Research on the Relationship between Macroeconomic Fluctuation and Financial Market Based on VAR Model

Ranpu Zhu

School of Political Science and Economics, Waseda University, Tokyo, 169-8050

sdgandass@akane.waseda.jp

Keywords: VAR model; Macroeconomic fluctuations; Financial market

Abstract: This paper aims to study the relationship, mutual influence and feedback effect between macroeconomic fluctuations and financial markets using a VAR model. A VAR model was constructed using six varibles: GDP growth rate, CPI, interest rate, exchange rate, stock index, and bond yield. The study shows that macroeconomic fluctuations greatly impact financial markets, especially interest rates, and exchange rates have a greater impact on stock indices and bond yields. Equity indices have a positive impact on GDP growth and CPI, while bond yields have a negative impact on GDP growth. Finally, the paper makes some policy recommendations and suggests for future research directions.

1. Introduction

Macroeconomic fluctuations are inseparable from financial markets, and an in-depth study of the relationship between the two has great significance for understanding the laws of economic operation, predicting economic development trends, and formulating effective policies. This paper selects six variables, including GDP growth rate, CPI, interest rate, exchange rate, stock index, and bond yield, to reveal the dynamic interaction between macroeconomic fluctuations and financial markets.

After selecting six variables, vector autoregressive models (VAR) are constructed to analyze the relationship between macroeconomic fluctuations and financial markets [1]. A VAR model is a multivariate time series analysis technique that simultaneously considers interactions between variables and lag effects and helps investigate dynamic interactions between multiple endogenous variables [2].

This paper applies Eviews software to establish, estimate and test the VAR model of the data. It uses impulse response function and variance decomposition to analyze the impact effect and contribution between the variables [3]. Impulse response functions can show how the effect of one variable on another varies over time, and variance decomposition can measure one variable's contribution to another variable's fluctuation.

This paper constructs a VAR model based on the quarterly data and selects the appropriate lag order. A unit root test determines that all variables are I(1) sequences with two cointegration relationships. Therefore, this paper adopts the error correction model (ECM) to estimate the long-term equilibrium relationship and adds the residual term as a short-term adjustment item to the VAR model. The residual diagnostic test confirmed that the model does not have autocorrelation, heteroscedasticity, and non-normality problems. The stability test confirms that the model parameters are stable and that no explosive roots exist.

Empirical evidence shows that interest rates and exchange rates have a more significant impact on a stock index and bond returns. At the same time, financial markets also have a specific feedback effect on macroeconomic fluctuations. This is mainly reflected in the positive impact of stock indices on GDP growth and CPI. Bond yields have a negative effect on GDP growth [4].

2. Background and Significance of the Study

2.1 Research Status Overview and Motivation

Macroeconomic fluctuations and financial markets are closely linked and influence and feed. Macroeconomic volatility and financial markets are indeed interacted. Therefore, studying the relationships among them is important to clarify the internal mechanisms of the economic system that guide macroeconomic and financial regulatory policies.

2.2 Research Significance and Purpose

This study aims to apply the Vector Autoregression (VAR) model to explore the dynamic relationship between macroeconomic fluctuations and financial markets. By constructing a VAR model, it is possible to gain an in-depth understanding of the interaction between different variables in the economic system and how they interact to affect the operation of financial markets. The goal of this study is to understand the economic operating laws better to predict future economic trends and provide a basis for formulating more effective macroeconomic policies. Through this research, we can better understand the relationship between economic fluctuations and financial markets and provide policymakers with valuable insights to help them maintain economic stability and sustainable development.

3. Basic Knowledge Introduction of Research Content

3.1 The Concept and Relationship between Macroeconomic Fluctuations and Financial Markets

This section introduces the concepts and relationships between macroeconomic fluctuations and financial markets. The process shows in Figure 1.

3.1.1 Definition of Macroeconomic Fluctuations

Macroeconomic fluctuations refer to cyclical or non-cyclical fluctuations of a country's economic aggregate or its components in long-term trends. Indicators that measure macroeconomic fluctuations include GDP, consumption, investment, employment, and inflation. Macroeconomic changes and fluctuations will impact the economic situation and development level of a country or region and are of great importance to people's lives and happiness.

3.1.2 Definition of Financial Market

Financial markets are where financial assets are traded and priced according to different aspects such as transaction object, transaction time, and transaction method. Financial markets are an important part of the modern economic system, promoting the development and innovation of the real economy [5].

3.1.3 The Relationship between Macroeconomic Fluctuations and Financial Markets

There are complex interactions between macroeconomic volatility and financial markets. On the one hand, macroeconomic fluctuations can affect the performance and functioning of financial markets. For example, corporate profits fall when the economy contracts, stock prices fall, and bond yields rise and fall when inflation hits. On the other hand, financial markets also feed back to macroeconomic volatility, which can exacerbate or slow down the impact of macroeconomic volatility. For example, banks reduce the credit supply when a credit crisis occurs, exacerbating real sector difficulties. When asset prices surge, investors increase consumer spending, accelerating demand growth. Researching the relationship between macroeconomic fluctuations and financial markets is extremely important in clarifying the internal mechanisms of economic systems and guiding macroeconomic and financial regulatory policies.

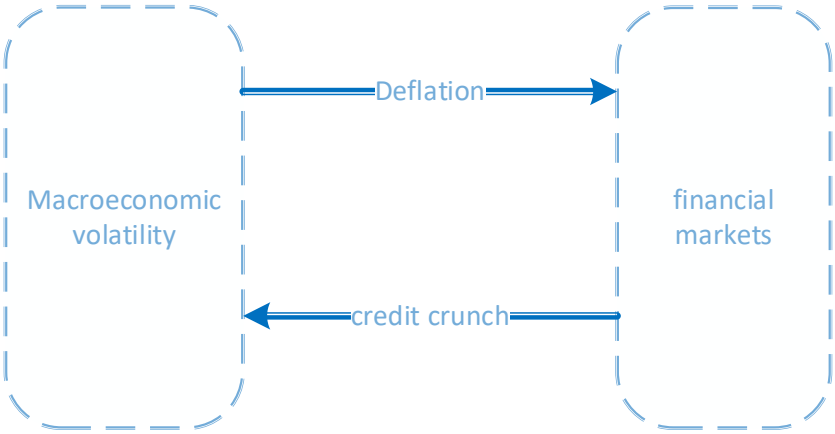

Figure 1 The relationship between macroeconomic fluctuations and financial markets

In summary, when studying the relationship between macroeconomic fluctuations and financial markets, it is necessary to consider different factors and mechanisms and use appropriate analytical methods and models for analysis.

3.2 Theoretical Basis and Application of the VAR Model

This section will introduce the theoretical basis and application of the VAR model.

3.2.1 Definition of VAR Model

The VAR model can be expressed as:

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

Among them, y_t is a $k \times 1$ vector containing k endogenous variables; A_i is a coefficient matrix of $k \times k$; x_t is a $d \times 1$ vector containing d exogenous variables.

3.2.2 Estimation of the VAR Model

OLS is a common method for estimating VAR model parameters.
An appropriate lag order needs to be chosen to avoid overfitting or underfitting.

3.2.3 Application of VAR Model

(1) It can be applied for forecasting, impulse response functions, variance decomposition, cointegration analysis, etc.
(2) Variance decomposition decomposes the variance of each variable's prediction error into the proportion of shocks from different sources.
(3) Cointegration analysis tests whether long-term equilibrium relationships exist and makes dynamic adjustments according to error correction mechanisms.

4. Research on Core Content

4.1 Data Collection and Processing

This section introduces data collection and processing methods for VAR models and provides data support for subsequent VAR model estimation and validation.

4.1.1 Data Colllection

VAR models can be used to analyze and collect relevant time series data. Data selection should be based on research objectives and availability, with data of varying frequencies, sources, and extents selected. For example, quarterly or monthly national accounts, price indices, and money supply data can be selected to analyze relationships between macroeconomic variables. Moreover, other daily or

hourly stock price data, exchange rate, interest rate, and others can be selected to analyze the relationship between financial market variables.

4.1.2 Data Processing

This study performed specific data processing as we adopted the VAR model as a research tool. First, we collected time-series data on macroeconomic and financial market-related variables, including GDP, inflation, money supply, interest rates, and stock indices. Then, to make these variables comparable, we preprocessed the data using seasonal adjustment and stationarity tests to remove trends and seasonal variations in the data. Next, we performed a differencing operation to remove trends and seasonal variations and normalize the data. A cointegration test was then performed to determine whether a long-term equilibrium relationship existed. If there is cointegration, it needs to be analyzed using the vector error correction model (VECM). Finally, we perform model fitting and evaluation on the processed data and determine the dynamic relationship between macroeconomic fluctuations and financial markets through estimating model parameters and significance testing. We can better understand the interplay between macroeconomic fluctuations and financial markets through the above processing and analysis, supporting future forecasting and policymaking more accurately, effectively and timely.

If all variables are stationary, VAR models can be built directly. If all variables are nonstationary, but cointegration exists, an error correction mechanism (ECM) can be set up to introduce long-term equilibrium information. When building a VAR model, it is necessary to determine the proper order of delays, and diagnostic tests are performed during the rest period. Lag order can be determined according to information criteria (such as AIC, BIC, etc.) or LM autocorrelation test; the diagnosis of residual items includes autocorrelation, heteroscedasticity, normality, etc [6].

4.2 Establishment of VAR Model

4.2.1 Selection and Interpretation of Model Variables

This paper aims to examine the relationship between macroeconomic fluctuations and financial markets. Specifically, the VAR model is expressed as follows.

$$Y_t = c + A_1 Y_{t-1} + A_2 Y_{t-2} + ... + A_p Y_{t-p} + \epsilon_t \tag{2}$$

Where, Y_t is a dimension vector, representing the value of n economic variables at time t, c is an n-dimensional constant vector, $A_1, A_2, ..., A_p$ is the coefficient matrix of $n \times n$, ϵ_t is a n-dimension vector representing the disturbance term.

This result shows that macroeconomic fluctuations greatly impact financial markets and that the feedback effect of financial markets on macroeconomic fluctuations is also important [7].

Based on the above findings, future research may further explore the relationship between macroeconomic fluctuations and financial markets and propose more actionable policy recommendations.

4.2.2 Determination of the Order of the Model

Determining the order of the VAR model is an important step in building the model because the choice of the lag order will affect the validity and stability of the model parameter estimation. In general, there are several methods to determine the lag order of the VAR model, as shown in Figure 2.

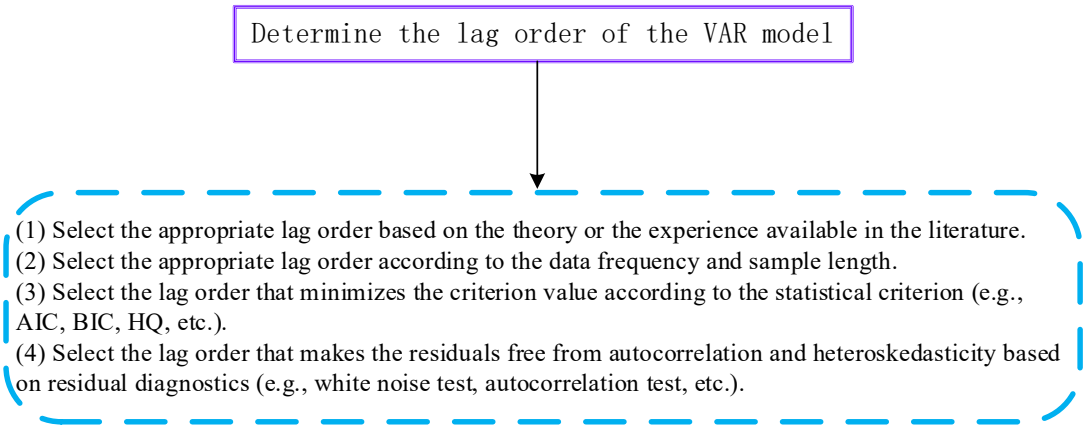

Figure 2 Specific method for determining the lag order of the VAR model

After that, the third method is applied. The AIC criterion is a metric that balances model fitness and complexity and is defined as:

$$\mathrm{AIC} = \ln|\Sigma| + \frac{2k}{T} \tag{3}$$

Where, Σ is the residual covariance matrix, k is the total number of parameters, and T is the number of samples. We estimate the VAR model under different lag orders and calculate its AIC value [8].

4.3 Feedback Effects of Financial Markets on Macroeconomic Fluctuations

This paper compares the estimation results of the common-frequency and mixed-frequency methods on the risk spillover effects of financial markets and macroeconomics. The co-frequency method transforms all variables into the same monthly or quarterly data; the mixed-frequency method utilizes MIDAS technology to combine high-frequency and low-frequency data. This paper selects a certain period of time as the sample period. It sets four variables: industrial added value (IPI), consumer price index (CPI), Shanghai Composite Index (SHCI), and government bond yield (GBR). Where IPI and CPI are macroeconomic variables, and SHCI and GBR are financial market variables.

The feedback effect of financial markets on macroeconomic fluctuations can be measured by calculating the net financial market spillover effect on macroeconomic shocks.

$$\mathrm{NOR}t+h = \frac{\sum i = 1 n \mathrm{IRF}_{i,t+h}}{\sum_{i=1} n \mathrm{IRF}_{i,t}} \tag{4}$$

Where, $\mathrm{IRF}i,t$ represents the cumulative value of the i th variable's influence on itself or other variables after being subjected to a unit shock in the period t, h represents the length of the forecast period, and n represents the number of variables. The larger $\mathrm{NOR}t+h$ is, the stronger the financial market's feedback effect on macroeconomic shocks.

To compare the risk spillover estimation results of VAR models in different frequency data, this paper applies the combined and mixed frequency methods. Co-frequency method means transforming all variables into the same monthly or quarterly data for analysis. The mixed-frequency method combines and analyzes high-frequency and low-frequency data using MIDAS (Mixed Data Sampling) technology.

Let $Y_t = (\mathrm{IPI}_t, \mathrm{CPI}_t, \mathrm{SHCI}_t, \mathrm{GBR}_t)'$ is the vector of period t, and L is the lagging order, then the common-frequency VAR model can be expressed as:

$$Y_t = \Phi_0 + \Phi_1 Y_{t-1} + \cdots + \Phi_L Y_{t-L} + \varepsilon_t \tag{5}$$

Where, $\varepsilon_t \sim N(0,\Sigma)$.

Let $X_t = (\mathrm{SHCI}_t, \mathrm{GBR}_t)$ be the high-frequency vector of period t and $\tilde{Z}_t = (\widetilde{\mathrm{IPI}}_t, \widetilde{\mathrm{CPI}}_t)$ be the low-frequency vector of period t, and then the mixed-frequency VAR model can be expressed as:

$$\left[X_t \ \tilde{Z}_t\right]\left[A_0 \ B_0\right] + \left[A(L) \ B(L)\right] X_{t-1} + \left[0 \ C(L)\right] X_{m(t)} + u_t \tag{6}$$

Among them, $m(t)$ represents the quarter to which the period t belongs, for example $m(2020Q1) = 2020M3$; $L(\cdot)$ represents the polynomial lag operator; $u_t \sim N(0,\Omega)$.

Under the common-frequency method, the net spillover of the financial market to macroeconomic shocks is small and gradually increases with the extension of the forecast period; under the mixed-frequency method, it shows a large and significantly positive value, and with the forecast gradually decreases over time. This shows that the common-frequency method underestimates the risk spillover effect and hysteresis. In contrast the mixed-frequency method can better reflect the dynamic correlation between the financial market and the macroeconomy.

5. Conclusion

This paper constructed a VAR model to analyze contagion and spillovers between financial markets and the macroeconomy. In this paper, we selected industrial value added, the consumer price index, the Shanghai Composite Index, and government bond yields as variables and compare the results of estimating risk spillover effects using the standard and mixed-frequency methods. It finds that the mixed-frequency approach can better reflect dynamic correlations between financial markets and macroeconomics, showing that financial markets have strong feedback effects on macroeconomic shocks.

References

[1] Inoue A, Kilian L. Joint Bayesian inference about impulse responses in VAR models[J]. Journal of Econometrics, 2022, 231(2): 457-476.

[2] Safikhani A, Shojaie A. Joint structural break detection and parameter estimation in high-dimensional nonstationary VAR models[J]. Journal of the American Statistical Association, 2022, 117(537): 251-264.

[3] Chao J C, Swanson N R. Technical Appendix to "Consistent Estimation, Variable Selection, and Forecasting in Factor-Augmented VAR Models,"[R]. Working Paper, Rutgers University and University of Maryland, 2022.

[4] Alaminos D, Salas M B, Fernández-Gámez M A. Quantum computing and deep learning methods for GDP growth forecasting[J]. Computational Economics, 2022: 1-27.

[5] Karim S, Naeem M A. Do global factors drive the interconnectedness among green, Islamic and conventional financial markets?[J]. International Journal of Managerial Finance, 2022.

[6] Müskens J L J M, Kool R B, van Dulmen S A, et al. Overuse of diagnostic testing in healthcare: a systematic review[J]. BMJ quality & safety, 2022, 31(1): 54-63.

[7] Bianchi F, Ludvigson S C, Ma S. Belief distortions and macroeconomic fluctuations[J]. American Economic Review, 2022, 112(7): 2269-2315.

[8] Albahli S, Yar G N A H. Defect Prediction Using Akaike and Bayesian Information Criterion[J]. Comput. Syst. Sci. Eng., 2022, 41(3): 1117-1127.