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INTEREST RATE HIKE AND THE INSTABILITY IN THE U.S. BANKING INDUSTRY

HUONG T.T. LE[1*], LAI VAN VO[2]

1. Northeastern Illinois University, USA.
2. Western Connecticut State University, USA

* Corresponding Author: Huong T.T. Le, College of Business and Technology, Northeastern Illinois University, 5500 N. St Louis Ave, Chicago, Illinois, USA, 60625.
✉ h-le9@neiu.edu

Abstract

This paper investigates the effect of interest rate changes on the U.S. banks' performance captured by unrealised losses, investment securities allocation, and deposit withdrawal. We show that a sudden surge in interest rates could lead to massive losses, potentially erasing the market value of a bank's equity capital. We further show that the U.S. banks have switched more available-for-sale securities to held-to-maturity securities to reduce the realised losses. Moreover, such an increase in interest rates could prompt depositors, particularly those with uninsured deposits, to withdraw their funds. These findings align with bank-level data and highlight significant risks to banks, as evidenced by recent abrupt failures in the U.S. banking sector.

Keywords: bank collapse bank runs, deposit withdrawal, interest rate risk, securities reallocation

1. Introduction

A primary role of banks is to perform maturity transformation by accepting short-term deposits and providing long-term loans and investments. This process generates income for banks, as the long-term rates are typically higher than short-term rates, as explained in most textbooks (Drechsler et al, 2021). Nevertheless, this function also exposes banks to significant risk. If interest rates unexpectedly rise, the cost of borrowing can surpass the income earned from assets, resulting in a reduction of net interest margin (NIM) and a depletion of the bank's capital. This situation can be particularly dire for banks with low equity holdings, as an increase in interest rates can lead them to be at risk of collapse. Thus, interest rate risk is a fundamental concern in the banking industry.

However, in their recent study, Drechsler, Savov, and Schnabl (2021) argue that a large maturity mismatch does not expose banks to interest rate risk because "the deposit franchise gives banks market power over retail deposits, which allows them to borrow at rates that are both low and insensitive to market interest rates." According to the authors, depositors are unlikely to leave their bank even when better rates are available elsewhere, thus giving banks a competitive advantage. As a result, the authors conclude that interest rate risk does not pose a significant threat to banks. Nevertheless, the recent rapid collapses of some banks, such as Silicon Valley Bank and Signature Bank, cast doubt on the validity of this theory and its assumptions.

In this paper, we mainly employ aggregate data from the U.S. banking industry to examine the effect of interest rates on the U.S. banks' instability. We argue that a sudden increase in interest rates could lead to massive losses for banks. These losses could be realised or unrealised, but the market value of bank equity would drop significantly (English et al., 2018; Jiang et al., 2023; and Vo and Le, 2023).

Additionally, when banks face significant losses, depositors, especially those with uninsured deposits, could withdraw their deposits or reduce their deposits to the insured level. This deposit withdrawal could cause bank runs, especially for banks with concentrated depositors (Vo and Le, 2023).

The current evidence in the U.S. banking industry supports our arguments. A sudden increase in interest rates in 2022 resulted in huge realised and unrealised losses for banks. According to the current report by FDIC, the total unrealised losses on investment securities alone reached $690 billion in the third quarter of 2022.[1] Additionally, the total domestic deposits dropped by $304 billion in the second quarter and $185 billion in the third quarter of the same year. This situation has been more serious for small banks (e.g., regional and community banks) or for banks operating in narrow markets.

Analysing the Silicon Valley Bank's financial statements, Vo and Le (2023) identify four primary reasons leading to the bank's collapse: substantial losses in the bank's assets, the withdrawal of deposits, low capital, and inefficient risk management system. Similarly, Jiang et al. (2023) estimate the losses of bank assets in the U.S. and demonstrate that the losses can reach an average of 10% in 2022. Furthermore, they reveal that 10% of banks have greater unrealised losses and 10% of banks have lower capitalisation than those of SVB. This estimation indicates that many banks in the U.S. are at risk.

Our paper complements these results by investigating the effect of interest rate hikes on the unrealised losses from debt securities and deposit withdrawals at the aggregate level. We focus on debt securities because of three main reasons. First, debt securities are the main proportions of banks' total assets, accounting for about 25% in recent years. Second, the effects of interest rate on debt securities are similar those on loans and leases, which are the main categories in banks' total assets. Third, unlike unrealised losses on loans and leases, data on debt securities' unrealised losses are publicly available.

Using aggregate data of U.S. banks from 2009 to 2022, we first show that there is a positive relationship between interest rates and unrealised losses as well as deposit withdrawals. This relationship is particularly pronounced during the COVID-19 pandemic period of 2021-2022, which coincided with a surge in interest rates. Our multivariate analysis confirms that interest rates have a significant impact on unrealised losses. Furthermore, we find that U.S. banks have switched from available-for-sale (AFS) securities to held-to-maturity (HTM) securities as a means of reducing realised losses when interest rates increase. We also observe a positive effect of interest rates on deposit withdrawals. These findings suggest that rising interest rates expose U.S. banks to high unrealised losses on debt securities and significant deposit withdrawals, thereby increasing the risk of bank failure.

Employing bank-level data in the U.S., we find consistent conclusions: an increase in interest rates prompts banks to switch more to HTM securities by reducing investments in AFS securities. Moreover, banks tend to experience greater losses on these securities and higher uninsured deposit withdrawals. The securities switch is more pronounced for large banks or banks with low capital. However, the losses are more pronounced for small banks or banks with high capital or uninsured deposits. Additionally, large banks or banks with substantial uninsured deposits tend to experience higher uninsured deposit withdrawals.

To the best of our knowledge, this is the first paper examining the effects of the hikes in interest rates in 2022 on the U.S. banks' instability at the aggregate level. We show that an increase in interest rates is associated with high unrealised losses as well as deposit withdrawals. These results indicate that

[1] https://www.fdic.gov/analysis/quarterly-banking-profile/qbp/2022dec/.

interest rate hikes could pose significant risks to banks, as evidenced by the recent abrupt failures in the U.S. banking sector.

The remainder of the paper is as follows. In Section 2, we discuss sample selection and methodology. Section 3 analyses the effect of interest rates on unrealised losses on debt securities and deposit withdrawal at the aggregate level. Section 4 examines the effect of changes in interest rates on banks at the individual level. Finally, Section 5 concludes the paper.

2. Sample Selection and Methodology

We collect aggregate banking data from the Federal Deposit Insurance Corporation (FDIC). We define the debt securities ratio (SECU) as the proportion of total debt securities to the banks' total assets and the deposit ratio (DEPA) as the fraction of total deposit to total assets. Similarly, we compute the available-for-sale (AFS) securities, held-to-maturity (HTM) securities, and deposit ratios as the fractions of these variables over the banks' total assets. The unrealised losses on AFS securities ratio (UNLA) is the proportion of unrealised losses to AFS securities, the unrealised losses on HTM securities ratio (UNLH) is the fraction of unrealised losses to HTM securities, and the total unrealised losses on debt securities ratio (UNL) is the proportion of total unrealised losses to total debt securities.

To measure the switch from AFS to HTM securities, we consider two measures: (1) SWITCH as the difference between the change in HTM securities and the change in AFS securities scaled by 1 million, and (2) CDIFF as the change in the ratios of HTM securities over total securities to AFS securities to total securities. We define the insured deposit withdrawal ratio (CINW) as the negative percentage of the changes in insured deposits, and uninsured deposit withdrawal ratio (CUNINW) as the negative percentage of the changes in uninsured deposits. Similarly, the total deposit withdrawal (CDEPW) is the ratio of the negative change in total deposits.

We collect the fed funds effective rate (FED) from the Federal Research Bank of St. Louis, and Gross Deposit Product Ratio (GDP) and Customer Price Index (CPI) from the Bureau of Labor Statistics. We use CPI to measure the level of inflation in the U.S.[2]

To measure the effect of interest rates on banks' performance, we use the following base-line regression:

$$Y_t = \beta_1 CFED_t + \beta_2 MACRO_{t-1} + \beta_3 BANK_{t-1} + \varepsilon_t \quad (1)$$

where Y is either unrealised losses ratio (CUNL, CUNLA, or CUNLH), debt securities switches (SWITCH, or CDIFF), or deposit withdrawals (CINW, CUNINW, or CDEPW), FFUND is the fed funds effective rate, CFED is the fed funds effective rate, MACRO is a vector of macroeconomic variables, including GDP and CPI, and BANK is a vector of banks' characteristics, including the securities ratio (SECU) and the deposit ratio (DEPA).

We include GDP and CPI because they are important macro variables (e.g., Næs et al. 2011; and Vo 2014). We include banks' characteristics because they can affect unrealised losses and deposit withdrawals (Le, Narayana, and Vo 2016). Because these variables are time-series, we use unit root test (Augmented Dickey–Fuller test) to verify whether they are stationary. For non-stationary

[2] The results are qualitatively the same when we use the yield on 1-year Treasury bills or 3- year Treasury notes to substitute for the fed funds effective rate.

variables, we follow the literature (e.g., NÆs et al. 2011, and Vo 2014) to detrend them before we include them into the regression model.

To robustly assess the impact of interest rate changes on bank performance, we collected bank-level data from the Federal Financial Institutions Examination Council (FFIEC) spanning 2009 to 2022. We excluded observations lacking information on total assets, total liabilities and equity capital, or deposits. We calculated the deposit ratio as the ratio of total deposits to total assets and return on assets (ROA) as the ratio of net income to total assets. The HTM securities ratio was determined by dividing HTM securities by total assets, and the AFS securities ratio was computed similarly. Uninsured deposits were defined as the ratio of time deposits exceeding $250,000 to total deposits. Due to the lack of disclosure by most banks regarding unrealised losses on HTM and AFS securities, we utilised realised losses on these securities as a proxy, calculating the loss ratio as the proportion of total realised losses on these securities relative to total assets.

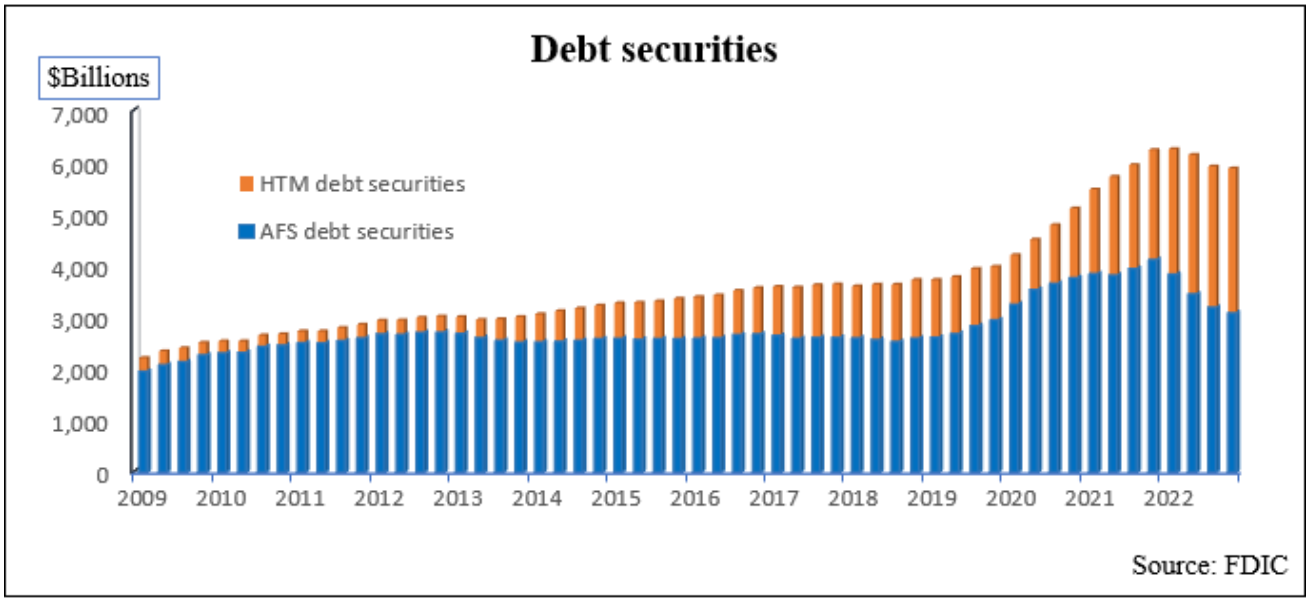
3. The Main Results

3.1 Descriptive Statistics

After the financial crisis of 2007-2009, the total assets of U.S. banks grew steadily from around $13 trillion in 2009 to $18.6 trillion by the end of 2019. However, this figure had increased tremendously during the COVID-19 pandemic, peaking in the second quarter of 2022 at $24 trillion. Similarly, total debt securities increased from $2.2 trillion at the beginning of 2009 to $4.0 trillion at the end of 2019. In just a short period of COVID-19 pandemic of 2020 -2022, total debt securities surged by $2.2 trillion, representing a growth of over 56%.

Among debt securities, the value of AFS securities were relatively stable until 2019. In contrast, the proportion of HTM securities grew slightly during this period. However, both categories of debt securities significantly increased from 2020 to 2021. AFS significantly grew to $4.11 trillion at the end of 2021 before decreasing to $3.08 trillion by the end of 2022. On the other hand, HTM securities increased from $1.03 trillion at the end of 2019 to $2.80 trillion by the end of 2022. These figures demonstrate that U.S. banks invested more in both types of debt securities from 2020 to 2021 but increasingly switched from AFS securities to HTM securities in 2021 and 2022. This trend is attributed to the rapid change in interest rates from the beginning of 2022.

Figure 1: Debt securities



Banks do not have to report unrealised losses from HTM securities but are required to recognise unrealised losses from AFS in their financial reports. As a result, by switching from AFS to HTM securities, banks' financial information appears more attractive to readers when interest rates increase. Additionally, this reallocation allows banks to have more favourable equity capital ratios, making them appear healthier.

During the financial crisis of 2007-2009, the unrealised losses of US banks reached a peak of $65 billion in the second quarter of 2008. After that, unrealised losses decreased and unrealised gains on investment securities started to appear from the second quarter of 2009. However, the unrealised losses surged in 2022, when the interest rates increased. The amounts of unrealised losses peaked at the highest ever of $690 billion in the second quarter of the same year.

Figure 2: Unrealised gains (losses) on investment securities

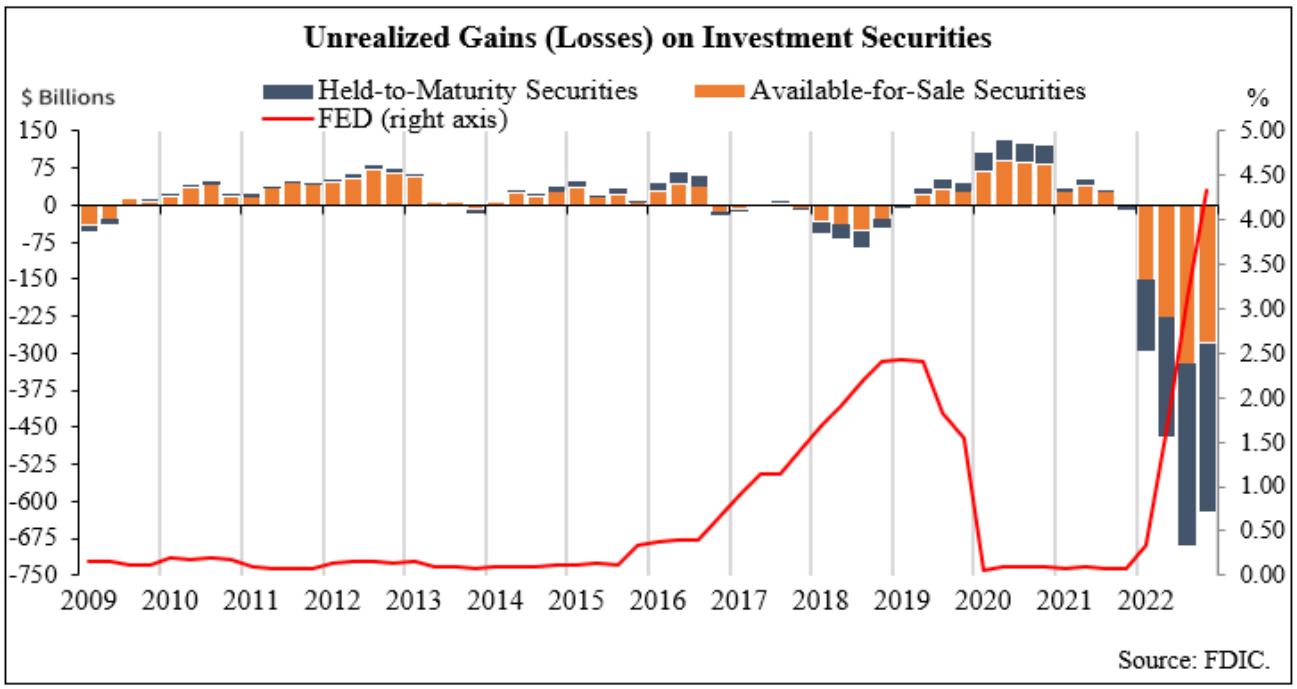
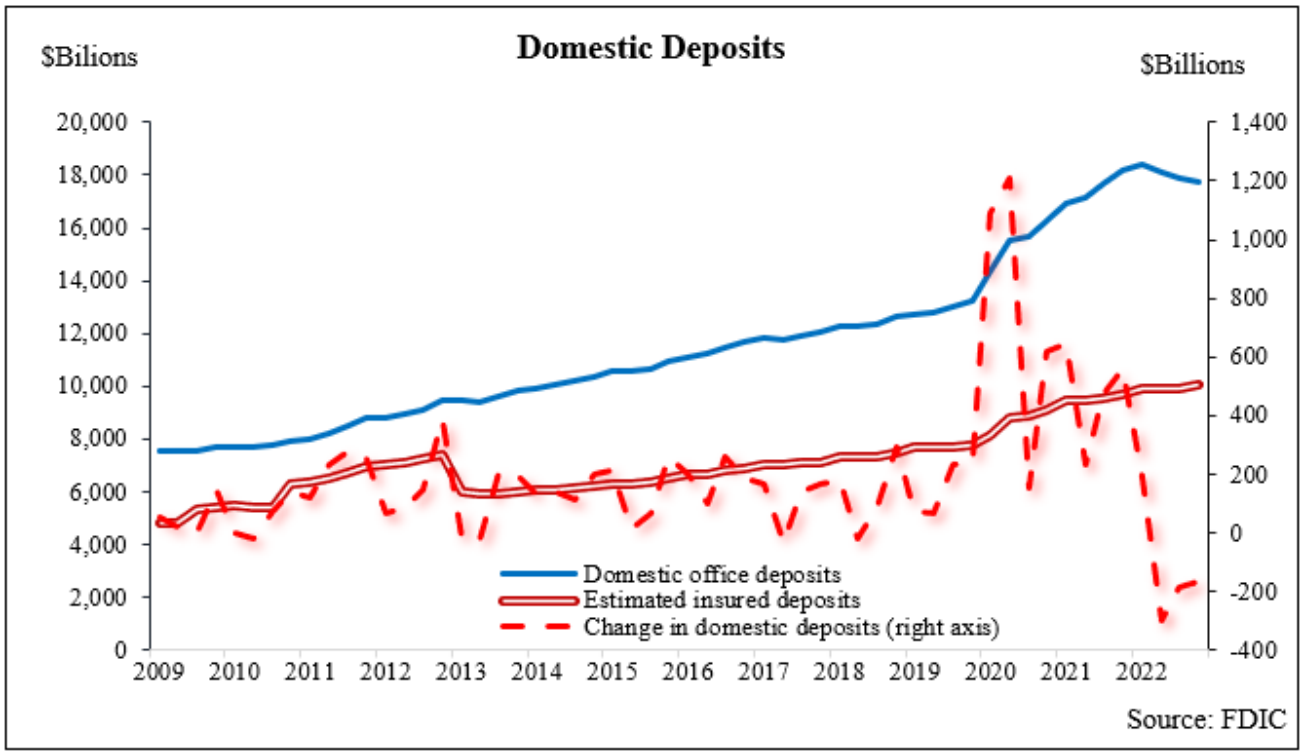


Figure 2 shows that before 2022, the unrealised gains (losses) mainly come from AFS securities, accounting for more than 85%. However, this trend was broken in 2022 when the unrealised losses on HTM securities counted for more than 50%. This evidence implies that HTM is more sensitive to the surge in interest rates than AFS securities.

For deposits, Figure 3 shows that the total domestic deposits, in general, increased steadily from 2009 until the beginning of 2022. However, these deposits experienced a significant surge from the first quarter of 2020 to the first quarter of 2022, before a substantial decrease afterward. In the second quarter of 2022, about $304 billion was withdrawn from the banking system. The withdrawals have occurred recently, with over $167 billion withdrawn every quarter.

Figure 2: Domestic deposits



3.2 Univariate Analysis

In this section, we quantify the relationship among variables used in our paper. Table 1 shows that the fed funds effective rate (CFED) is positively correlated with three measures of unrealised losses. The p-values of these correlations are smaller than 0.05, significant at the conventional levels. Consistent with the evidence in the previous section, these results indicate that the U.S. banks tend to have more unrealised losses when interest rates increase.

Table 1: Correlation Matrix

	CFED	CUNL	CUNLA	CUNLH	SWITCH	CDIFF	CINW	CUNINW	CDEPW	GDP	CPI	CSECU
CUNL	0.453***											
	(0.00)											
CUNLA	0.443***	0.997***										
	(0.00)	(0.00)										
CUNLH	0.415***	0.9421***	0.9193***									
	(0.00)	(0.00)	(0.00)									
SWITCH	0.672***	0.659***	0.651***	0.617***								
	(0.00)	(0.00)	(0.00)	(0.00)								
CDIFF	0.651***	0.631***	0.617***	0.598***	0.954***							
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)							
CINW	0.114	0.077	0.079	0.090	0.177	0.127						
	(0.40)	(0.58)	(0.56)	(0.51)	(0.19)	(0.35)						
CUNINW	0.177*	0.020	0.019	-0.001	0.079	0.061	-0.824***					
	(0.09)	(0.88)	(0.89)	(0.99)	(0.56)	(0.65)	(0.00)					
CDEPW	0.570***	0.172	0.167	0.171	0.4693*	0.330**	0.368***	0.166				
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.40)	(0.09)	(0.00)			
GDP	0.042	0.061	0.067	0.050	0.204	0.182	0.206	0.040	0.389***			
	(0.76)	(0.66)	(0.62)	(0.72)	(0.13)	(0.18)	(0.13)	(0.77)	(0.00)			
CPI	0.373***	0.504***	0.509***	0.397***	0.612***	0.607***	0.036	0.091	0.210	0.335**		
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.79)	(0.50)	(0.12)	(0.01)		
CSECU	-0.202	-0.210	-0.226*	-0.127	-0.246*	-0.063	-0.119	0.072	-0.109	0.170	-0.039	
	(0.14)	(0.12)	(0.09)	(0.35)	(0.07)	(0.65)	(0.38)	(0.60)	(0.43)	(0.21)	(0.78)	
CDEPA	-0.215	-0.018	-0.024	0.039	-0.360**	-0.255*	-0.340**	-0.011	-0.577***	-0.303**	-0.226*	0.508***
	(0.11)	(0.90)	(0.86)	(0.78)	(0.01)	(0.06)	(0.01)	(0.94)	(0.00)	(0.02)	(0.09)	(0.00)

Note: This table reports the paired correlations among variables used in the paper. CUNL is the negative change in the banks' unrealised losses on investment securities, CUNLA is the negative change in the banks' unrealised losses on available-for-sale-securities, and CUNLH is the negative change in the banks' unrealised losses on held-to-maturity securities. SWITCH is the difference between the change in HTM securities and the change in AFS securities scaled by 1 million, CDIFF is the change in the ratios of HTM securities to AFS securities. CINW is the banks' insured deposit withdrawal, CUNINW is the banks' uninsured deposit withdrawal, and CDEPW is the banks' total deposit withdrawal. CFED is the change in the fed funds effective rate, GDP is the GDP growth rate, CPI is the CPI index, CSECU is the change in the banks' securities to total assets ratio, and CDEPA is the change in the banks' deposit to total assets ratios. The *, **, and *** denote statistical significance at 10%, 5% and 1% levels, respectively.

Table 1 also documents that fed funds effective rate positively correlated with both measures of the switch in debt securities. In contrast, the relationship between the fed funds effective rate and each measure of deposit withdrawal is divergent. While the relationship between the fed funds effective rate and insured deposit withdrawals is insignificant, the relationship between this rate and total deposit withdrawals is significantly positive. This means that when interest rates increase, uninsured depositors withdraw their funds from the banking industry.

Table 1 also presents the correlation between our main variables and other controlled variables. The relationship between CPI and each measure of unrealised losses is significantly positive, implying that the U.S. banks tend to experience high unrealised losses when inflation rate increases. In contrast, the GDP growth is not significantly correlated with the banks' losses.

3.3 Multivariate Analysis

To further investigate the effects of interest rates on bank performance, we employ the regression model (1). The results, reported in Table 2, show that there is a positive correlation between the

change in fed funds effective rate and three measures of unrealised losses. The coefficients of these correlations have p-values of less than 0.05, signifying significance at the 5% level. Inconsistent with the argument in Drechsler et al., (2021)'s article, this result suggests that as interest rates rise, U.S. banks are more likely to experience greater unrealised losses. In terms of magnitude, if fed funds rate increases by one standard deviation of the change in this rate (0.39%), the unrealised losses will increase by 2.92%.

Table 2: Interest Rate and Unrealised Losses

	$CUNL_t$	$CUNLA_t$	$CUNLH_t$
$CFED_t$	0.001**	0.001**	0.001**
	(0.031)	(0.044)	(0.029)
GDP_{t-1}	-0.000	-0.000	-0.000
	(0.599)	(0.601)	(0.843)
CPI_{t-1}	0.000***	0.000***	0.000
	(0.008)	(0.005)	(0.177)
$CSECU_{t-1}$	0.000	0.000	-0.000
	(0.575)	(0.552)	(0.987)
$CDEPA_{t-1}$	0.000	-0.000	0.000
	(0.960)	(0.973)	(0.717)
Intercept	-0.000	-0.000	-0.000
	(0.152)	(0.122)	(0.463)
N	56	56	56
Adj. R^2	0.2612	0.2684	0.1268

Note: This table reports the results from the regression of the banks' unrealised losses on the change in the interest rates and other variables. CUNL is the negative change in the banks' unrealised losses on investment securities, CUNLA is the negative change in the banks' unrealised losses on available-for-sale- securities, and CUNLH is the negative change in the banks' unrealised losses on held-to-maturity securities. CFED is the change in the fed funds effective rate, GDP is the GDP growth rate, CPI is the CPI index, CSECU is the change in the banks' securities to total assets ratio, and CDEPA is the change in the banks' deposit to total assets ratios. The *, **, and *** denote statistical significance at 10%, 5% and 1% levels, respectively

We have also investigated the impact of interest rates on the switch in debt securities. The findings presented in Table 3 indicate that this effect is positive, with p-values of the coefficients smaller than 0.01, signifying significance at the 1% level. Additionally, the table shows that the U.S. banks tend to switch from available-for-sale (AFS) securities to held-to-maturity (HTM) securities when the inflation rate rises.

Table 3: Interest Rate and the Switch between HTM and AFS securities

	$SWITCH_t$	$CDIFF_t$
$CFED_t$	24.982***	5.061***
	(0.000)	(0.000)
GDP_{t-1}	0.118	0.014
	(0.686)	(0.815)
CPI_{t-1}	2.246**	0.435**
	(0.034)	(0.048)
$CSECU_{t-1}$	2.070	0.494
	(0.635)	(0.587)
$CDEPA_{t-1}$	2.615	0.798
	(0.399)	(0.219)
Intercept	-0.043*	0.000
$CFED_t$	(0.072)	(0.971)
N	56	56
Adj. R^2	0.4868	0.4615

Note: This table reports the results from the regression of the switch between HTM and AFS securities on the change in the interest rates and other variables. SWITCH is the difference between the change in HTM securities and the change in AFS securities scaled by 1 million, CDIFF is the change in the ratios of HTM securities to AFS securities. CFED is the change in the fed funds effective rate, GDP is the GDP growth rate, CPI is the CPI index, CSECU is the change in the banks' securities to total assets ratio, and CDEPA is the change in the banks' deposit to total assets ratios. The *, **, and *** denote statistical significance at 10%, 5% and 1% levels, respectively.

Table 4 presents the results of the regression analysis for deposit withdrawals with the change in the fed funds effective rate and other controlled variables. The findings in the table indicate that the effect of the fed funds effective rate on insured deposit withdrawals is not significant. In contrast, the fed funds effective rate has a significant and positive correlation with the withdrawal in either total deposits or uninsured deposits. This implies that as interest rates rise, uninsured depositors tend to withdraw their funds from the banking industry, resulting in a decrease in the banks' total deposits.

Table 4: Interest Rate and the change in deposit

	$CINW_t$	$CUNINW_t$	$CDEPW_t$
$CFED_t$	0.869	8.157**	3.445***
	(0.572)	(0.042)	(0.000)
GDP_{t-1}	0.119	-0.328	-0.002
	(0.206)	(0.172)	(0.966)
CPI_{t-1}	0.069	-1.189	-0.278
	(0.836)	(0.166)	(0.136)
$CSECU_{t-1}$	-3.769***	13.231***	0.674
	(0.009)	(0.001)	(0.221)
$CDEPA_{t-1}$	2.647***	-8.582***	0.019
	(0.010)	(0.001)	(0.961)

Intercept	-0.022***	0.004	-0.016***
	(0.005)	(0.846)	(0.000)
N	56	56	56
Adj. R^2	0.0844	0.2081	0.3522

Note: This table reports the results from the regression of the banks' deposit withdrawal on the change in the interest rates and other variables. CINW is the banks' insured deposit withdrawal, CUNINW is the banks' uninsured deposit withdrawal, and CDEPW is the banks' total deposit withdrawal. CFED is the change in the fed funds effective rate, GDP is the GDP growth rate, CPI is the CPI index, CSECU is the change in the banks' securities to total assets ratio, and CDEPA is the change in the banks' deposit to total assets ratios. The *, **, and *** denote statistical significance at 10%, 5% and 1% levels, respectively.

Overall, the findings from Table 1 to Table 4 suggest that an increase in interest rates leads to substantial unrealised losses on investment securities for U.S. banks. Additionally, the results indicate that a rise in interest rates is linked to the withdrawal of uninsured deposits, which represent roughly 45% of total deposits held by banks. These results align with recent research on banking fragility, such as the studies conducted by Jiang et al. (2023) and Vo and Le (2023). The results suggest that U.S. banks may be vulnerable to risk during periods of surging interest rates.

4. Bank-level Analysis

Our primary analysis examines the impact of interest rate hikes on bank performance at the aggregate level. To ensure the robustness of our findings, we extend our investigation to the bank level by modifying regression model (1) as follows:

$$\text{Perform}_{i,t} = \beta_1 \Delta\text{FED}_t + \beta_2 \text{MACRO}_{t-1} + \beta_3 \text{ABANK}_{t-1} + \beta_4 \text{BANK}_{i,t-1+} \beta_5 \text{BANK-DUMM}_i + \varepsilon_t \quad (2)$$

where Perform is a measure of bank performance, including debt securities switches (the difference between the change in HTM securities and change in AFS securities), change in HTM securities, change in AFS securities, losses on HTM and AFS securities, realised losses on both HTM and AFS securities ratio, and change in uninsured deposit ratio. ΔFED is the change in the fed funds effective rate in percentage, MACRO is a vector of macroeconomic variables, including GDP and CPI, and ABANK is a vector of banks' characteristics at aggregate level, including the securities ratio (SECU) and the deposit ratio (DEPA). BANK is a vector of bank-level characteristics, which consists of the logarithm of total assets, ROA, deposit ratio, capital ratio, HTM securities ratio, and AFS securities ratio.

Table 5 presents the results from regression model (2). The first column indicates that the coefficient for the change in interest rate is positive and statistically significant at the 1% level (p-value = 0.00). This suggests that as interest rates rise, banks tend to increase their holdings of HTM securities. Notably, the change in interest rate is significantly positively correlated with changes in HTM securities and negatively correlated with AFS securities. These findings imply that higher interest rates prompt banks to invest more in HTM securities while reducing their AFS securities holdings. Additionally, the results indicate that banks experience greater losses, particularly in AFS securities, and that depositors are more likely to withdraw uninsured deposits when interest rates increase. The coefficient for the change in interest rate is negative and significant at the 1% level (p-value = 0.00).

Table 5: Interest Rate and Bank Performance

	ΔSE_t	ΔHTM_t	ΔAFS_t	$\Delta LOSS_t$	$\Delta UNDEP_t$
ΔFED_t	0.001***	0.001***	-0.001***	0.000***	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
GDP_t	0.002**	0.002***	-0.001	-0.000***	0.003***
	(0.029)	(0.000)	(0.454)	(0.000)	(0.000)
CPI_t	-0.127***	0.027***	0.155***	0.001***	-0.015***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$CSECU_t$	-0.479***	-0.081***	0.397***	0.007***	-0.118***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$CDEPA_t$	0.007	0.002	-0.004	-0.007***	-0.122***
	(0.574)	(0.592)	(0.676)	(0.000)	(0.000)
LAT_{t+1}	0.003***	0.000	-0.003***	-0.000***	0.001***
	(0.000)	(0.625)	(0.000)	(0.000)	(0.000)
ROA_{t+1}	-0.032*	-0.009	0.023	0.011***	0.017**
	(0.050)	(0.160)	(0.110)	(0.000)	(0.024)
DEP_{t+1}	-0.020***	0.004***	0.024***	0.000	-0.010***
	(0.000)	(0.000)	(0.000)	(0.784)	(0.000)
CAP_{t+1}	0.011*	-0.019***	-0.031***	-0.001***	-0.001
	(0.088)	(0.000)	(0.000)	(0.000)	(0.601)
HTM_{t+1}	-0.063***	-0.067***	-0.004	-0.000***	-0.006***
	(0.000)	(0.000)	(0.269)	(0.000)	(0.000)
AFS_{t+1}	0.086***	0.003***	-0.083***	-0.000***	-0.004***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$UNDEP_{t+1}$	0.007**	-0.004***	-0.011***	-0.000***	-0.140***
	(0.036)	(0.001)	(0.000)	(0.000)	(0.000)
Intercept	-0.030***	-0.001	0.028***	0.001***	0.008***
	(0.000)	(0.520)	(0.000)	(0.000)	(0.001)
N	300,349	300,349	300,349	300,349	300,349
Adj. R^2	0.0432	0.0334	0.0506	0.0201	0.0822

Note: This table reports the results from the regression model (2). ΔFED is the change in the fed funds effective rate in percentage, GDP is the GDP growth rate, CPI is the CPI index, CSECU is the change in the banks' securities to total assets ratio, and CDEPA is the change in the banks' deposit to total assets ratios. SE is the switch from AFS to HTM securities, HTM is the HTM securities ratio, AFS is the AFS securities ratio, LOSS is the realised losses on both HTM and AFS securities, UNDEP is uninsured deposit ratio, LAT is the logarithm of total assets, and CAP is the capital ratio. The *, **, and *** denote statistical significance at 10%, 5% and 1% levels, respectively.

To further explore how changes in interest rates affect bank performance, we examine the moderating role of specific bank characteristics. We modify regression model (2) by incorporating interactions between the change in interest rate and key bank characteristics, such as size (logarithm of total assets), capital ratio, and uninsured deposit ratio. Our focus is on the coefficients of the change in interest rates and these interaction terms.

Column 1 of Table 6 reveals that the coefficient for the change in interest rates becomes significantly negative, while the interaction term is significantly positive. This indicates that larger banks are more inclined to shift towards HTM securities by reducing their AFS securities investments in response to rising interest rates. However, columns (2) and (3) suggest that smaller banks have incurred higher securities losses, whereas larger banks face greater withdrawals of uninsured deposits. This observation aligns with the notion that larger banks typically attract substantial depositors with more uninsured deposits and maintain more diversified asset portfolios.

Table 6: Interest Rate, Bank Characteristics, and Bank Performance

	ΔSE_t	$\Delta LOSS_t$	$\Delta UNDEP_t$	ΔSE_t	$\Delta LOSS_t$	$\Delta UNDEP_t$	ΔSE_t	$\Delta LOSS_t$	$\Delta UNDEP_t$
ΔFED_t* LAT_{t+1}	0.001***	-0.000*	-0.000***						
	(0.000)	(0.066)	(0.000)						
ΔFED_t* CAP_{t+1}				-0.017***	0.000***	0.001			
				(0.000)	(0.001)	(0.373)			
ΔFED_t* $UNDEP_{t+1}$							-0.002	0.000**	-0.002*
							(0.498)	(0.030)	(0.086)
ΔFED_t	-0.005***	0.000**	0.002***	0.003***	-0.000*	-0.001***	0.001***	0.000	-0.000***
	(0.000)	(0.017)	(0.000)	(0.000)	(0.096)	(0.000)	(0.000)	(0.207)	(0.000)
GDP_t	0.003**	-0.000***	0.003***	0.002**	-0.000***	0.003***	0.002**	-0.000***	0.003***
	(0.022)	(0.000)	(0.000)	(0.025)	(0.000)	(0.000)	(0.029)	(0.000)	(0.000)
CPI_t	-0.129***	0.001***	-0.014***	-0.129***	0.001***	-0.015***	-0.128***	0.001***	-0.015***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$CSECU_t$	-0.471***	0.007***	-0.120***	-0.476***	0.007***	-0.118***	-0.478***	0.007***	-0.118***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$CDEPA_t$	0.006	-0.007***	-0.122***	0.010	-0.007***	-0.122***	0.007	-0.007***	-0.122***
	(0.610)	(0.000)	(0.000)	(0.393)	(0.000)	(0.000)	(0.563)	(0.000)	(0.000)
LAT_{t+1}	0.002***	-0.000***	0.001***	0.003***	-0.000***	0.001***	0.003***	-0.000***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ROA_{t+1}	-0.029*	0.011***	0.016**	-0.031*	0.011***	0.017**	-0.032*	0.011***	0.017**
	(0.074)	(0.000)	(0.033)	(0.055)	(0.000)	(0.025)	(0.051)	(0.000)	(0.024)
DEP_{t+1}	-0.021***	0.000	-0.010***	-0.020***	0.000	-0.010***	-0.020***	0.000	-0.010***
	(0.000)	(0.739)	(0.000)	(0.000)	(0.740)	(0.000)	(0.000)	(0.768)	(0.000)
CAP_{t+1}	0.010	-0.001***	-0.001	0.015**	-0.001***	-0.002	0.011*	-0.001***	-0.001
	(0.127)	(0.000)	(0.705)	(0.027)	(0.000)	(0.559)	(0.087)	(0.000)	(0.605)
HTM_{t+1}	-0.063***	-0.000***	-0.005***	-0.063***	-0.000***	-0.006***	-0.063***	-0.000***	-0.006***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
AFS_{t+1}	0.085***	-0.000***	-0.004***	0.085***	-0.000***	-0.004***	0.085***	-0.000***	-0.004***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$UNDEP_{t+1}$	0.007**	-0.000***	-0.140***	0.007**	-0.000***	-0.140***	0.007**	-0.000***	-0.139***
	(0.020)	(0.000)	(0.000)	(0.031)	(0.000)	(0.000)	(0.029)	(0.000)	(0.000)
Intercept	-0.027***	0.001***	0.007***	-0.029***	0.001***	0.008***	-0.030***	0.001***	0.008***
	(0.000)	(0.000)	(0.004)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.001)
N	300,349	300,349	300,349	300,349	300,349	300,349	300,349	300,349	300,349
Adj. R^2	0.0435	0.0201	0.0823	0.0434	0.0202	0.0822	0.0432	0.0201	0.0822

Note: This table reports the results from the regression model (2). ΔFED is the change in the fed funds effective rate in percentage, GDP is the GDP growth rate, CPI is the CPI index, CSECU is the change in the banks' securities to total assets ratio, and CDEPA is the change in the banks' deposit to total assets ratios. SE is the switch from AFS to HTM securities, HTM is the HTM securities ratio, AFS is the AFS securities ratio, LOSS is the realised losses on both HTM and AFS securities, UNDEP is uninsured deposit ratio, LAT is the logarithm of total assets, and CAP is the capital ratio. The *, **, and *** denote statistical significance at 10%, 5% and 1% levels, respectively.

Table 6 also shows that banks with low capital tend to switch more to HTM securities by reducing investments in AFS securities to reduce realised losses on these securities. Moreover, banks with a high uninsured deposit ratio tend to experience higher losses and higher uninsured deposit withdrawals when interest rates increase.

5. Conclusion

This paper investigates the impact of interest rate on the U.S. banks' performance measured by the unrealised losses on debt securities and deposit withdrawals at the aggregate level since the end of the financial crisis of 2007-2009. We first show that the U.S. banks only significantly invested in debt securities during the COVID-19 pandemic. The total value of investment securities grew at over 56% during the 2020-2021 period and started to decline in 2022 when interest rates surged. Among these securities, HTM ones nearly tripled, and they are still growing in 2022 while AFS securities have dropped. These results indicate that there exists a switch in banks' securities investments. Although the banks can hide unrealised losses on these securities, this shift makes banks' balance sheets more attractive as well as reduces the pressure on maintenance of banks' capital requirement.

Second, our analysis reveals that unrealised losses on U.S. banks' debt securities surged in 2022, peaking at an all-time high of $690 billion in the second quarter of the year. We also observed a significant shift in the unrealised losses (or gains) on available-for-sale (AFS) and held-to-maturity (HTM) securities. Prior to the COVID-19 pandemic, AFS securities accounted for over 85% of unrealised losses (or gains), but during the pandemic, this figure decreased to less than 50%. In contrast, HTM securities showed a sharp increase in unrealised losses (or gains), exceeding 50% during the same period. These results suggest that HTM securities are more sensitive to interest rate surges than AFS securities.

Third, we document that total domestic deposits increased significantly from 2020 to the first quarter of 2022, but have since largely dropped, mainly due to a decline in uninsured deposits. However, insured deposits have continued to grow during the COVID-19 pandemic.

Fourth, using the regression model, we show that interest rates are significantly correlated with the banks' unrealised losses. Moreover, we also document that uninsured depositors withdraw their funds from banking system when interest rates increase. As a result, the total deposits are negatively related to interest rates.

Finally, we reinforce these findings through an analysis of bank-level data, yielding consistent results. An increase in interest rates encourages banks to reallocate investments from AFS securities to HTM securities. Additionally, banks face increased losses on these securities and greater withdrawals of uninsured deposits. This shift toward HTM securities is more significant among large banks or those with lower capital. Conversely, smaller banks or institutions with higher capital or uninsured deposits incur more substantial losses. Furthermore, large banks or those with a higher proportion of uninsured deposits are particularly vulnerable to elevated uninsured deposit withdrawals.

The findings in our paper provide implications for policymakers. First, a surge in interest rates could lead to significant losses for banks. Second, uninsured depositors may withdraw their funds from the banking system as interest rates rise. Both high losses and deposit withdrawals can pose risks to banks, potentially causing some banks to fail if they do not manage their assets and liabilities properly.

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