KENNESAW STATE UNIVERSITY

Impact of High Interest Rates on Small Banks' Financial Performance

CSBS 2023 Annual Data Analytics Competition Final Report

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1. Abstract

The banking sector faces a challenge due to the recent tightening of the Federal Reserve's monetary policy, as shown by the rapid increase in the Federal Funds Effective Rate. This is further compounded by the ongoing economic crisis, which is expected to worsen into a recession in the summer of 2023. These high-interest rates are likely to affect the profitability of banks and increase credit default rates. To explore the impact of interest rates on bank performance, this study analyzes two types of relatively small banks, namely commercial and savings banks. The research findings highlight the varied effect of interest rates on banks' performance. Additionally, we conducted stress tests on the national banking system to evaluate its resilience to interest rate shocks under both baseline and severe scenarios. Our study concludes that interest rates should remain at current levels or be decreased gradually in the short term.

2. Background and motivation

The COVID-19 pandemic, coupled with the short-term shutdown of the economy, led to a rise in inflation due to supply chain disruptions and job market tightening (Stiglitz, Regmi, 2022). The inflation was further exacerbated by stimulus checks (Ball, Leigh, Mishra, 2022) which, as we show later, had a net negative impact on the economy. To combat inflation, the Federal Reserve System (FED) initiated an interest rate hike, which in turn exacerbated the current economic crisis and keeps impacting the banking industry by affecting their capital positions and increasing banks' risk profiles (White, 2023). The immediate impact leads to increased costs of borrowing money, market volatility, and aggregate demand shrinkage, which will affect banks' financial performance and their credit portfolio.

In this study, we have two main objectives. Firstly, we aim to investigate the impact of high-interest rates on banks' performance through explanatory econometric models. Secondly, we intend to stress test three indicators of banking performance. The main motivation behind the work is the current worsening of the global banking sector with the bankruptcy of Silicon Valley Bank and buyout of Credit Swiss being the most recent examples of financial industry's struggles. Since personnel reduction contributes to unemployment, we also analyze the impact of the Federal Funds Rate (FFR) on personnel expenses in the banking sector. To achieve these objectives, we have formulated a set of hypotheses, divided into primary and secondary hypotheses, as outlined in Table 1.

Table 1. The hypotheses investigated in the current study.

Hypotheses	
Primary	**Secondary**
1.1. Banks' net income will be negatively affected by high interest rates	**2.1.** The US banking system will overall experience increase of net losses
1.2. Banks will reduce operating expenses by reducing workforce and cutting bonuses	**2.2.** The US banking system will overall experience increase in total NPL portfolio.
1.3. Banks will experience rise of their credit card portfolio's NPL	**2.3.** The US banking system will experience overall decrease of net income

For the primary hypotheses, we examine Non-Performing Loans (NPL) from the credit card portfolio and the net income of the bank. We chose the credit card line of business for analysis because it is the most popular and accessible form of credit, and therefore, credit card portfolios are under high risk of exposure to interest rate changes. For the secondary hypotheses, we investigate net losses on loans and leases, the total loan portfolio's NPL, and the net income across all banks in the nation. The difference between primary and secondary hypotheses is that the former will be investigated by means of panel regression, while the latter will be tested by building

an Auto-Regressive Distributed Lag (ARDL) regression model on aggregated data over all national banks.

3. Data sources and glossary

For this study, we constructed a novel set of data comprised of several time-series datasets and one panel dataset. The panel we are building consists of banks' both specific and macroeconomic variables, which are described further below. Both panel and time-series datasets have a time-series dimension of 80 quarters, spanning from the first quarter of 2003 (2003Q1 in Stata) to the last quarter of 2022 inclusive (2022Q4). The cross-section dimension of the panel dataset consists of six categories of banks. A detailed description of the panel is given in the corresponding section.

3.1 Macroeconomic data

Macroeconomic indicators are collected from the Federal Reserve Bank of St. Louis database (FRED). All variables, except the FFR and unemployment rate, are annualized and seasonally adjusted quarterly averages expressed as percentage changes from the preceding period. These variables, by construction, do not require seasonality adjustments. Table 2 shows the variable names, their interpretations, and their tickers which will allow the reader to easily recover the time series data from FRED[1].

Table 2. Description of the macroeconomic data used in this study.

Time series	FRED ticker	Name in Stata	Meaning
Real expenditures	DPCERL1Q225SBEA	rexp	Real personal consumption expenditures, percent change from preceding period, quarterly, seasonally adjusted annual rate
Real GDP	A191RL1Q225SBEA	rgdp	Real gross domestic product, change, percent change from preceding period, seasonally adjusted annual rate
Real disposable personal income	DSPIC96_PC1	rincome	Real disposable personal income, percent change from year ago, quarterly, seasonally adjusted annual rate
Sticky price inflation less food and energy	CORESTICKM158SFRBATL	inflation	Sticky price CPI, seasonally adjusted annualized quarterly average
Unemployment rate	UNRATE	unemp	Seasonally adjusted quarterly average unemployment rate based on labor force defined as people over 16 years old and residing in 50 states or Columbia D.C. less active duty US Army personnel and people residing in institutions (mental and penal, etc.)
Real gross private domestic investment	GPDI_PC1	rgdi	Gross private domestic investment, percent change from year ago, quarterly, seasonally adjusted annual rate
Federal Funds Rate	FEDFUNDS	fedfund	FFR, percent, quarterly, not seasonally adjusted

[1] All files – macroeconomic and bank specific – are also accessible for downloading in Namazbai Ishmakhametov's GitHub https://github.com/Namaz13/csbs and also included as appendices to the submission archive.

We preferred to use sticky price inflation over traditional Personal Consumption Expenditure (PCE) inflation since the former indicator is based on goods and services that change prices relatively infrequently. Therefore, this indicator reflects inflation expectations to a greater degree compared to indices based on goods and services changing prices on a more frequent basis (Federal Reserve Bank of Atlanta, 2023).

All macroeconomic time series have been tested for the presence of a unit root using the Augmented Dickey-Fuller (ADF) test with up to four lags and with drift. We decided to include the drift term in all unit root tests since all macroeconomic variables are vulnerable to external shocks such as the COVID-19 global pandemic, the stimulus program, and the Russian invasion of Ukraine. Due to variables being percentage changes, we decided not to conduct the ADF test with a trend. The p-value threshold is set at 5% ($\alpha = 0.05$) and all p-values are listed in Table A in the appendices. The p values for Real GDP, Real Expenditure, and Real income are below 5%. Thus, we conclude that only these variables will be used at the levels in the current study. Due to the ongoing debates about the (non)stationarity of interest rates, unemployment, investments, and inflation, as well as mixed evidence from Table A and due to the possibility of the ADF test being sensitive to the way macroeconomic indicators were calculated (e.g. quarterly average versus end-of-quarter value), we decided to differentiate all time series with mixed results. Hence, we are using the first differences of the FFR, Unemployment Rate, Inflation, and Private Investment.

3.2 Bank-specific data

We limited our panel to six types of banks, depending on the type of business and size of assets. A bank might be either commercial or savings. The sizes of the portfolio are between \$0.1B and \$0.3B, \$0.3B and \$1B, and over \$1B US dollars. For the panel regression, we defined them as small, medium, and large. We omitted larger banks since our primary interest is relatively small banks; therefore, giant banks such as JP Morgan Chase, Goldman Sachs, etc., are not considered in this work. Thus, we have six possible combinations of banks, shown in Table 3.

Table 3. Types of banks considered in this study.

FFIEC code	Type of business	Size of assets' portfolio, USD
4	Commercial	Over 1 billion
5	Commercial	Between 300 million and 1 billion
6	Commercial	Between 100 million and 300 million
101	Savings	Over 1 billion
102	Savings	Between 300 million and 1 billion
103	Savings	Between 100 million and 300 million

The bank-specific variables are aggregated over a peer group of banks pulled from the data repository of the Federal Financial Institutions Examination Council (FFIEC). To independently retrieve these time series[2], one should go to the FFIEC data repository: "https://cdr.ffiec.gov/public/ManageFacsimiles.aspx" and choose "Peer Group Average Report" for the last quarter of 2022. Then, one should choose the corresponding code for banks: 4, 5, 6, 101, 102, and 103 for panel models, and NATIONAL for the ARDLs model. The list of bank-specific variables is shown in Table 4.

[2] Data are also available on Namazbai Ishmakhametov's GitHub and are also submitted as part of submission archive.

Table 4. Bank-specific variables used in this study.

Variable	Dimension	Stata name	Unit of measurement
Personnel expense	For each of six types of banks	personnel	Percent of average assets
Net income	For each of six types of banks	netinc	Percent of average assets
Non-performing credit card loans 90+ days delinquency	For each of six types of banks	npl_cc	Percent of non-current loans and leases in credit card portfolio
Net Interest Income ratio to Averaged Earning Assets	For each of six types of banks	nii_avgass	Percent of average assets
Provision: Loan and Lease Losses	For each of six types of banks	provision	Percent of average assets
Total LN&LS-90+ Days Past Due	Aggregated nationally	n_npl	Percent of total loan portfolio
Net income	Aggregated nationally	n_netinc	percent of average assets
Standardized Tier1 capital ratio	Aggregated nationally	n_tier	Capital ratio
Net Loss to Average Total LN&LS (income statement)	Aggregated nationally	n_netloss	Percent of average assets
Core deposits (bal. sheet)	Aggregated nationally	n_coredep	Percent of average assets
Net Loans and Leases (bal. sheet)	Aggregated nationally	n_nll	Percent of average assets

3.3 Panel data structure

The panel consists of bank-specific variables for the six types of banks mentioned in the previous section and all macroeconomic indicators. The total dimension of the panel is 6 by 80, thus yielding 480 observations. We also conducted the Levin-Lin-Chu (LLC) panel unit root test, yielding the results shown in Table B in the appendices. The LCC test's null hypothesis says at least one of the panels contains a unit root. Since the LLC test rejects the null hypothesis for Net Income but the p-value is close enough to $\alpha = 0.1$, we double check the Net Income with panel stationarity test that tests stationarity as well as the null hypothesis. We used the Hadri panel stationarity test with Bartlett kernel with up to 4 lags. This has resulted in a p-value of 0.087. Based on this evidence, we concluded that Net Income is also stationary across all panels, so we used it in levels rather than first differences.

4. Stress-testing national banking system

5.1 Stress-testing the dataset's structure

The stress-testing dataset consists of bank-specific time-series data based on data aggregated over all banks in the U.S. and macroeconomic time series. Time series for this model are also pulled from FRED and FFIEC datasets for the period from 2003Q1 to 2022Q4, with the option NATIONAL chosen for Peer Average Group Report.

5.2 Addressing the extrapolation forecast concern

One major challenge with using econometric methods for forecasting is the need to extrapolate into the future. This becomes problematic when the regression model has to rely on projected

values of independent variables that are not present in the training dataset. In some cases, there may be concerns that the regression models used in a study are not optimal due to unprecedented interest rate hikes. However, this is not an issue in the current study because there have been two instances since 2000 when the FFR was increased at an aggressive pace, as depicted in the Fig. 1 below.

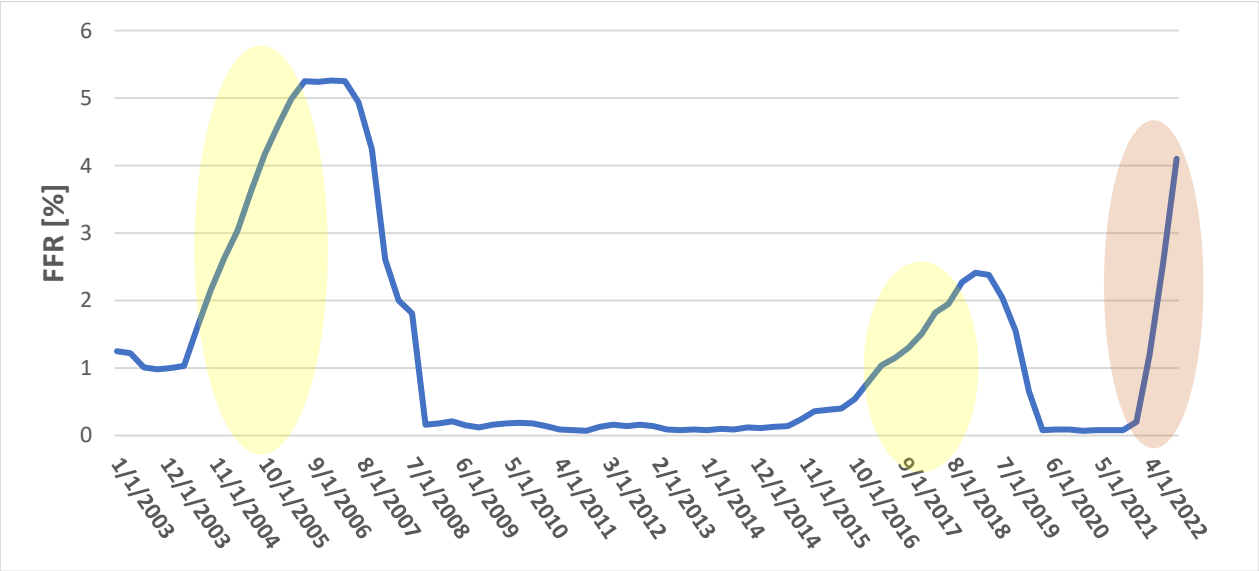


Figure 1. Evolution of FFR for the period between 2003 and 2022.

While the interest rate hike in 2004-2005 and 2017-2018 is not as steep as in 2022, it is still steep enough to provide enough training experience for the regression models for our limited study. Therefore, we proceeded as usual when building the models without further adjustments.

5.3 Stress-testing scenarios

In order to perform simulations of banks' performance indicators under the impact of high-interest rates, we need scenarios for future values of FFR, unemployment, inflation, and GDP, as well as some bank-specific variables that were used in regressions. According to the transcript of the Chairman of FED, Mr. Jerome Powell, after the Federal Open Market Commission on March 22nd meeting, the FED was considering a pause in hiking interest rates the days before the meeting (FOMC Press conference, 2023). Based on this limited evidence, we proceeded with the assumption that the 2023Q1 quarterly average interest rate of 4.5% will not rise further, so we are not considering an interest rate hike scenario. We constructed two possible scenarios for the evolution of interest rates in 2023-2024, as shown in Table 5. Due to the high uncertainty of the ongoing economic situation, we withhold from specifying whether the alternative scenario is severe or optimistic until we see the forecasts.

Table 5. FFR evolution scenarios for quarterly average rates.

Period	Baseline	Alternative
2023Q2	4.5	4
2023Q3	4.5	3.5
2023Q4	4.5	3.5
2024Q1	4.25	3
2024Q2	4.25	3
2024Q3	4.00	2.5
2024Q4	4.00	2.5

As seen in the table, the baseline scenario assumes that interest rates will stay at current levels throughout 2023 and will gradually decrease by 0.25% in 2024 every six months. The alternative scenario assumes a much more aggressive cut of 0.5% every six months.

Our projections for unemployment and GDP growth are based on FED's latest Monetary Policy report which provides median consensus forecasts of main macroeconomic indicators. Consensus is achieved among the members of the Federal Reserve Board and presidents of twelve Federal Reserve Banks based on their individual assumptions (Board of Governors of the Federal Reserve System, 2023), as shown in Table 6. The projected values are for each year from 2023 through 2025 as well as for the long run.

Table 6. Federal Reserve consensus projections of main macroeconomic indicators.

Indicator	2023	2024
Change in real GDP	0.5	1.6
Unemployment rate	4.6	4.6
PCE inflation	2.8	2.3

Since the values are given for a year, we assume that quarterly averages will be the same, hence we simply interpolate the values to obtain the projections. The bank specific scenarios are obtained by simply assuming that values of bank specific variables will be exactly the same as in corresponding quarters. Therefore, the final set of assumptions for all variables in stress testing models are shown in Table 7.

Table 7. Stress testing assumptions from 2023Q2 to 2024Q4.

Date	n_coredep	n_tier	unemp	rgdp	inflation	fedfund_base	fedfund_alt
2023Q2	81.83	16.17	4.6	0.5	2.8	4.5	4
2023Q3	81.79	15.98	4.6	0.5	2.8	4.5	3.5
2023Q4	81.35	15.89	4.6	0.5	2.8	4.5	3.5
2024Q1	81.67	16.91	4.6	1.6	2.3	4.25	3
2024Q2	81.83	16.17	4.6	1.6	2.3	4.25	3
2024Q3	81.79	15.98	4.6	1.6	2.3	4	2.5

5.4 Stress-testing methodology

The stress-testing methodology consists of several steps. These are described as follows:

1. Withhold period from 2021Q1 to 2023Q1 to use for out-of-sample forecast simulation (similar to hold-out dataset concept in machine learning)
2. Withhold period from 2023Q2 to 2024Q4 since these are projections and are used for actual stress-testing forecast
3. Estimate appropriate ARDL model for each indicator being stress-tested on the remaining data – from 2003Q1 to 2020Q4
4. Obtain quasi-forecasts from 2021Q1 to 2023Q1
5. Compare forecasts with actual observed historical values and assess forecasting strength of the ARDL model
6. Build actual stress-testing forecasts

As mentioned in the introduction, we will stress test the following three indicators, aggregated over all banks in U.S.:

1. net income

2. net losses for loans and leases
3. NPL based on total loan portfolio

5. Exploratory analysis

6.1 Impact of stimuli

In this section we briefly assess the impact of stimulus checks program on inflation. The stimulus checks have injected money into the economy, leading to an increase in consumption, therefore rising inflationary pressure. The timeline of the stimulus program is shown in Fig A in the appendices. We calculated excess inflation by subtracting the three-year average from the current inflation and we also calculated economic loss due by multiplying the real GDP by excess inflation. These impacts are illustrated in Fig. 2. and Fig. 3. respectively.

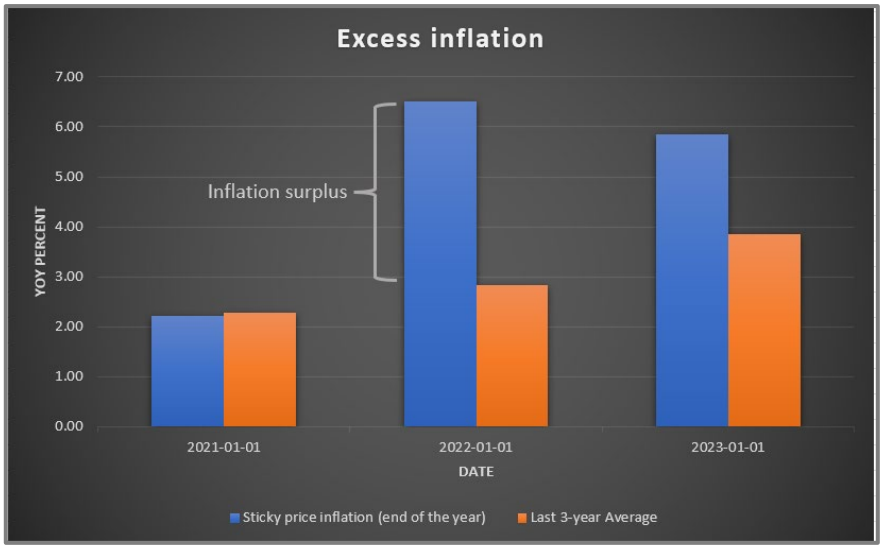


Figure 2. Excess inflation impact.

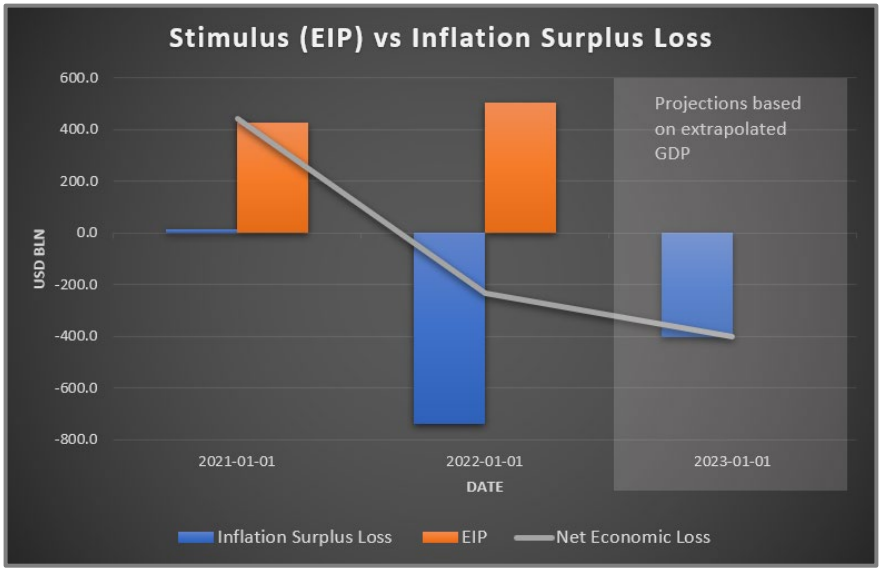


Figure 3. Stimulus checks impact.

This excessive inflation might negatively affect low-income households who are more vulnerable to price hikes, thus offsetting positive impacts of stimulus program in the long run. These additional inflationary pressures might have been yet another motivation for FED to start

aggressively raising FFR. The policy change is already showing some influence on the banking sector by decreasing total amount of loans as illustrated in Fig. 4.

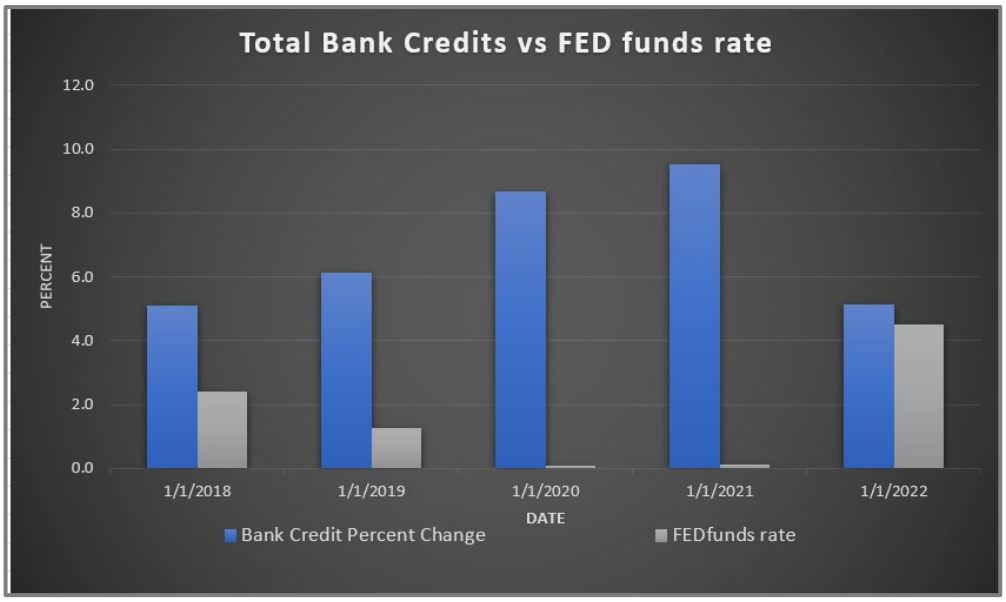


Figure 4. Total bank credits vs FED funds rate.

6.2 Macroeconomic indicators

A brief graphical analysis of the main macroeconomic indicators – inflation and GDP – is provided in Fig. B and Fig. C. The line chart of observed and steady-state (three period moving average) inflations shows early signs of slowdown which might signify efficiency of FED's current policy. On the other hand, comparison of observed and steady-state GDP shows no sign of economic activity decline which might be due to lag in reporting economic output statistics.

6.3 Banking sector overview

In this section we briefly analyze current state of banking sector for the six types of banks included in the panel. The commercial and industrial loans are the biggest part of total loan portfolio for all six types of banks, as illustrated in Fig. E and F in the appendices. However, there is a distinct trend in commercial banks performance: starting 2021 the commercial and industrial loans started rapidly decreasing in the total loan portfolio and have almost achieved parity with core deposits in 2022.

The density analysis of non-performing loans for six groups of banks shows that large and medium savings banks are having unusually high rates of NPL as illustrated in Fig. 5. On the other hand, commercial banks of all sizes are experiencing a decrease of net profits at higher scale compared to savings banks since they have much heavier left tails in net income distribution as illustrated in Fig. 6.

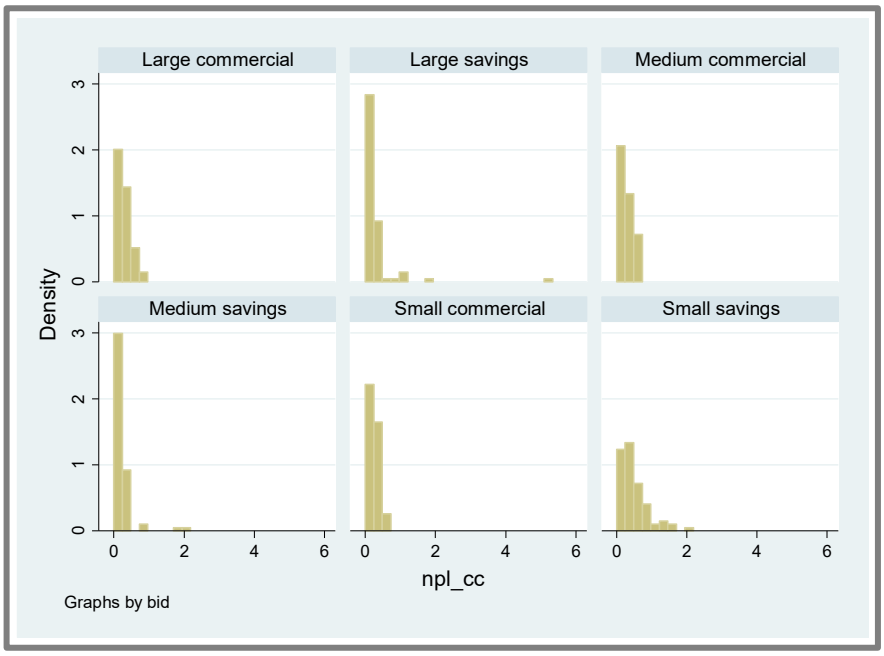


Figure 5. NPL rates for the banks considered.

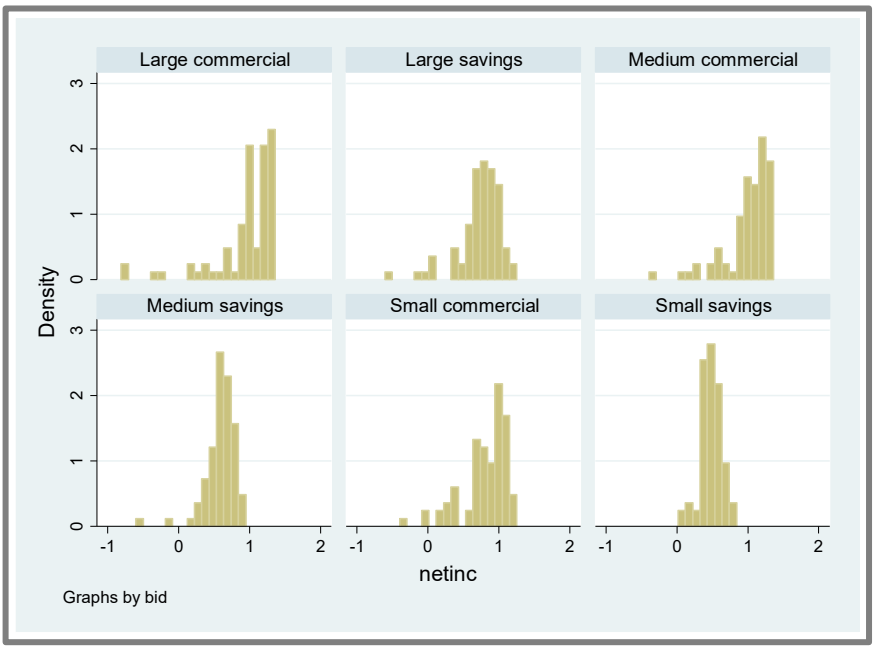


Figure 6. Net income for the banks considered.

6.4 Correlation Analysis

To provide further evidence in favor of panel regression models, we computed the Pearson correlation coefficient between Net Income and FFR. Correlations are calculated for each one of the six bank types to illustrate the uneven effect of interest rate across different types and sizes of banking businesses. See Table 8.

Table 8. Pearson correlation coefficients between Net Income and FFR.

Type of bank	ρ
Commercial banks with assets over $1 BLN	0.373
Savings banks with assets over $1 BLN	0.406
Commercial banks with assets between $300 MLN and $1 BLN	0.332

Savings banks with assets between $300 MLN and $1 BLN	0.378
Commercial banks with assets between $100 MLN and $300 MLN	0.329
Savings banks with assets between $100 MLN and $300 MLN	0.336

Based on the table, we can conclude that the correlation between Net Income and FFR varies across types and sizes of banks.

6. Models' specifications

7.1 Panel models for banks' performance indicators

We propose the following panel regression models for the banking performance indicators. The summation indicates that we are using up to two lags of corresponding variables in our regressions.

$$Net\ Inc_{i,t} = \propto_0 + \sum_{j=0}^{2} \Delta FFR_{i,t-j} + \sum_{j=0}^{2} \Delta Unemp_{i,t-j} + \sum_{j=0}^{2} NII_{i,t-j} + \sum_{j=0}^{2} Prov_{i,t-j} + \mu_i + \varepsilon_{i,t} \quad (1)$$

$$NPL_{i,t} = \propto_0 + \sum_{j=0}^{2} \Delta FFR_{i,t-j} + \sum_{j=0}^{2} \Delta Unemp_{i,t-j} + \sum_{j=0}^{2} NII_{i,t-j} + \sum_{j=0}^{2} Prov_{i,t-j} + \mu_i + \varepsilon_{i,t} \quad (2)$$

$$Personnel_{i,t} = \propto_0 + \sum_{j=0}^{2} \Delta FFR_{i,t-j} + \sum_{j=0}^{2} \Delta Unemp_{i,t-j} + \sum_{j=0}^{2} NII_{i,t-j} + \sum_{j=0}^{2} Prov_{i,t-j} + \mu_i + \varepsilon_{i,t} \quad (3)$$

Here:

- Net Inc – net income of banks
- NPL – non-performing credit card loans
- Personnel – personnel expense
- FFR – Federal Funds Rate
- Unemp – rate of unemployment
- NII – Net interest income ratio to average earning assets
- Prov – provision for loan and leases losses
- μ_i – unobserved time-invariant heterogeneity (latent factors inherent to banking group)
- $\varepsilon_{i,t}$ – idiosyncratic error term (stochastic disturbance, random error)

And, we expect the following outcomes from the regression models:

- FFR will have uncertain impact on banking income – on the one hand, higher interest rates might lead to slowdown of economy, thus reducing profits, on the other hand high interest rates may increase interest income of banks
- FFR will have overall positive effect on NPL – i.e. increase of interest rates will lead to increase of non-performing loans

- FFR will have an overall negative effect on personnel expenses – in other words, increase of interest rates will lead to decrease of personnel expenses which might be manifested as lay-offs or bonus cuts.

Due to the dynamic nature of the macroeconomic relationships, we decided to proceed with a dynamic panel model instead of random or fixed regressions (RE and FE respectively). Moreover, RE and FE are rarely applicable in real-world modeling due to vulnerability to endogeneity. Therefore, we estimate the panel regressions using a one-step Arellano-Bond Generalized Method of Moments estimator which uses lagged values of the dependent variable as instruments to ensure orthogonality conditions (Arellano, Bond, 1991). The estimation results are listed below with coefficients significant at $\alpha = 0.05$ highlighted in bold, and the residuals diagnostics are shown in Fig. 7. through Fig. 9. The full estimation tables are in appendices.

$$\begin{aligned}\text{Net Income}_{i,t} = {} & \mathbf{0.130} + \mathbf{0.613} \cdot \text{Net Income}_{i,t-1} + 0.096 \cdot \Delta\text{FFR}_{i,t} - 0.177 \cdot \Delta\text{FFR}_{i,t-1} \\ & + \mathbf{0.007} \cdot \Delta\text{FFR}_{i,t-2} + \mathbf{0.248} \cdot \text{NIIAVG}_{i,t} - \mathbf{0.177} \cdot \text{NIIAVG}_{i,t-1} \\ & + \mathbf{0.006} \cdot \text{RGDP}_{i,t} + \mathbf{0.003} \cdot \text{RGDP}_{i,t-2} - \mathbf{1.097} \cdot \text{PROV}_{i,t} + \mathbf{0.664} \cdot \text{PROV}_{i,t-1} \\ & + \mathbf{0.052} \cdot \Delta\text{UNEMP}_{i,t} + 0.003 \cdot \Delta\text{UNEMP}_{i,t-1} + \mu_i + \varepsilon_{i,t}\end{aligned}$$

$$\begin{aligned}NPL_{i,t} = {} & -0.416 + 0.332 \cdot NPL_{i,t-1} + 0.006 \cdot \Delta FFR_{i,t} - 0.018 \cdot \Delta FFR_{i,t-1} \\ & - 0.069 \cdot \Delta FFR_{i,t-2} - 0.075 \cdot NIIAVG_{i,t} - 0.469 \cdot NNIAVG_{i,t-1} - 0.223 \\ & \cdot NNIAVG_{i,t-2} + 0.005 \cdot RGDP_{i,t} - 0.003 \cdot RGDP_{i,t-1} - 0.002 \cdot RGDP_{i,t-2} \\ & + 0.042 \cdot PROV_{i,t} + 0.097 \cdot PROV_{i,t-1} + 0.018 \cdot \Delta UNEMP_{i,t} \\ & - 0.042 \cdot \Delta UNEMP_{i,t-1} + 0.045 \cdot \Delta UNEMP_{i,t-1} + \mu_i + \varepsilon_{i,t}\end{aligned}$$

$$\begin{aligned}PERS_{i,t} = {} & -0.010 + \mathbf{0.948} \cdot PERS_{i,t-1} - 0.007 \cdot \Delta FFR_{i,t} + 0.004 \cdot \Delta FFR_{i,t-1} \\ & + \mathbf{0.007} \cdot \Delta FFR_{i,t-2} + \mathbf{0.042} \cdot NIIAVG_{i,t} + 0.012 \cdot NNIAVG_{i,t-1} - 0.032 \\ & \cdot NNIAVG_{i,t-2} - 0.001 \cdot RGDP_{i,t} - 0.001 \cdot RGDP_{i,t-1} - 0.001 \cdot RGDP_{i,t-2} \\ & - 0.012 \cdot PROV_{i,t} + 0.003 \cdot PROV_{i,t-1} + 0.012 \cdot PROV_{i,t-2} \\ & - \mathbf{0.006} \cdot \Delta UNEMP_{i,t} + 0.001 \cdot \Delta UNEMP_{i,t-1} + 0.003 \cdot \Delta UNEMP_{i,t-1} + \mu_i \\ & + \varepsilon_{i,t}\end{aligned}$$

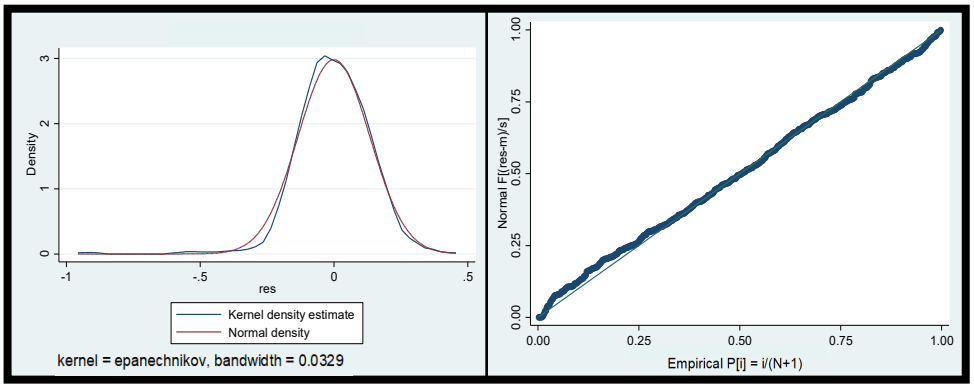


Figure 7. Normality check for residuals of Net Income regression.

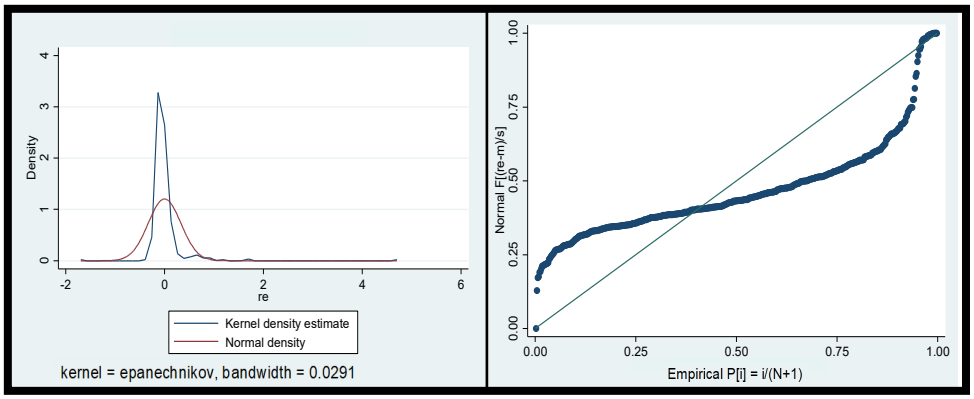


Figure 8. Normality check for residuals of NPL model.

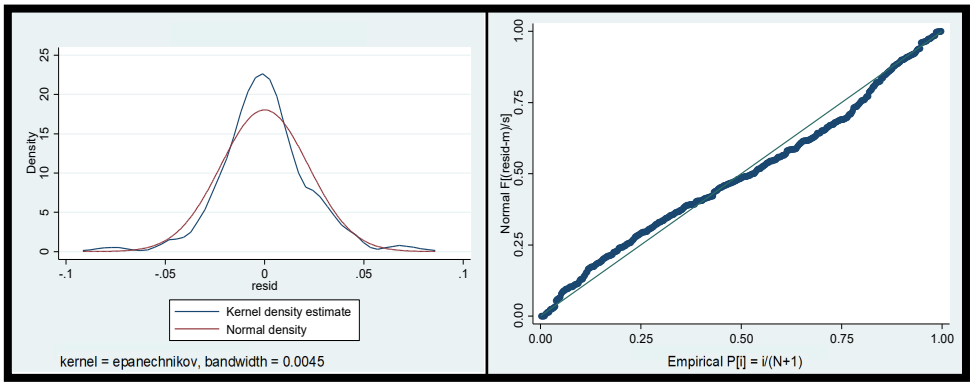


Figure 9. Normality check for residuals of personnel expense model

Upon carrying the Sargan's over-identification test, all 3 models passed the test which concludes the instruments are valid (see Table C in appendices). However, the NPL model fails normality of residuals check as shown in Fig. 8.

For the net income model, the interest rate has overall positive effect on net income of banks. The first two lags are insignificant at $\alpha = 0.05$, however the lag of second difference of FFR shows that 1% increase of FFR leads to 0.1% increase of net income two quarters later. Residuals of this model are also normal as shown on P-P plot and on comparison between standard normal distribution and kernel density estimate of residuals' distribution. The NPL model seems to be mis-specified based on residuals normality check and all lags of Federal Funds are insignificant. We therefore omit interpreting the panel level NPL regression. As expected, FFR has a small but statistically significant net negative impact on personnel expenses. A 1% increase in interest rate leads to a ~0.01% decrease in personnel expenses in the corresponding quarter. The effect is, however, barely significant.

7.2 Stress testing national banking system

After confirming that rising interest rates have a theoretically plausible, statistically significant, and economically significant impact on banks' net income, we proceeded to stress test the aggregated national-level banking income, aggregated net loss, and aggregated NPL under two interest rate scenarios. To create these scenario simulations, we estimated the impact of the FFR on the total net income of the US banking sector, which is the national aggregate in the FFIEC dataset. In other words, we conducted a regression analysis of the all-American average net income on the FFR, while controlling for macroeconomic and bank-specific variables. We then used this analysis to create simulations based on an ARDL time-series model. This model assumes that the

evolution of the dependent variable is influenced by its past values as well as the current and past values of the independent variables. To create the simulations, we built a simple ARDL model that uses only interest rates as an exogenous variable, making it equivalent to an ARMAX model. However, due to having only 80 observations, we only used one lag for each variable except for FFR and dependent variable in order to preserve degrees of freedom. The ARDL specifications for all three models are provided below and based on Eqs. 4.

$$Perf_t = \propto_t + \sum_{j=1}^{2} \beta_j \cdot Perf_{t-j} + \sum_{j=1}^{2} \gamma_j \cdot FFR_{t-j} + \sum_{j=1}^{1} \delta_j \cdot Mac_{t-j} + \sum_{j=1}^{1} \varphi_j \cdot Bank_{t-j}\, \varepsilon_t \quad (4)$$

where:

- Perf – performance indicator: Net Income, Net Loss and NPL
- Mac – set of macroeconomic variables: unemployment and GDP
- Bank – set of bank specific variables: net loans and leases, core deposits and Tier 1 capital
- ε_t – idiosyncratic error term at time t

The estimated time series regressions are shown below with full estimation tables being listed in appendices.

$$\begin{aligned} INCOME_t = {} & 0.092 + \mathbf{0.662} \cdot INCOME_{t-1} + 0.224 \cdot INCOME_{t-2} + \mathbf{0.112} \cdot \Delta FFR_t \\ & - \mathbf{0.142} \cdot \Delta FFR_{t-1} + \mathbf{0.109} \cdot \Delta FFR_{t-2} + \mathbf{0.382} \cdot \Delta TIER_t - 0.078 \cdot \Delta TIER_{t-1} \\ & - 0.001 \cdot \Delta UNEMP_t - 0.001 \cdot \Delta UNEMP_t + \varepsilon_t \end{aligned}$$

$$\begin{aligned} NETLOSS_t = {} & -0.029 + \mathbf{1.130} \cdot NETLOSS_{t-1} - 0.022 \cdot \Delta FFR_t + \mathbf{0.127} \cdot \Delta FFR_{t-1} \\ & - \mathbf{0.079} \cdot \Delta FFR_{t-2} - 0.0003 \cdot \Delta RGDP_t + 0.002 \cdot \Delta RGDP_{t-1} - \mathbf{0.356} \cdot \Delta TIER_t \\ & + 0.319 \cdot \Delta TIER_{t-1} + \mathbf{0.043} \cdot \Delta UNEMP_t + 0.039 \cdot \Delta UNEMP_{t-1} \\ & - \mathbf{0.086} \cdot \Delta COREDEP_t + \mathbf{0.030} \cdot \Delta COREDEP_{t-1} + \varepsilon_t \end{aligned}$$

$$\begin{aligned} NPL_t = {} & 0.001 + \mathbf{0.947} \cdot NPL_{t-1} - 0.001 \cdot \Delta FFR_t - 0.0002 \cdot \Delta FFR_{t-1} - 0.006 \cdot \Delta FFR_{t-2} \\ & + 0.0003 \cdot \Delta RGDP_t - 0.00001 \cdot \Delta RGDP_{t-1} + 0.010 \cdot \Delta TIER_t \\ & - \mathbf{0.022} \cdot \Delta TIER_{t-1} - 0.002 \cdot \Delta UNEMP_t - 0.006 \cdot \Delta UNEMP_{t-1} \\ & - 0.0004 \cdot \Delta COREDEP_t + 0.001 \cdot \Delta COREDEP_{t-1} + \varepsilon_t \end{aligned}$$

Based on these outputs, we conclude that FFR has a net positive impact on net income in the span of two quarter with Tier 1 capital ratio being also positively related to net income. The net loss is positively related to changes in the first and second lags of FFR. In other words, a 1% increase of FFR leads to 0.048% increase of net loss during the analyzed period. Unemployment raises net loss while core deposits are overall negatively related to loss. The NPL model has not detected significant impact of FFR when two lags were used and should be re-assessed in future.

In order to assess the quality of ARDL model, we performed Breusch-Pagan heteroscedasticity test and Breusch-Godfrey autocorrelation test. The results are shown in Table J in the appendices. The results indicate that models do not violate serial correlation assumptions, however, heteroscedasticity is present in all models, therefore we use robust versions of regressions for stress testing. Now we proceed to out-of-sample forecast simulations for performance indicators from 2021Q1 to 2023Q1 to compare with historical data. These are shown in Fig. 10 through 12. with 95% confidence bands in grey.

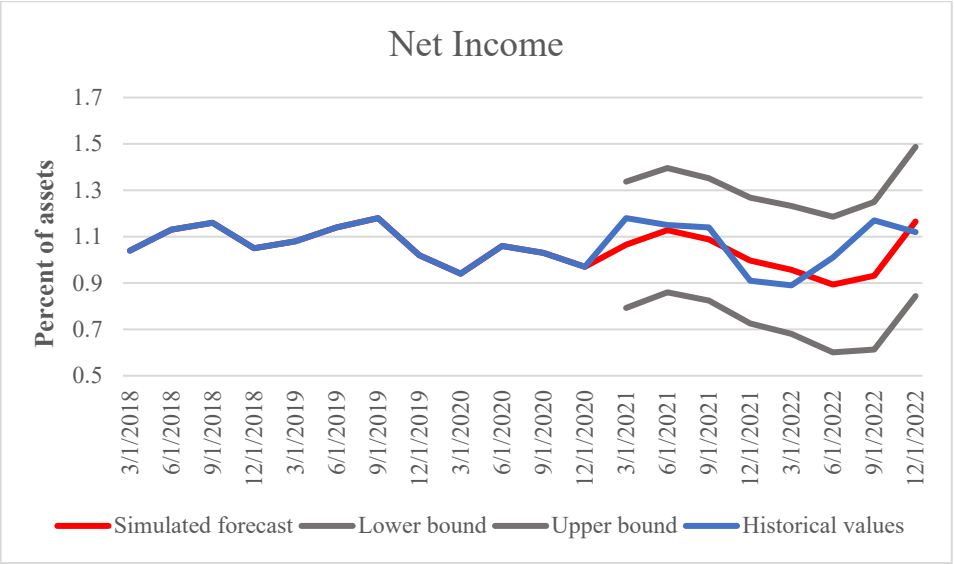


Figure 10. Out-of-sample simulations for net income.

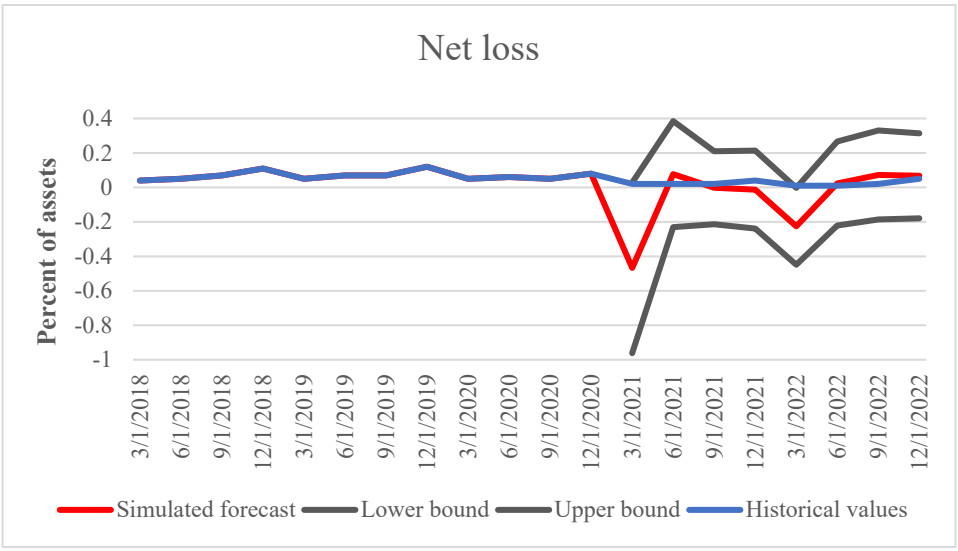


Figure 11. Out-of-sample simulations for net loss.

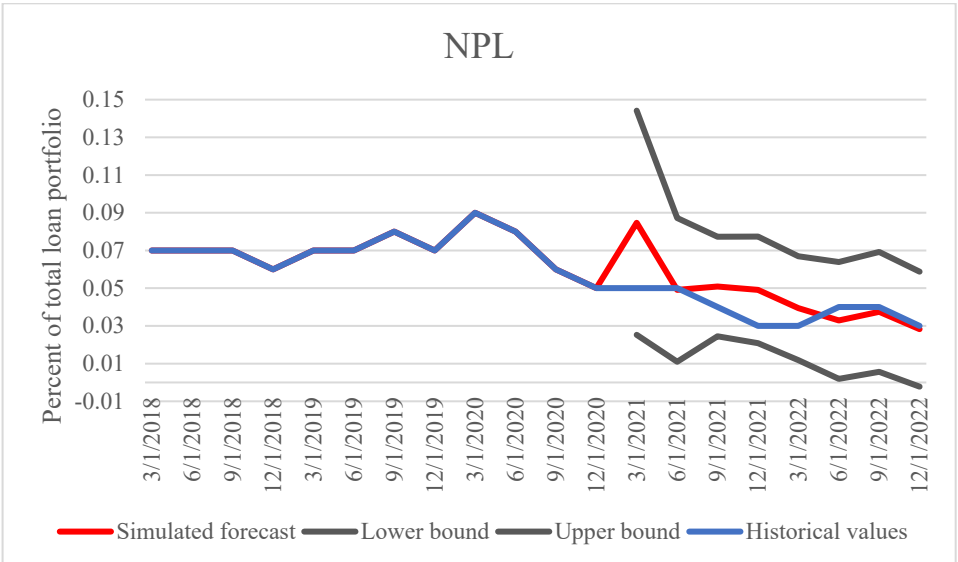


Figure 12. Out-of-sample simulations for NPL.

The out-of-sample forecast simulations show that all three ARDL models are capable of adequately forecasting future values. Now we proceed to actual forecasting of net income based on baseline and alternative scenarios. The forecasts are in Table K in the appendices and outlined in Fig. 13 through 15 below.

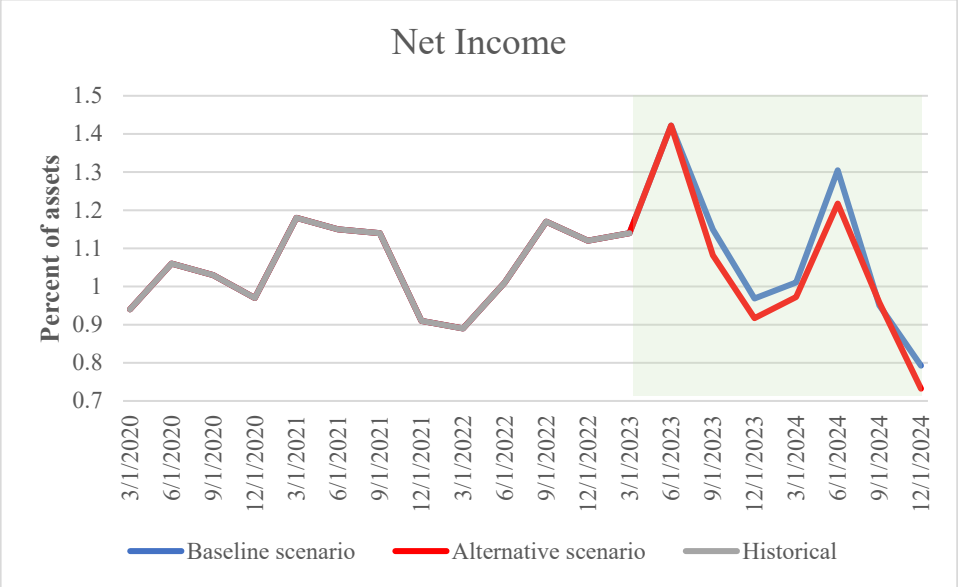


Figure 13. Forecasting of the net income variable.

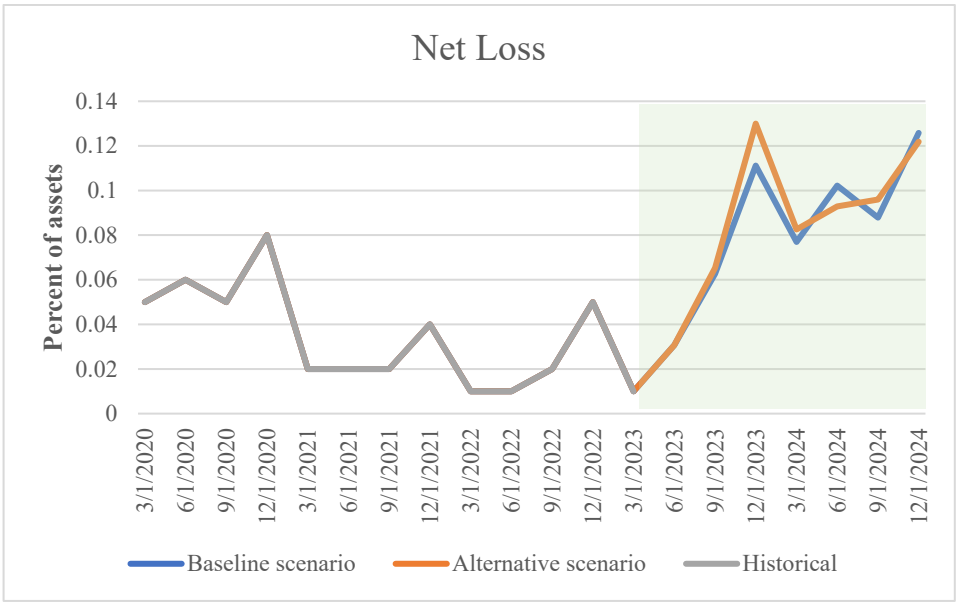


Figure 14. Forecasting of the net loss variable.

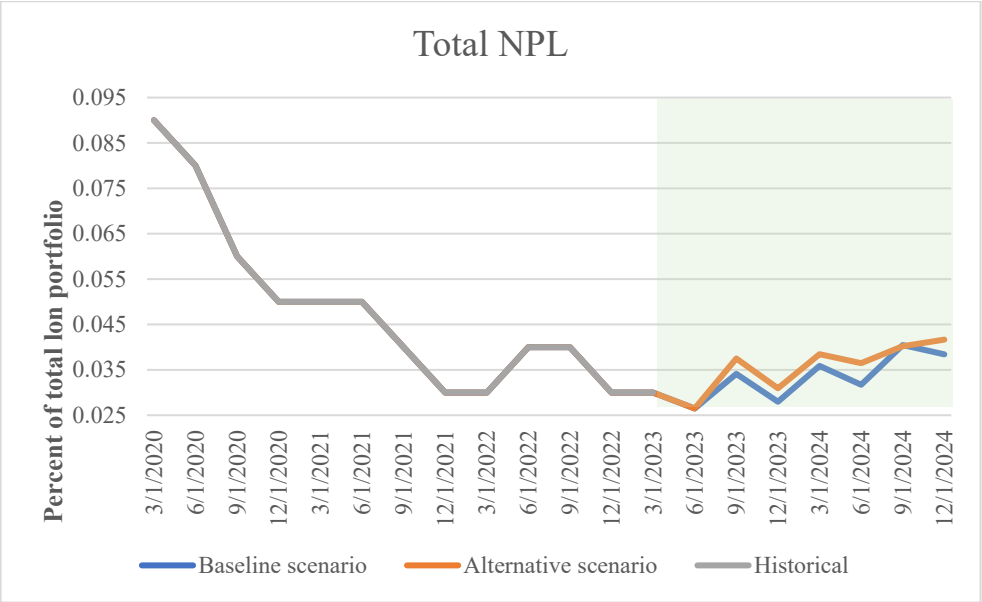


Figure 15. Forecasting of the NPL variable.

Based on the forecasts, it can be concluded that the alternative scenario has a more severe impact on banking performance metrics – the net income will shrink more compared to the baseline, while NPL will experience a significant increase under the alternative scenario. Hence, the alternative scenario turns out to be severe, and immediate policy implication for the FED should be to decrease FRR at a very slow pace or even keep it at current levels in the next seven quarters.

7. Conclusions

The FFR is one of the most crucial macroeconomic and financial factors that influences all sectors of the economy, including banking institutions. However, since the banking sector is a complex structure, it cannot be linked to interest rates through simple relationships, and the interaction between interest rates and the banking sector should be studied using multiple models.

In this study, we attempted to analyze the impact of the current high interest rates on the banking industry. We investigated the relationship between main banking performance indicators, such as net income, NPL, and personnel expense, and the FFR by using dynamic panel regression for six types of banks. We discovered that the impact of interest rates is uneven across different types and sizes of banking businesses. In general, we observed that the FFR is positively related to banks' net income when accounting for the second lag: a 1% increase in interest rates leads to a mild increase in net income by approximately 0.1% six months later. The relationship between interest rates and personnel expense seems to be negative, with a 1% increase in the FFR seemingly leading to a 0.001% decrease in personnel expense in the corresponding quarter. Although this relationship is statistically significant, the magnitude of the coefficient suggests that the actual effect can be considered negligible. On the other hand, the panel regression failed to provide a statistically significant link between NPL and the FFR, which requires further investigation in subsequent studies.

After analyzing the panel level impact of the FFR on the banking sector, we conducted a stress test for three major banking performance indicators: net income, net losses from loans and leases, and NPL, calculated as aggregated averages of the entire US banking system. We investigated the links between these indicators and interest rates using three ARDL models while controlling for macroeconomic variables (such as the rate of unemployment) and bank-specific variables (such as the Tier 1 capital ratio). We tested the resilience of the banking system under baseline and

alternative scenarios. The baseline scenario assumed a very slow decrease in interest rates, while the alternative scenario posited a very aggressive pace of interest rate decrease. The predictive power of the ARDL models was proven by conducting out-of-sample forecast simulations, and the models were used to forecast the future trajectories of the indicators being studied. The results of the stress-testing exercise suggest that the alternative scenario has a severe impact on banks' performance, and therefore the immediate recommendation for monetary policymakers is to keep the interest rate at the current level or decrease it very slowly, by no more than 25 basis points over the next seven quarters.

8. References

Ball, L.M., Leigh, D. and Mishra, P., 2022. Understanding US Inflation During the COVID Era (No. w30613). National Bureau of Economic Research.

Stiglitz, J.E. and Regmi, I., 2023. The causes of and responses to today's inflation. *Industrial and Corporate Change*, *32*(2), pp.336-385.

White C., 2023. Rising Interest Rates Complicate Banks' Investment Portfolios. Federal Reserve Bank of St. Louis. https://www.stlouisfed.org/on-the-economy/2023/feb/rising-rates-complicate-banks-investment-portfolios Last accessed: 3/29/2023

Federal Reserve Bank of Atlanta, Sticky Price Consumer Price Index less Food and Energy [CORESTICKM158SFRBATL], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/CORESTICKM158SFRBATL, April 21, 2023.

Arellano, M. and Bond, S., 1991. Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. The review of economic studies, 58(2), pp.277-297.

FOMC Press conference, 2023. Transcript of Chair Powell's Press Conference March 22, 2023. Federal Reserve System media center. https://www.federalreserve.gov/mediacenter/files/FOMCpresconf20230322.pdf Last accessed: 3/31/2023

Board of Governors of the Federal Reserve System, 2023. Monetary Policy Report. March 3, 2023. https://www.federalreserve.gov/monetarypolicy/files/20230303_mprfullreport.pdf Last accessed: 4/10/2023

9. Appendices

Table A. The p-values of the ADF test for the macroeconomic indicators.

Time series	With drift	Without drift
Private Investment	0.0102	0.1491
Inflation	0.0311	0.3339
Real Expenditure	0.0000	0.0005
Real Income	0.0000	0.0000
Unemployment Rate	0.0296	0.3234
Real GDP	0.0000	0.0006
Federal Funds Rate	0.0178	0.2275

Table B. The p-values for the panel unit root tests for bank-specific variables.

Variable	p-value
personnel	0.015
netinc	0.121
npl_cc	0.000
nii_avgass	0.000
provision	0.015

Table C. Sargan's test for over-identification.

Model	p-value	Conclusion
Net Income	0.9060	Instruments are valid
Non-performing loans	0.5314	Instruments are valid
Personnel expenses	0.7578	Instruments are valid

Table D. The estimation results for net income panel model.

	Coef.	Standard error (SE)
L.netinc	0.613***	(0.0387)
D.fedfund	0.00930	(0.0196)
LD.fedfund	-0.0244	(0.0209)
L2D.fedfund	0.0957***	(0.0199)
nii_avgass	0.248***	(0.0867)
L.nii_avgass	-0.177**	(0.0892)
rgdp	0.00655***	(0.00229)
L.rgdp	0.00621***	(0.00139)
L2.rgdp	0.00307***	(0.000892)
provision	-1.097***	(0.0446)
L.provision	0.664***	(0.0608)
D.unemp	0.0524***	(0.00894)
LD.unemp	0.00312	(0.0119)
Constant	0.130	(0.0928)
Observations	456	
Number of bank_id	6	

*** p<0.01, ** p<0.05, * p<0.1

Table E. The estimation results for NPL panel model.

	Coef.	Standard error (SE)
L.npl_cc	0.332***	(0.0458)
D.fedfund	0.00556	(0.0593)
LD.fedfund	-0.0178	(0.0711)
L2D.fedfund	-0.0685	(0.0611)
D.unemp	0.0181	(0.0285)
LD.unemp	-0.0422	(0.0383)
L2D.unemp	0.0447	(0.0372)
rgdp	0.00479	(0.00737)
L.rgdp	-0.00624	(0.00839)
L2.rgdp	-0.00225	(0.00316)

nii_avgass	-0.0747	(0.267)
L.nii_avgass	0.469	(0.407)
L2.nii_avgass	-0.223	(0.262)
provision	0.0421	(0.142)
L.provision	0.0969	(0.154)
L2.provision	-0.0249	(0.138)
Constant	-0.416	(0.281)
Observations	456	
Number of bank_id	6	

*** p<0.01, ** p<0.05, * p<0.1

Table F3. The estimations results for personnel expense panel model.

	Coef.	Standard error (SE)
L.personnel	0.948***	(0.0159)
D.fedfund	-0.00673*	(0.00398)
LD.fedfund	0.00345	(0.00475)
L2D.fedfund	0.00655	(0.00408)
D.unemp	-0.00594***	(0.00193)
LD.unemp	0.000584	(0.00256)
L2D.unemp	0.00322	(0.00249)
rgdp	-0.000546	(0.000499)
L.rgdp	-0.000634	(0.000565)
L2.rgdp	-0.000813***	(0.000214)
nii_avgass	0.0415**	(0.0177)
L.nii_avgass	0.0159	(0.0271)
L2.nii_avgass	-0.0320*	(0.0175)
provision	-0.0122	(0.00963)
L.provision	0.00328	(0.0103)
L2.provision	0.0115	(0.00923)
Constant	-0.0102	(0.0250)
Observations	456	
Number of bank_id	6	

*** p<0.01, ** p<0.05, * p<0.1

where:

- L means one quarter lagged value
- L2 means two quarter lagged values
- D is first difference
- LD – first lag of first difference
- L2D – second lag of first difference.

Table G. The estimation results of time-series stress testing model for net income.

	Coef.	Standard error (SE)
L.n_netinc	0.662***	(0.134)
L2.n_netinc	0.224	(0.147)
D.fedfund	0.112**	(0.0549)
LD.fedfund	-0.142**	(0.0607)

L2D.fedfund	0.109*	(0.0585)
D.unemp	0.000500	(0.0197)
LD.unemp	-0.00739	(0.0153)
D.n_tier	0.382***	(0.0969)
LD.n_tier	-0.0783	(0.154)
Constant	0.0924	(0.0742)
Observations	69	
R-squared	0.786	

*** p<0.01, ** p<0.05, * p<0.1

Table H. The estimation results of time-series stress testing model for net loss.

	Coef.	Standard error (SE)
L.n_netloss	1.130***	(0.0867)
D.fedfund	-0.0215	(0.0454)
LD.fedfund	0.127**	(0.0492)
L2D.fedfund	-0.0790*	(0.0462)
D.rgdp	-0.000349	(0.00414)
LD.rgdp	0.00168	(0.00366)
D.unemp	0.0426**	(0.0178)
LD.unemp	0.0389	(0.0320)
D.n_tier	-0.356***	(0.0815)
LD.n_tier	0.319***	(0.0927)
D.n_coredep	-0.0862***	(0.0168)
LD.n_coredep	0.0296**	(0.0136)
Constant	-0.0288	(0.0221)
Observations	69	
R-squared	0.847	

*** p<0.01, ** p<0.05, * p<0.1

Table I. The estimation results of time-series stress testing model for NPL.

	Coef.	Standard error (SE)
L.n_npl	0.947***	(0.0366)
D.fedfund	-0.00656	(0.00565)
LD.fedfund	-0.000242	(0.00596)
L2D.fedfund	-0.00588	(0.00579)
D.rgdp	0.000245	(0.000515)
LD.rgdp	-9.94e-05	(0.000454)
D.unemp	-0.00185	(0.00219)
LD.unemp	-0.00563	(0.00401)
D.n_tier	0.0104	(0.00924)
LD.n_tier	-0.0219*	(0.0115)
D.n_coredep	-0.000394	(0.00167)
LD.n_coredep	0.000484	(0.00169)
Constant	0.00459	(0.00465)
Observations	69	
R-squared	0.938	

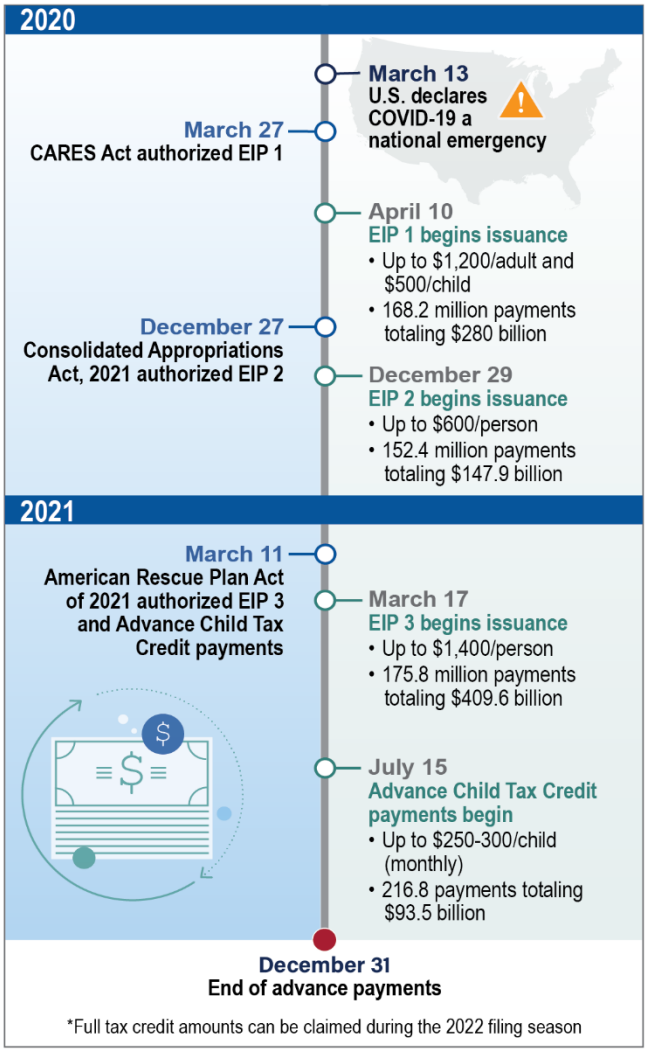
*** p<0.01, ** p<0.05, * p<0.1

Table J. Diagnostic test results for the ARDL models.

ARDL model	Breusch-Godfrey serial correlation test	Breusch-Pagan heteroscedasticity test
Net Income	0.0506	0.000
Net Loss	0.3334	0.000
NPL	0.7340	0.000

Table K. Forecasts from 2023Q2 to 2024Q4 for the 3 models.

	Net Income		Net Loss		NPL	
Indicator	**Baseline**	**Alternative**	**Baseline**	**Alternative**	**Baseline**	**Alternative**
2023Q2	1.422085	1.422085	.0306462	.0306462	.0264934	.0264934
2023Q3	1.149356	1.082141	.062652	.0653211	.0341085	.0375121
2023Q4	.9687312	.9168683	.1111319	.1299865	.0279915	.0309327
2024Q1	1.010741	.9726176	.0769721	.0825125	.0358638	.0384637
2024Q2	1.304726	1.217642	.1021727	.0928622	.0317083	.0364724
2024Q3	.9504356	.9581119	.08786	.0959527	.0404529	.0402217
2024Q4	.7925008	.732155	.125812	.121824	.0384185	.0416514



Source: GAO analysis of legislation and IRS and Bureau of the Fiscal Service data. | GAO-22-106044

Figure A: Stimulus program timeline (source: GAO)

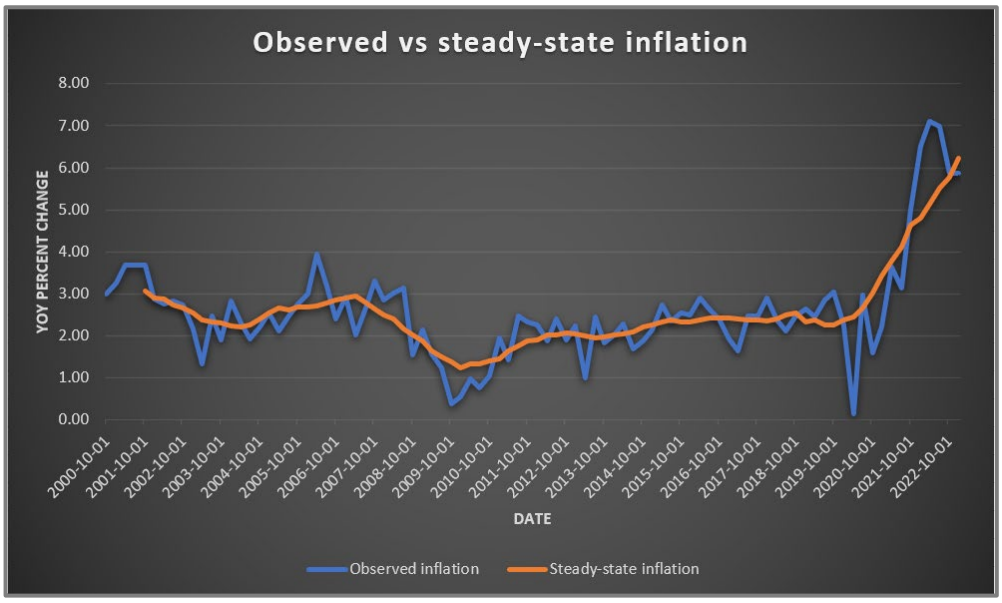


Figure B. Observed vs steady-state inflation

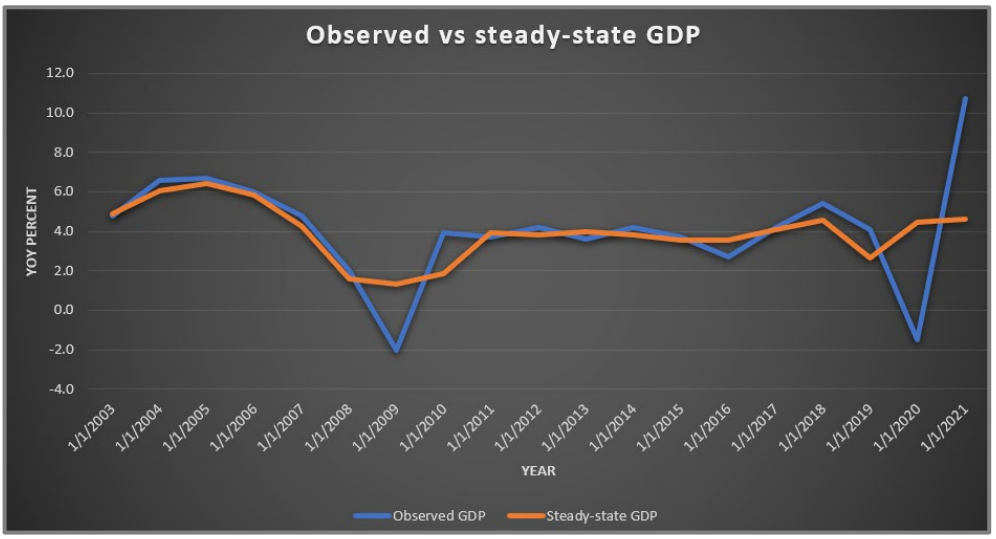


Figure C. Observed vs steady-state GDP.

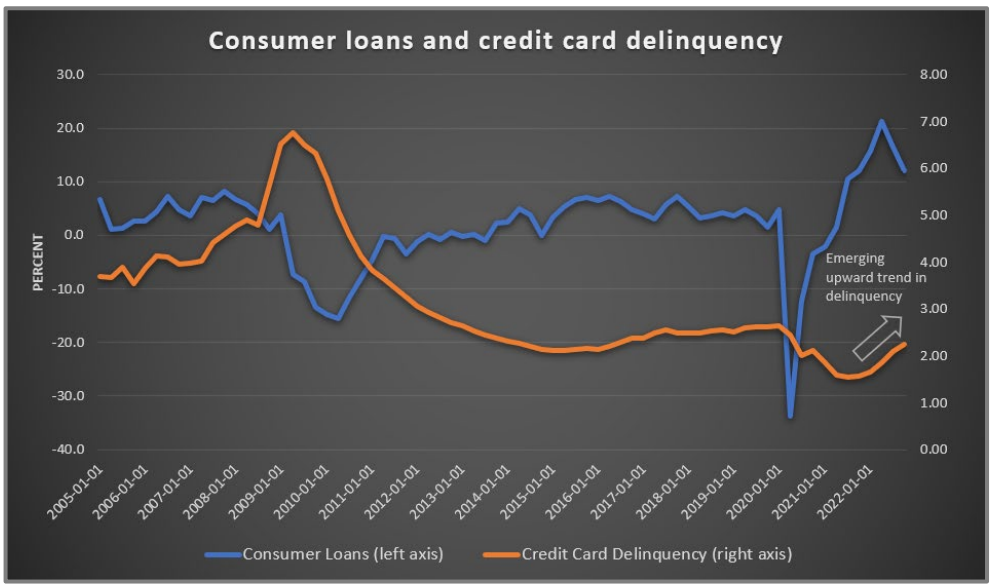


Figure D. Consumer loans and credit card delinquency.

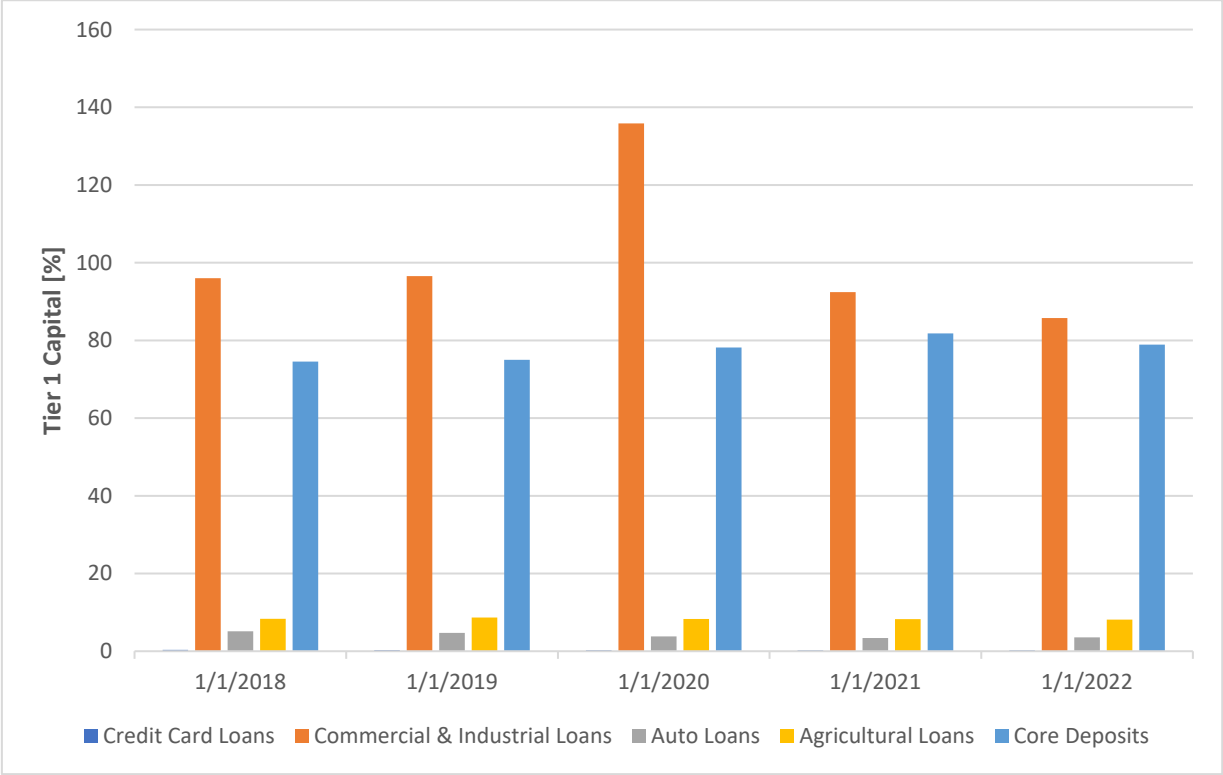


Figure E. Credit portfolio structure of large commercial banks

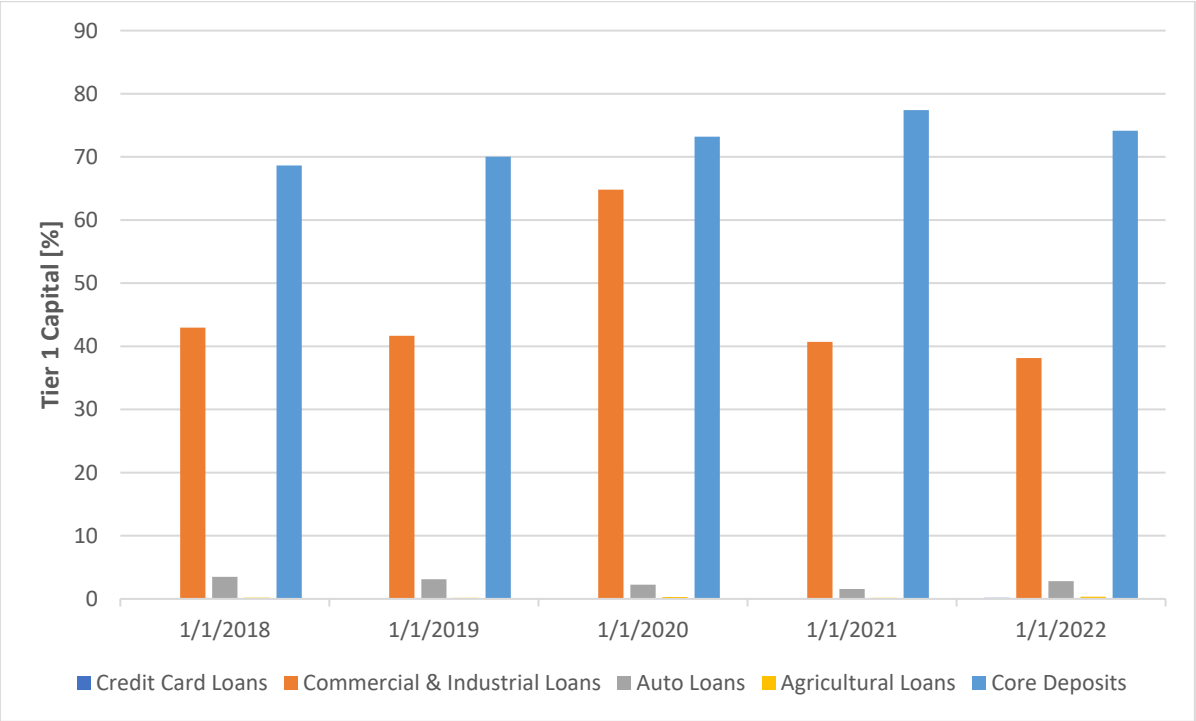


Figure F. Credit portfolio structure of large savings banks.