NETWORK ANALYSIS OF THE CHINESE A-SHARE STOCK MARKET

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BACKGROUND

- Global financial markets closely monitored the implementation of the Federal Reserve's policy to incrementally increase interest rates, a process that initiated in early 2022.
- The Chinese A-share market exerts significant influences on international investors and financial systems.
- The implementation of this monetary policy had a crucial impact on the stock markets in the United States, and its repercussions spread across the international financial markets, resulting in a noticeable impact on the A-share market in China.

RESEARCH QUESTIONS

- How do changes in key Chinese market indices in 2022 correlate with adjustments in the Federal Reserve's interest rate policy?
- Considering the observed trends in market indices, what implications do these changes have on the Return on Investment (ROI) across various industry sectors in the Chinese A-share market?
- What is the nature and dynamic of the correlation network based on the ROI of different stocks among the top 500 companies by market capitalization in the Chinese market in 2022?

DATA

In this study, we analyze the Chinese A-share stock data from January 2021 to December 2022. The data is sourced from the ``baostock'' Python library and the official Federal Reserve website. We collect data on:

- Stock data including date, stock codes, volumes, prices, etc. The descriptions of the important attributes are shown in the table below.
- Information on the Federal Reserve's policy changes in 2022.
- The Shanghai Composite Index and the CSI 300 Index.

Attribute	Description
Date	Record date for the stock data (Monthly)
Code	Stock code as listed on the exchange
Close	Closing price of the stock at the end of the month
Volume	Number of shares traded during the month
Return	Monthly return, calculated as the percentage change in closing price month-over-month
Industry	Industry sector of the given stock

METHODOLOGY

Network Construction

In this study, we adhere to the fundamental methods outlined in Chi et al.(2010), with adaptations for our specific data analysis focus:

- Time Series Data: We consider the time series data x_i(t) for stock i at time t, specifically focusing on the ROI of Chinese A-share market stocks. The analysis period covers January 2021 to December 2022, aligning with the timeline of the Federal Reserve policy changes.
- Cross-Correlation Calculation: The cross-correlation between the ROI time series of stock i and stock j is calculated as:

$$C_{ij} = \frac{\sum_t [(x_i(t) - \bar{x_i}) \cdot (x_j(t) - \bar{x_j})]}{\sqrt{\sum_t (x_i(t) - \bar{x_i})^2 \cdot \sum_t (x_j(t) - \bar{x_j})^2}}$$

- Network Edges: An edge in the network is established between two stocks if their cross-correlation exceeds a specified threshold. Here we set the threshold θ=0.7.
- Lagged Correlation for Time-sensitive Analysis: Considering the time-lag effect in stock prices, especially relevant in the context of policy impact analysis, the cross-correlation is modified to include a time lag Δt:

$$\tilde{C_{ij}}(\Delta t) = \frac{\sum_t [(x_i(t) - \bar{x_i}) \cdot (x_j(t + \Delta t) - \bar{x_j})]}{\sqrt{\sum_t (x_i(t) - \bar{x_i})^2 \cdot \sum_t (x_j(t + \Delta t) - \bar{x_j})^2}}$$

Network Visualization

- To visualize the distribution of the different industry sectors exist in this dataset, we color each node (stock) based on the industry sector it belongs to. There are 28 industry sectors in this dataset.
- To examine the temporal dynamic change of the correlation network according to the monthly ROI of each stock, we create 24 different network visualizations representing each month from January 2021 to December 2022. In each of these graphs, we color the nodes according to the value of ROI into red (> 20%), green (between -20% and 20%), and blue (< -20%).

Crucial Quantities

In this work, we focus on specific calculations that are crucial for understanding the impact of Federal Reserve policy changes:

- Market Capitalization Over Time: For each stock, the market capitalization Vi over the considered time range is defined as its maximum value, which is particularly relevant for assessing market responses to policy shifts.
- Stock Performance Analysis: The performance Wi,t of each stock at time t is evaluated in terms of ROI, crucial for understanding the cascading effects in the market post-policy changes.

RESULTS

Temporal Analysis Results Under the Fed's 2022 Rate Hike Policy

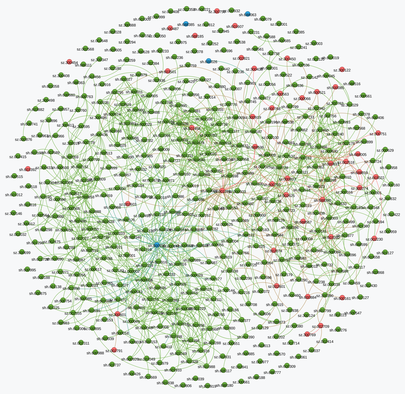

Figure 1: Network of ROI Snapshot of March 2022

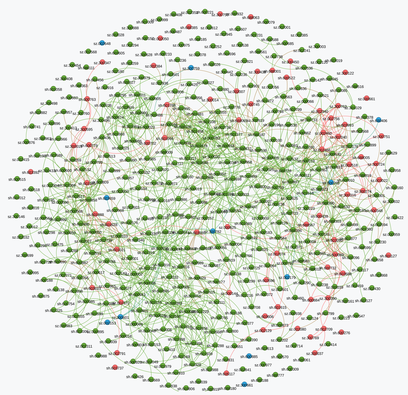

Figure 2: Network of ROI Snapshot of June 2022

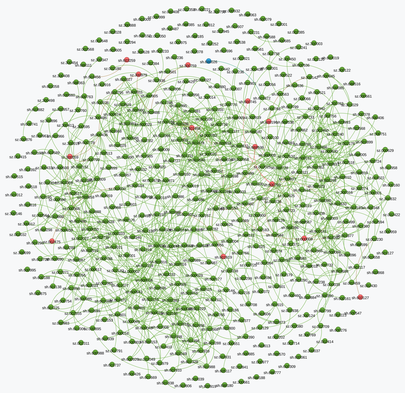

Figure 3: Network of ROI Snapshot of September 2022

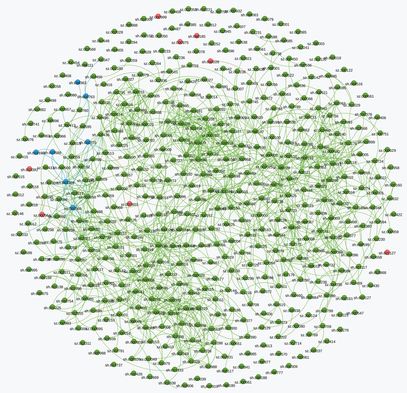

Figure 4: Network of ROI Snapshot of December 2022

Fed's 2022 Rate Hike Policy Timeline		
Month	**Rate Change (bps)**	**Federal Funds Rate**
Dec 14, 2022	+50	4.25% to 4.50%
Nov 2, 2022	+75	3.75% to 4.00%
Sept 21, 2022	+75	3.00% to 3.25%
July 27, 2022	+75	2.25% to 2.50%
June 16, 2022	+75	1.50% to 1.75%
May 5, 2022	+50	0.75% to 1.00%
March 17, 2022	+25	0.25% to 0.50%
January 27, 2022	+25	0% to 0.25%

CONCLUSION

- **Market Response to Interest Rate Increases**: Analyzing historical market index data and network visualizations reveals a negative impact on the Chinese A-share market in response to interest rate hikes by the Federal Reserve, with varying degrees of influence across different industries.
- **Dynamics in Sectors and Time**: Contrasting temporal return networks with industry-specific network visualizations illuminates sectors that are more interconnected, indicating potential collective resilience or vulnerability to shifts in international monetary policy.
- **Adjustment of Investment Approaches**: The observed network patterns over several months offer a strategic perspective for portfolio management. When faced with changes in economic policy, examining central nodes based on performance can guide investment decisions.

Group by Industry Sectors

- Figure 1 shows the visualization of the network of stocks based on correlation threshold of 0.7 using monthly price return during 01/01/2021 to 12/31/2022. Nodes are colored by different industries.
- Visualization Interpretation: The network visualization tailored to the industry shows clustered patterns of stocks, illustrating the associated performance of companies in comparable sectors.
- Sectoral Insights: Analyzing the nodes that make up a given industrial cluster might reveal information about the potential effects of the Federal Reserve's interest rate policy on various sectors.

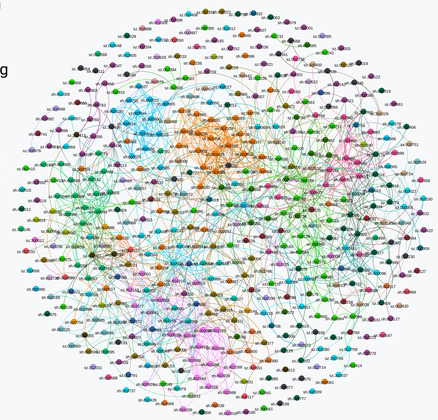

Figure 5: Network Grouped by Industry Sectors

Sample Indices Graph

- Figure 6 shows the close price change of two important market indices: CSI 300 Index and Shanghai Composite Index.
- The price of the stock first decreased for almost 5 months, then starting to increasing a little, then dropped again.
- In general, we see the negative impact of the Fed's policy on those two indices as well.

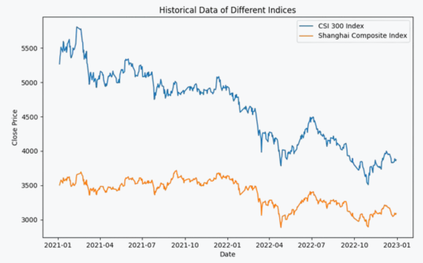

Figure 6: Historical Stock Price on Two Key Market Indices

REFERENCES

- Chi, K. T., Liu, J., & Lau, F. C. (2010). A network perspective of the stock market. *Journal of Empirical Finance*, 17(4), 659-667.
- Huang, W. Q., Zhuang, X. T., & Yao, S. (2009). A network analysis of the Chinese stock market. *Physica A: Statistical Mechanics and its Applications*, 388(14), 2956-2964.
- Sun, W., Tian, C., & Yang, G. (2015). Network analysis of the stock market.