603-Quantitative Analysis of Financial Markets

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1 Introduction

This project aims to predict the future risk of several major U.S. banks—**Bank of America, JP Morgan Chase, U.S. Bancorp, Wells Fargo, PNC Financial ServicesFifth Third,citizens banks and Silicon Valley Bank(SVB)** —by analyzing the dynamics of their credit businesses. The analysis will focus on key **bank-specific data** (such as loan growth, non-performing loans, and capital ratios) and **macro-market data** (including interest rates, GDP growth, and inflation). By applying advanced econometric models like **VAR**, **GARCH**, and **ARIMA** the project will assess the impact of these dynamics on liquidity, capital adequacy, and overall credit liquidity risk. This evaluation will also explore potential systemic vulnerabilities and the risk of bank runs, providing insights into the stability of the financial system.

2 Core Research Question

1. How does the credit business of commercial banks in the United States affect their liquidity?
2. Does this influence, when combined with macroeconomic variables, exacerbate liquidity risks and potentially lead to bank runs?

3 Research Objectives(variables)

3.1 American bank data w.r.t loan business

1.**PCLC (Provision for Loan Losses)**
2.**RLL (Reserve for Loan/Asset Losses)**
3.**INTAL (Loans - Net of Total Allowance for Loan Losses)**
4.**INDLF (Loans, Net - Incl Direct Lease Financing)**
5.**DPTC (Deposits - Total)**
6.**LFT (Loans - Foreign)**
7.**LDT (Loans - Domestic)**
The missing values we can find on the annual report of each bank.

3.2 Macro-market data of America

1.**CPI (Consumer Price Index)**
2.**GDP (Gross Domestic Product)**
3.**FF (Federal Funds)**
4.**LTAVG (Treasury Long Term Average Inflation-indexed)**
5.**National Deposit Rates: Savings**
6.**Rate of Credit card, Automobile loan, and Mortgage**
7.**Unemployment Rate**

3.3 Liquidity data

1. LCR (Liquidity Coverage Ratio) sample: Bank of America 2023 annual report

Table 16 Average Global Liquidity Sources Composition

	Three Months Ended December 31	
(Dollars in billions)	**2023**	2022
Cash on deposit	**$ 380**	$ 174
U.S. Treasury securities	**197**	252
U.S. agency securities, mortgage-backed securities, and other investment-grade securities	**299**	427
Non-U.S. government securities	**21**	15
Total Average Global Liquidity Sources	**$ 897**	$ 868

Our GLS are substantially the same in composition to what qualifies as High Quality Liquid Assets (HQLA) under the final U.S. Liquidity Coverage Ratio (LCR) rules. However, HQLA for purposes of calculating LCR is not reported at market value, but at a lower value that incorporates regulatory deductions and the exclusion of excess liquidity held at certain subsidiaries. The LCR is calculated as the amount of a financial institution's unencumbered HQLA relative to the estimated net cash outflows the institution could encounter over a 30-day period of significant liquidity stress, expressed as a percentage. Our average consolidated HQLA, on a net basis, was $590 billion and $605 billion for the three months ended December 31, 2023 and 2022. For the same periods, the average consolidated LCR was 115 percent and 120 percent. Our LCR fluctuates due to normal business flows from customer activity.

Figure 1: Annual report of BAC

3.4 Dependent Variable(Y):

LCR(Liquidity Coverage Ratio)

3.5 Explanatory Variable(X):

Total loan, Loan-to-deposit ratio, Non-performing loan, Loan ratio, CPI, Rate of Credit card, Automobile loan, and Mortgage

4 Methodology

4.1 Data Sources

Yahoo, Wrds, www.federalreserve.gov/, Annual report of each bank

4.2 Model Selection

1. **VAR Model (Vector Autoregression Model)** The VAR model can be used to examine the effect of macroeconomic factors and related loan variables on liquidity, helping assess risk trends.
For a VAR (Vector Autoregression) model with k variables, assuming each variable is related to its own past values as well as the past values of other variables, the VAR model can be represented as:

$$y_t = A_1 y_{t-1} + A_2 y_{t-2} + \cdots + A_p y_{t-p} + \varepsilon_t$$

Where:

- y_t is a k-dimensional vector at time t, containing the k variables.
- $A_1, A_2, \ldots, A_p$ are $k \times k$ coefficient matrices for each lag period.
- p is the lag order.
- ε_t is the error term, a k-dimensional white noise vector representing unexplained random disturbances.

2. **GARCH Model (Generalized Autoregressive Conditional Heteroskedasticity Model)** Analyzing the extent of increased volatility in lending operations during macroeconomic shocks (such as sharp rises in interest rates or inflation spikes).

3. ARIMA (AutoRegressive Integrated Moving Average) Utilizing ARIMAX models allows for the integration of both the time series nature of liquidity data and the influence of exogenous bank-specific variables, providing a comprehensive analysis applicable to various banking environments. (more details in the "Liquidity Risk" proposal)

4.3 Data Preprocessing

Handle missing values, stationarity tests, differencing

Here is the step of applying the VAR and GARCH model:

Step	Description	Purpose
1. Data Preparation		
- Bank Loans	Total loans, Loan-to-Deposit Ratio (LDR), average loan interest rate, non-performing loans	Capture the lending behavior and risk status of banks
- Liquidity Indicators	LCR (Liquidity Coverage Ratio)	Measure bank liquidity
- Macroeconomic Variables	GDP (Gross Domestic Product), CPI (Inflation), Unemployment rate	Assess the impact of macroeconomic factors on bank loans
- Data Preprocessing	Handle missing values, perform stationarity tests	Ensure data is suitable for time series modeling, removing trends and volatility
2. VAR Model Analysis		
- Lag Order Selection	Use AIC/BIC information criteria to determine the lag length	Determine the optimal lag length in the VAR model for proper fitting
- VECM Analysis (Cointegration)	Identify long-term cointegration relationships and use VECM to analyze short-term deviations and long-term equilibrium	Determine whether long-term equilibrium exists between variables; if yes, use VECM to capture dynamics
- Granger Causality Test	Test for causality between variables	Identify whether past values of one variable can predict another
3. Impulse Response Function (IRF)		
- Shock Transmission	Analyze how shocks to bank loans, liquidity, or macroeconomic variables affect other variables	Study how a change in one variable transmits through the system to impact other variables
- Dynamic Effects	Interpret transmission effects between variables	Understand how variables interact dynamically and for how long
4. Variance Decomposition		
- Contribution to Variability	Assess each variable's contribution to the variance of other variables (short-term vs. long-term)	Measure the contribution of each variable to system volatility, quantifying the sources of variation
- Source of Risk	Identify key risk factors in the system	Help identify which variables contribute the most risk to system volatility
5. GARCH Model Analysis		
- Variable Selection	Choose significant variables from VAR analysis for GARCH modeling	Select the significant variables identified in VAR for further volatility analysis
- Volatility Analysis	Use GARCH to study conditional volatility patterns	Analyze the volatility patterns of the variables, particularly autocorrelation in volatility
- Model Conditional Heteroskedasticity	Investigate the autoregressive structure of volatility and predict future fluctuations	Study how the volatility of variables evolves over time and forecast future volatility

Table 1: The step of applying VAR and GARCH model

4.4 Model Evaluation

4.4.1 ARIMA model:

Suitable for dealing with stationary time series. Non-stationary data can be transformed into stationary data by differential processing, and then model fitting can be performed. ARIMA captures trends and seasonal changes in lending data.

4.4.2 GARCH model:

It is suitable for analyzing volatility, especially in financial time series. If the data shows heteroscedasticity (such as volatility in loan growth rates over time), the GARCH model can help better understand and predict future volatility.

4.4.3 VAR model:

The VAR model is very effective when analyzing the relationship between multiple time series variables. If there are other relevant variables (such as GDP growth rate, interest rate, unemployment rate, etc.), the VAR model can be used to capture the dynamic relationship between them.

We plan to choose a model between ARIMA and VAR, and then combine it with GARCH.

5 Expected Outcomes

Based on data from the past decade (10 years), the trend of bank lending in America can be influenced by the following:

The increase in loans reduces short-term liquidity and increases liquidity pressure, but brings more interest income. Fewer loans to improve liquidity to ease pressure, but cut interest income, affecting long-term earnings. A rise in non-performing loans would reduce the flow of capital back into the country and exacerbate the liquidity squeeze.

Economic growth: If the American economy continues to grow, borrowing demand from businesses and individuals is likely to rise, leading to an increase in lending.
Higher interest income contributes to the overall financial health of the bank. But too much lending can leave banks with less available liquidity, especially when demand for loans surges and banks need to ensure they have enough deposits or external sources of financing to meet withdrawals.

Interest rate changes: The central bank's interest rate policy directly affects lending rates. If interest rates rise, borrowing costs increase, which could dampen demand for loans. The reverse could spur borrowing.Banks' loan portfolios could expand rapidly, creating outflow pressure that could reduce liquidity.

Policies and regulations: Government financial policies and regulations, such as mortgage restrictions or incentives, directly affect the volume and structure of bank lending and liquidity.

Conclusion: If the economy remains solid, interest rates remain low, and the housing market stabilizes, there could be moderate growth in bank lending over the next two years.As loan growth is moderate, bank liquidity pressure is not large, there is still room for better management.
But demand for loans could weaken if the economy slows or interest rates rise, helping reduce liquidity pressures, but rising default risks could lead to a deterioration in bank asset quality and indirectly exacerbate the liquidity squeeze.

6 Feasibility/Question

5.1 We chose to use the VAR and GARCH models, and chose the ARIMA model as alternative, is this feasible?
5.2 Whether the variable needs to be modified?
5.3 Do we need to make some assumption with the model we take?
5.4...

7 Conclusion

Summarize the impact of the American credit business of banks on bank liquidity. Summarize the effect exacerbated when loans are combined with macroeconomic variables(such as GDP, and inflation rate). Summarize the volatility of bank loans in different economic environments. Point out the uncertainties in our prediction. Providing some suggestions to these banks from the perspective of quantity finance.