and the effect of non-official exchange rate in private banks is different from state commercial and specialized state banks. Also, the effect of the official exchange rate in state-owned commercial banks is different from specialized state-owned banks.

Table 8. Equality effect of non-official exchange rate through ownership.

	Wald test	null hypothesis of equality effect through ownership
Private owned banks and State owned Commercial banks	8.699 (0.003)	rejected
Private owned banks and State owned Specialized banks	8.954 (0.017)	rejected
State owned Commercial banks and State owned Specialized banks	2.995 (0.083)	rejected

Note: Table7 report results the equality test of official exchange rate coefficients for banks through ownership. Row (1) compares coefficients $non-official\ exchange\ rate_t$ between private owned banks and state owned commercial banks in Table7 . Row (2) compares coefficients $non-official\ exchange\ rate_t$ between private owned banks and state owned specialized banks in Table7. Row (3) compares coefficients $non-official\ exchange\ rate_t$ between state owned commercial banks and state owned specialized banks in Table6. The value is Chi-square and number in () is probability.
Source: *Researcher calculations*

5. Concluding Remarks

This paper provides an in-depth analysis of the linear and non-linear effects of official and non-official exchange rates on the financial soundness of Iranian banks, considering the role of ownership structure. By utilizing advanced econometric methods such as ARDL and State Space approaches, it offers a comprehensive assessment of macroeconomic variables and bank-specific factors affecting financial stability from 1996 to 2024.

The use of both the ARDL (Autoregressive Distributed Lag) model and the State-Space model is intentional and grounded in the complementary strengths each method brings to the analysis. The ARDL model serves as a robust tool to establish baseline and general relationships at the sector level, identifying dynamics effects. The State-Space model, on the other hand, allows us to address the core research question with more granularity by disentangling the effects of exchange rates based on bank ownership and by accommodating time-varying and non-linear dynamics. Including both models strengthens the robustness of our findings and enriches our understanding of how different segments of the Iranian banking sector are affected by official and unofficial exchange rate movements.

The ARDL approach is particularly suitable for modeling and estimating the dynamic relationships between exchange rate variables (official and unofficial) and the overall financial soundness index of Iranian banks, especially in the presence of variables with different orders of integration (I(0) and I(1)).

This method allows us to providing a general overview at the sectoral and aggregated level without distinguishing bank ownership types.

The ARDL model is effective for examning the general time dynamics and threshold effects of exchange rates on the banking sector as a whole.

After establishing general relationships using ARDL, the State-Space model is employed to delve deeper into the heterogeneity among banks with different ownership structures (private banks, state-owned commercial banks, state-owned specialized banks).

The State-Space framework is dynamic and flexible, allowing for time-varying parameters and a richer characterization of the underlying processes. This enables us to capture the differential and possibly non-linear responses of various bank groups to exchange rate shocks across different periods.

By using the Kalman filter, the State-Space model accounts for unobserved components and offers more detailed insights into the temporal effects and ownership-specific sensitivities, which are not easily captured by traditional ARDL models.

The findings align with many previous studies that emphasize the critical role of exchange rates in shaping banking performance. For instance, consistent with Keshtgar et al. (2020) and Njagi & Nzai (2022), the results demonstrate the destabilizing effects of excessive exchange rate volatility, particularly on credit and liquidity risks, while moderate fluctuations tend to enhance financial soundness. Similarly, studies like Babazadeh & Farrokhnejad (2012) and Almaqtari et al. (2018) are supported by the evidence that macroeconomic factors, including inflation and GDP growth, play a significant role in influencing bank resilience.

However, this study diverges from previous research in three major respects. First, it introduces a dual analysis of Iran's unique dual exchange rate system, exploring both official and non-official rates, which is absent in most prior studies that focus on single exchange rate regimes. Second, while earlier works often rely on narrow financial performance metrics like ROA, ROE, or NPL ratios, this research develops a composite measure of financial soundness using IMF's CAELS methodology. This allows for a broader and more integrated evaluation of banking sector stability. Third, the study accounts for ownership-specific differences, highlighting the distinct impacts of exchange rate volatility on private banks, state-owned commercial banks, and state-owned specialized banks—an area often overlooked in the literature.

The results establish that both official and non-official exchange rates exert complex, non-linear effects on the financial soundness of Iranian banks. There is evidence of threshold effects, where moderate increases in exchange rates improve stability before excessive volatility leads to destabilization. State-owned

banks are more vulnerable to official exchange rate fluctuations, while private banks exhibit stronger sensitivity to non-official exchange rates due to their reliance on informal currency market activities.

In addition to exchange rate effects, internal financial metrics such as bank size, liquidity ratios, and investment deposits significantly enhance stability, whereas high loan-to-asset ratios and interest income dependency increase risks. Furthermore, macroeconomic variables show inflation negatively impacts financial soundness, while GDP growth and stock market performance have positive effects.

Given these findings, several policy recommendations can be made:

Exchange Rate Stabilization: Policymakers should focus on mitigating excessive exchange rate volatility, particularly for non-official rates, which disproportionately affect private banks. This could involve narrowing the gap between the official and non-official exchange rates to reduce systemic risks.

For state-owned banks, policies should focus on improving operational efficiency and reducing reliance on government-determined exchange rates. For private banks, regulations should address risks associated with non-official exchange rate exposure, such as requiring higher capital adequacy ratios tied to foreign exchange transactions.

Measures to boost liquidity ratios, diversify revenue sources, and improve credit risk management should be prioritized across all banks to enhance their overall financial soundness.

Macroeconomic Measures: Controlling inflationary pressures and ensuring consistent economic growth are crucial to supporting banking stability. Policies that promote investor confidence and strengthen credit repayment capacity would mitigate the risks associated with exchange rate volatility.

This research contributes significantly to understanding the dynamics of exchange rate fluctuations and their varied effects on bank financial soundness in emerging markets. It highlights the importance of tailored policies addressing ownership-specific vulnerabilities and advocates for a more integrated approach to evaluating banking sector stability. The findings provide valuable insights for policymakers aiming to enhance resilience in the Iranian banking sector and similar economies facing dual exchange rate challenges.

Author Contributions

This article is the result of the author's research.

Funding

This research received no external funding.

Conflicts of Interest

The authors declare no conflict of interest.

Data Availability Statement

The data used in the study were taken from https://www.cbi.ir/page/4275.aspx.

Acknowledgements

Not applicable

References

Abbas Elhussein, N. H. & Elfaki Osman, O. E. 2019. Exchange Rate fluctuations and Financial Performance of Banks : Evidence from Sudan. International Journal of Economics and Finance, 11(12): 15-27. https://doi.org/10.5539/ijef.v11n12p15

Acaravci, S., & Ç alim, A. (2013). Turkish banking sector's profitability factors. International Journal of Economics andFinancial Issues, 3(1), 27-41.

Almaqtari, F., Al-Homaidi, E., Tabash, M., & Farhan, N. (2018). The determinants of profitability of Indian commercial banks: A panel data approach. International Journal of Finance and Economics, 24(1), 168-185 . https://doi.org/10.1002/ijfe.1655

Agenor, P.R., Jackson, T. P., & Pereira da Silva, L. 2020. Foreign Exchange Intervention and Financial Stability. BIS Working Papers No 889

Bani Yousef, A.N., Taha, R., Nurian Muhmad, S., Zainul Abidin, A. F. 2024. Foreign Exchange risk and Performance: Evidence from MENA Banks. *International Journal of Business and Society*, 25(3): 1054-1071. https://doi.org/10.33736/ijbs.8558.2024.

Babazadeh, M., & Farrokhnejad, F. (2012). Effects of Short-run and Long-run Changes in Foreign Exchange Rates on Banks' Profit. International Journal of Business and Management, 7, 70-77 . https://doi.org/10.5539/ijbm.v7n17p70

Carolyn C. Lagat1 and Daniel M. Nyandema2, The Influence of Foreign Exchange Rate Fluctuation on the Financial Performance of Commercial Banks Listed at the Nairobi Securities Exchange. British Journal of Marketing Studies, Vol.4, No.3, pp.1-11, May 2016

Chamberlain, S., Howe, J., & Popper, H. (1997). The Exchange Rate Exposure of U.S. and Japanese Banking Institutions. Journal of Banking and Finance, 21(6), 871-892. https://doi.org/10.1016/S0378-4266(97)00002-2

Cheluget, J., Sile, I., & Amoi, A.K. 2023. Effect of Exchange Rate and Inflation Rate on the Financial Performance of Banks in Kenyan: A Case of Co. Bank Limited. *International Journal of Research Publication and Reviews*, 4(2): 628-642, February 2023.

Hasanov, F., Bayramli, N., & Al-Musehel, N. (2018). Bank-Specific and Macroeconomic Determinants of Bank Profitability: Evidence from an Oil-Dependent Economy. International Journal of Financial Studies, 6 (2)78; https://doi.org/10.3390/ijfs6030078.

IMF. 2019 .Financial Soundness Indicators Compilation Guide . https://www.imf.org/en/Data/Statistics/FSI-guide

Isaac, L. (2015). Assessing the Impact of Exchange Rate Risk on Banks Performance in Nigeria. Journal of Economics and Sustainable Development, 6(6), 1-14.

Keshtgar, Nafiseh; Pahlavani, Mosayeb; Mirjalili, Seyed Hossein (2020) : The Impact of Exchange Rate volatility on Banking Performance (case of Iran), *International Journal of Business and Development Studies*,12(1): 39-56.https://doi.org/10.22111/ijbds.2020.5436.

Kemisola, O., Ademola, O., Olamide, J., &Moses, O. (2016). Exchange Rate Volatility and Banks Performance : Evidence from Nigeria. IIARD International Journal of Economics and Business Management, 2(4), 1-11.

Mohammadi, T. , Shakeri, A. , Taghavi, M. and Samanipour, H. (2020). Exchange Rate Threshold Affecting Financial Stability of Iranian Banks. Financial Management Strategy, 8(4), 1-22. doi: 10.22051/jfm.2020.29180.2261.

Seyed Kalaei, M.A., Ehsanfar, M.H., Mozafari Ahangar Kalaei, S. F. 2021. The Effect of Exchange Rate Fluctuations on the Lending Power of Banks in Iran. Islamic Economics & Banking , 10(34): 7-34.(In Persian).

Ngerebo, T. (2012). The impact of foreign exchange fluctuation on then intermediation of banks in Nigeria (1970 – 2004). African Journal of Business Management, 6(11), 3872-3879. https://doi.org/10.5897/AJBM09.113

Njagi, M. M., & Nzai, C. (2022). Effect of Exchange Rate Volatility on Performance of Commercial Banks in East Africa Community. Journal of Economics, 2(2), 1-13.

Taiwo, O., & Adesola, O. (2013). Exchange rate volatility and bank performance in Nigeria. Asian Economic and Financial Review, 3(2), 178-185.

Wong, T., Wong, J., & Leung, P. (2009). The Foreign Exchange Exposure of Chinese Banks. China Economic Review, 20(2) 174-182. https://doi.org/10.1016/j.chieco.2009.03.003.

Appendix

Table A1. Pearson Correlation Matrix.

	new financia soundn	offici excha rate	non – offic exchan rate	liquid assets total assets	loar tota asse	due t banks total liabili	invest depos total liabili	intere incon total incon	inflat	economic growth	stock price index	size
new financi soundı	1											
fficial e xchang rate	-0.141***	1										
non – offic exchan rate	-0.118***	0.799**	1									
liquid assets total assets	0.072*	0.628***	0.616**	1								
loan to total assets	-0.146**	-0.604**	-0.400**	-0.789**	1							
due to banks total liabiliti	-0.155*	-0.264**	-0.336***	0.083*	0.107**	1						
investr deposi total liabiliti	-0.101**	0.163***	0.098**	-0.221*	0.262*	-0.604***	1					
interes income total income	0.029**	-0.467**	-0.038*	-0.347***	0.676*	-0.136**	-0.205**	1				
inflatic	-0.161***	-0.079*	-0.074*	0.051**	-0.009**	0.376**	-0.314***	-0.049*	1			
econor growth	-0.002**	0.086**	0.119*	-0.163***	0.069**	-0.306**	0.167*	0.072**	-0.764*	1		
stock price index	-0.066**	0.011*	-0.109**	-0.461***	-0.321*	0.357**	-0.453***	-0.311**	0.270**	0.361**	1	

size	0.346**	-0.030**	-0.013*	0.264***	0.055*	0.295**	0.293**	0.028***	0.262*	-0.414**	0.757**	1

*Notes: TableA1: Pearson Correlation Matrix reports the Pearson correlation coefficients for the variables included in the analysis. . *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.*
Source: *Researcher calculations*

Table A2. Unitroot test results

Indicarors	Augmented Dickey-Fuller test statistic	Elliott-Rothenberg-Stock DF-GLS test statistic	Phillips-Perron test statistic	Kwiatkowski-Phillips-Schmidt-Shin test statistic	Elliott-Rothenberg-Stock test statistic	results
size	-3.196** [0.0323]	-2.636** [0.0145]	-3.199** [0.0320]	0.155**	5.458**	Null hypothesis is is reject, Level and intercept
Liquid asst to total asset	-6.958** [0.0000]	-6.483** [0.0000]	-9.232** [0.0000]	0.276**	2.631***	Null hypothesis is is reject, 1st difference and intercept
Loan to total asset	-3.056** [0.0433]	-3.111** [0048]	-2.971*** [0.0515]	0.488***	2.489*	Null hypothesis is is reject, Level and intercept
Due to banks to total liabilities	-4.521** [0.0016]	-4.489** [0.0002]	-4.509** [0.0017]	0.049**	2.054**	Null hypothesis is is reject, 1st difference and intercept

Investment deposit to total liabilities	-2.848*** [0.0660]	-2.825** [0.0094]	-2.848*** [0.0660]	0.104**	2.644*	Null hypothesis is reject, Level and intercept
Interest income to total income	-4.231** [0.0032]	-3.638** [0.0014]	-4.245** [0.0031]	0.079**	3.725**	Null hypothesis is reject, 1st difference and intercept
Inflation	-11.476** [0.0000]	-3.711** [0.0023]	-3.534** [0.0154]	0.102**	9.415**	Null hypothesis is reject, Level and intercept
Economic growth	-4.752** [0.0009]	-4.170** [0.0004]	-3.688** [0.0108]	0.080**	0.907**	Null hypothesis is reject, Level and intercept
Stock price index	-4.308** [0.0034]	-3.400** [0.0028]	-2.781** [0.0752]	0.078**	6.922**	Null hypothesis is reject, Level and intercept

*Note: * means 1% level, ** means 5% level and *** means 10% level*
Source: *Researcher calculations*

Table B1. ARDL Method estimation results

	Panel A: Official exchange rate				Panel B: Non- Official exchange rate			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Selected model	ARDL (1,4,2)	ARDL(1,1,1,0,1,1,1,1,1,1,1,1)	ARDL(1,4)	ARDL(1,1,1,0,0,0,1,1,0,1)	ARDL(1,0)	ARDL(1,1,1,1,1,0,0,0,1,0,0,0)	ARDL(1,0)	ARDL(1,0,1,0,0,1,0,1,0,0,1)
Total banks 'financial	0.291 (1.936) [0.0581]	0.180 (3.901) [0.0599]	0.288 (3.395)	0.548 (2.796) [0.0267]	0.294 (2.413)	0.866 (4.635) [0.0024]	0.288 (3.394)	0.721 (4.121) [0.0033]

soundness(-1)			[0.0045]		[0.0721]		[0.0177]	
Total banks 'financial soundness(-2)								
Total banks 'financial soundness(-3)								
Total banks 'financial soundness(-4)								
Official exchange rate	0.252 (2.885) [0.0899]	0.744 (4.563) [0.0043]	0.136 (2.854) [0.0407]	0.195 (3.139) [0.0349]				
Official exchange rate(-1)	0.899 (2.210) [0.0473]	0.213 (3.586) [0.0697]	0.348 (2.366) [0.0932]	0.291 (2.945) [0.0270]				
Official exchange rate(-2)	0.484 (3.476) [0.0188]		0.245 (2.940) [0.0631]					
Official exchange rate(-3)	0.488 (2.410) [0.0660]		0.452 (2.687) [0.0136]					
Official exchange rate(-4)	0.738 (1.905) [0.0022]		0.601 (2.924) [0.0111]					
Non-official exchange rate					0.149 (2.736) [0.0912]	0.365 (2.667) [0.0525]	0.110 (3.803) [0.0309]	0.234 (2.276) [0.0375]

Non-official exchange rate(-1)			0.161 (6.858) [0.0000]	
Non-official exchange rate(-2)				
Non-official exchange rate(-3)				
Non-official exchange rate(-4)				
Size	2.705 (5.992) [0.0141]	0.500 (3.317) [0.0059]	0.532 (2.264) [0.0579]	0.521 (2.0436) [0.0752]
Size(-1)		0.515 (2.910) [0.0097]	0.378 (1.960) [0.0098]	0.427 (2.730) [0.0121]
Liquid asset to total asset	0.005 (2.538) [0.0267]	0.443 (4.250) [0.0000]	0.269 (2.564) [0.0168]	0.561 (3.376) [0.0162]
Liquid asset to total asset(-1)	0.235 (2.2324) [0.0343]		0.225 (2.173) [0.0663]	
Loans to total asset	0.071 (3.181) [0.0862]	0.517 (2.179) [0.0863]	0.426 (2.661) [0.0077]	0.208 (2.856) [0.0416]
Loans to total asset(-1)	0.225 (2.858) [0.0037]			
Due to banks to total liability	-0.264 (-3.980) [0.0301]	-0.560 (-2.292) [0.0556]	-0.483 (-2.150) [0.0586]	-0.516 (-2.550) [0.0039]

Due to banks to total liability(-1)	-0.220 (-3.938) [0.0588]			-0.232 (-3.969) [0.0360]
Investment deposit to total liability	-0.541 (-2.147) [0.0164]	-0.211 (-2.700) [0.0728]	-0.188 (-2.171) [0.0566]	-0.579 (-3.359) [0.0783]
Investment deposit to total liability(-1)	-0.140 (-3.559) [0.0707]	-0.149 (3.108) [0.0041]		
Interest incomes to total income	0.310 (2.633) [0.0119]	0.908 (2.780) [0.0460]	0.651 (2.596) [0.0469]	0.350 (2.975) [0.0312]
Interest incomes to total income(-1)	0.789 (4.354) [0.0489]			0.943 (3.924) [0.0382]
Inflation	-0.687 (-5.678) [0.0298]	-0.264 (-4.540) [0.0014]	-0.263 (-3.425) [0.0111]	-0.218 (-2.822) [0.0224]
Inflation (-1)	-0.371 (-3.213) [0.0847]	0.136 (2.965) [0.0366]		
Economic growth	-0.209 (-2.776) [0.0187]	-0.193 (-2.559) [0.0376]	-0.375 (-2.819) [0.0258]	-0.435 (-3.913) [0.0195]
Economic growth(-1)	-0.125 (-4.291) [0.0502]			
Stock price index	-0.624 (-4.717) [0.0421]	-0.419 (-3.365) [0.0049]	-0.543 (-4.694) [0.0134]	-0.484 (-4.266) [0.0240]
Stock price	-0.404 (-4.146)			-0.477 (-2.702)

index(-1)		[0.0535]						[0.0271]
Official exchange rate^2	-0.286 (-6.041) [0.0474]	-0.127 (-1.814) [0.21131]						
Official exchange rate^2(-1)	-0.125 (-7.831) [0.0000]	-0.413 (-3.986) [0.0575]						
Official exchange rate^2(-2)	-0.657 (-5.811) [0.0000]							
Official exchange rate*ownership			-0.264 (-3.415) [0.0040]	-0.488 (-3.896) [0.0025]				
Non-official exchange rate^2					-0.451 (-3.392) [0.0021]	-0.163 (-2.489) [0.0063]		
Non-official exchange rate^2(-1)						-0.497 (-2.781) [0.0117]		
Non-official exchange rate*ownership							0.756 (3.541) [0.0593]	0.166 (4.364) [0.0209]
C	0.852 (4.831) [0.0004]	13.621 (5.418) [0.0324]	0.754 (3.500) [0.0035]	6.475 (4.466) [0.0029]	0.692 (5.306) [0.0000]	6.598 (5.120) [0.0014]	0.680 (5.607) [0.0000]	1.121 (3.246) [0.0628]
R-squared	0.670	0.989	0.523	0.882	0.801	0.899	0.807	0.869
F-statistic[Prob]	2.719 [0.0546]	8.473 [0.0110]	2.197 [0.0991]	3.101 [0.0666]	0.788 [0.0139]	3.668 [0.0436]	0.839 [0.0487]	3.324 [0.0450]

Durbin-Watson stat	2.786	2.744	2.182	3.0730	1.981	2.765	1.943	2.791
Breusch-Godfrey Serial Correlation LM Test: Null hypothesis: No serial correlation at up to 2 lags								
F-statistic	3.343 [0.1773]	1.499 [0.4360]	1.411 [0.2816]	20.0393 [0.3012]	0.044 [0.9569]	1.674 [0.0277]	0.270 [0.7656]	62.911 [0.7098]
Obs*R-squared	8.816 [0.1122]	14.996 [0.8578]	4.188 [0.1231]	22.2271 [0.1525]	0.1157 [0.9438]	10.0285 [0.7174]	0.692 [0.7072]	21.655 [0.4370]
Heteroskedasticity Test: Breusch-Pagan-Godfrey: Null hypothesis: Homoskedasticity								
F-stat	0.506 [0.8433]	1.972 [0.3908]	0.515 [0.8085]	0.7138 [0.2398]	0.633 [0.6017]	0.535 [0.8612]	0.804 [0.5052]	2.901 [0.2872]
Obs*R-squared	6.0596 [0.7339]	23.898 [0.352]	4.507 [0.7198]	2.1570 [0.2663]	2.074 [0.5571]	14.135 [0.6575]	2.577 [0.4614]	21.229 [0.3242]
Scaled explained SS	1.427 [0.9978]	0.292 [0.8331]	1.709 [0.9742]	2.0912 [0.0912]	1.275 [0.7351]	1.849 [0.1439]	1.461 [0.6912]	0.2445 [0.5724]
Ramsey RESET Test								
t-stat	0.811 [0.4341]	0.998 [0.5004]	2.002 [0.665]	2.633 [0.2389]	0.624 [0.5395]	2.260 [0.9654]	0.932 [0.3620]	3.533 [0.1756]
F-stat	0.659 [0.4341]	0.997 [0.5004]	4.010 [0.0665]	6.9352 [0.2389]	0.389 [0.539]	5.111 [0.9645]	0.870 [0.3620]	12.486 [0.1756]
Likelihood ratio	1.280 [0.2579]	17.294 [0.5609]	5.916 [0.2150]	16.204 [0.6649]	0.482 [0.4873]	15.406 [0.7241]	1.065 [0.3021]	57.236 [0.3982]
Normality test								
Jarque-Bera	1.218 [0.5431]	4.089 [0.1294]	0.114 [0.9442]	0.436 [0.8041]	0.693 [0.9653]	2.692 [0.2601]	0.164 [0.9211]	1.047 [0.5923]
Observation	22 after adjustment	23 after adjustment	22 after adjustment	24 after adjustment	25 after adjustment	22 after adjustment	25 after adjustment	22 after adjustment

Note: TableB1 reports the regression results of Equation (3). Sample is total banking network. Size is log of total asset. Ownership is dummy variable that it is 1, if bank is private own banks and 0 otherwise. : In all regressions, maximum dependent lags is 4 and it is selected automatically. Number models evaluated is 20.Model selection method is Akaike info criterion (AIC). Size, Liquid asset to total asset, Loans to total asset, Due to banks to total debt, Investment deposit total debt, Interest incomes to total income, Inflation, Economic growth, Stock price index are fixed repressors in all regressions and they are selected based on theories , literature and significant . Official exchange rate and non-official exchange rate are dynamic regressors in Panel A and B of TableA2 respectively.

Source: *Researcher calculations*