Exploring the relationship between macroeconomic indicators and the stock market

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Overview

01 BACKBROUNG

02 VISUALIZATION

03 METHODS

04 RESULTS

05 CONCLUSION

Background

Global economic crises (such as the 2008 financial crisis) can have a huge impact on global stock markets

We want to explore the correlation between macroeconomic factors and stock market

CPI and GDP are both important macroeconomic data, and we find that fluctuations in their data may be related to the stock market

Background

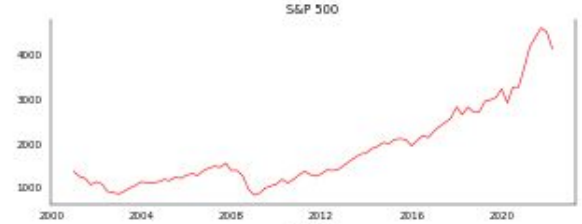
Introduction

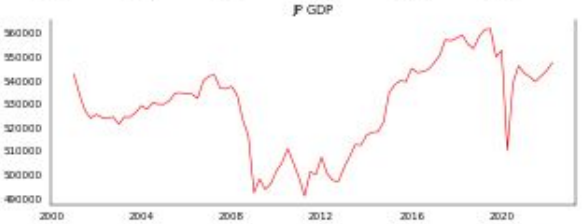
1.Economies：United States，China，Japan，the world's three largest economies

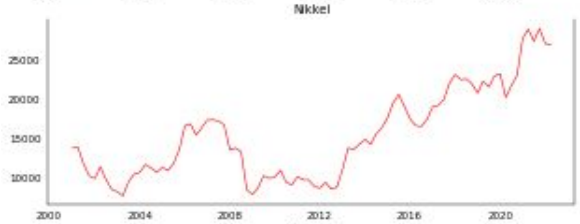
2.Stock market：S&P 500 Index，Shanghai Stock Exchange Index，Nikkei Index

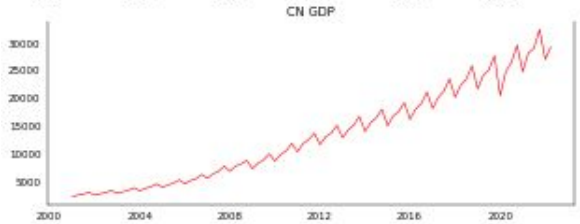
3. Data set：We collected GDP, CPI data and stock indices for the US, China and Japan from 2001 to 2022

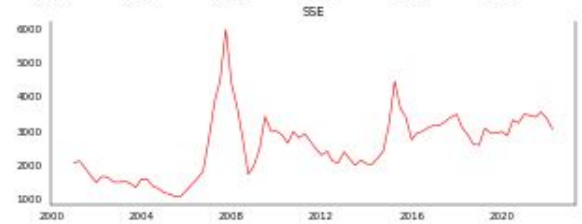
Visualization





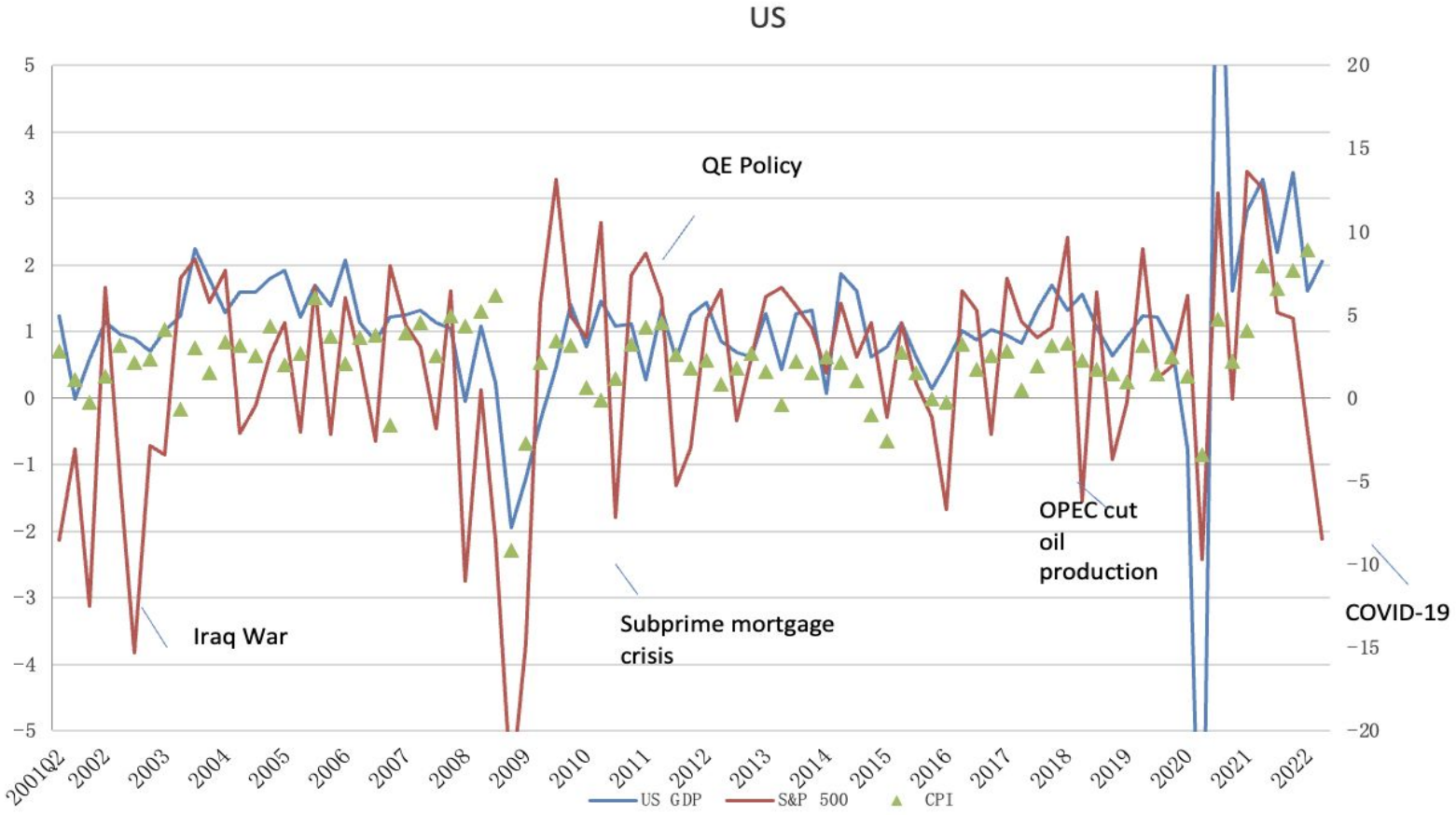






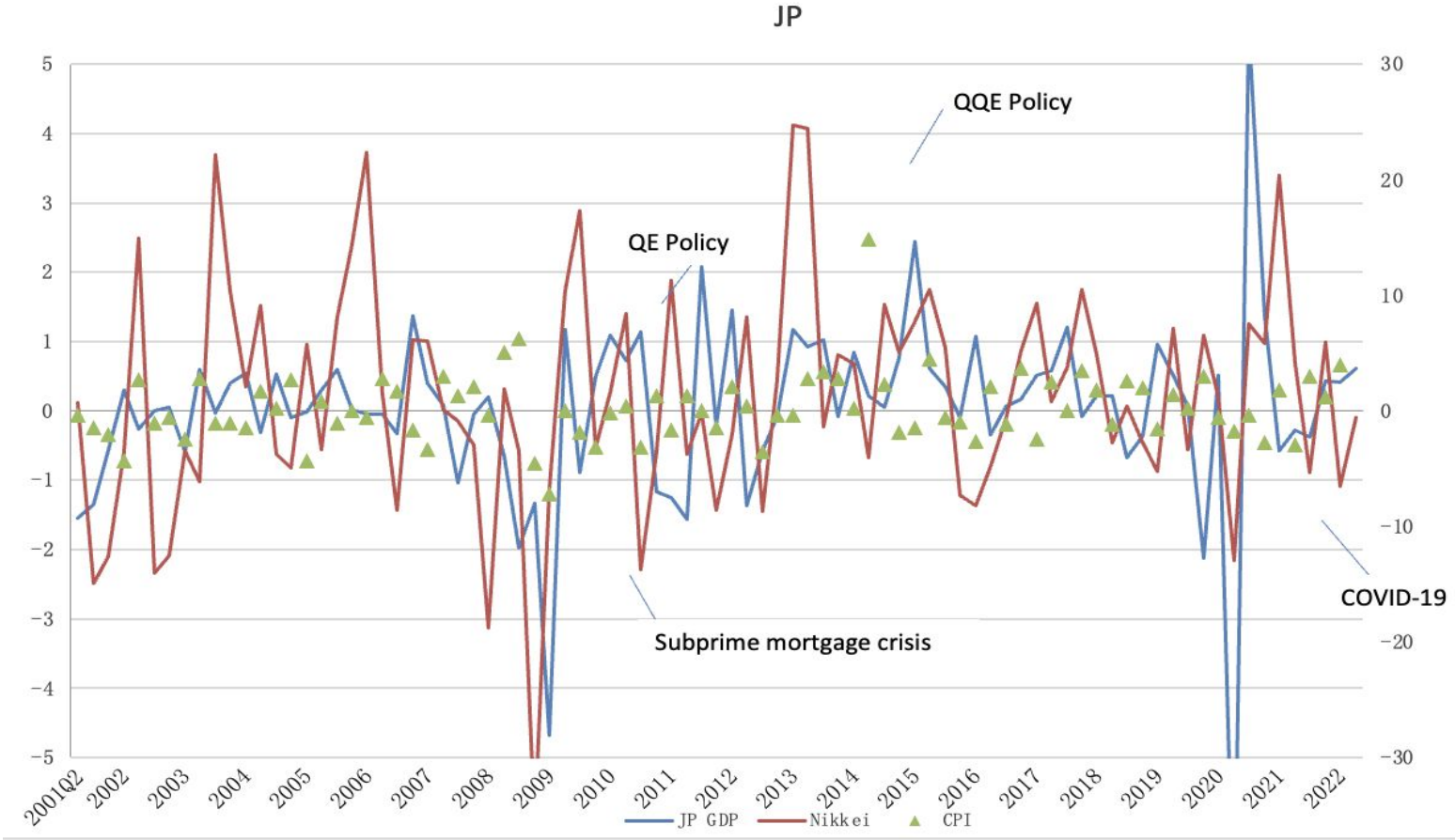
Visualization

US Data



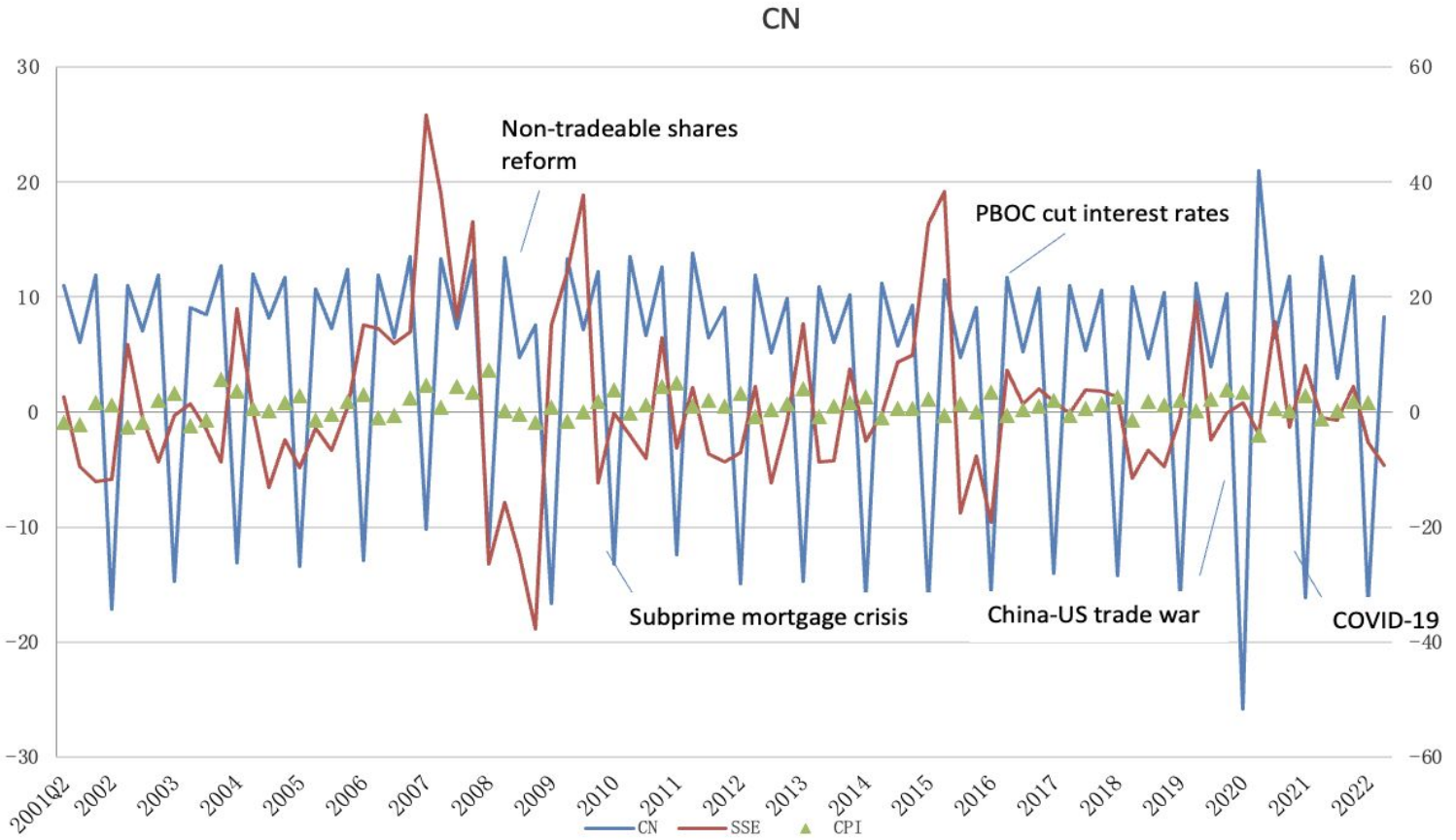
Visualization

Japan Data



Visualization

China Data



Methods

01

Augmented Dickey–Fuller test

determine if time series is stationary

02

Granger Causality Test

Measures whether one time series is useful in forecasting another.

03

Cointegration tests

identify if there is a long-run equilibrium relationship

04

VAR Model

autoregression model.

05

Durbin Watson Test

Check for Serial Correlation of Residuals.

06

Impulse response

Describe a time-series model for spiking stimuli.

ADF Test (Augmented Dicky-Fuller Unit Root Test)

$$\Delta y_t = \alpha + \beta t + \gamma y_{t-1} + \delta_1 \Delta y_{t-1} + \cdots + \delta_{p-1} \Delta y_{t-p+1} + \varepsilon_t,$$

1.Tests the null hypothesis that a unit root is present in a time series sample.

2. For a larger and more complicated set of time series models than Dicky-Fuller

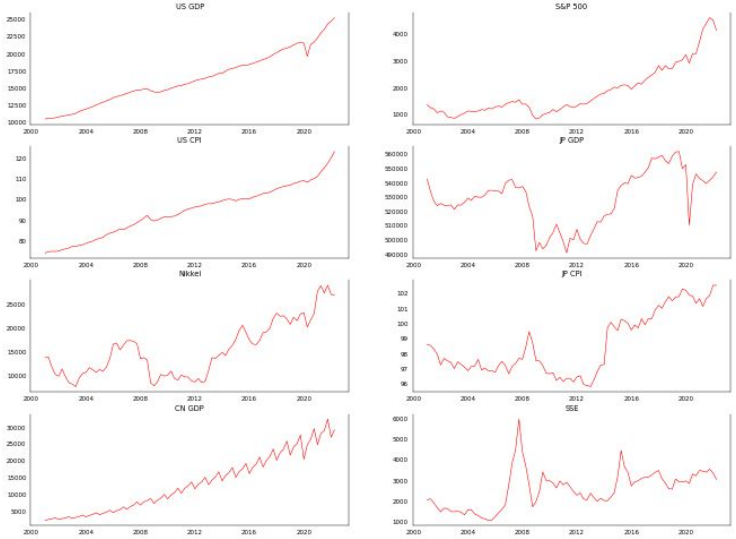
α **is constant** β **is time coefficient**

ADF test

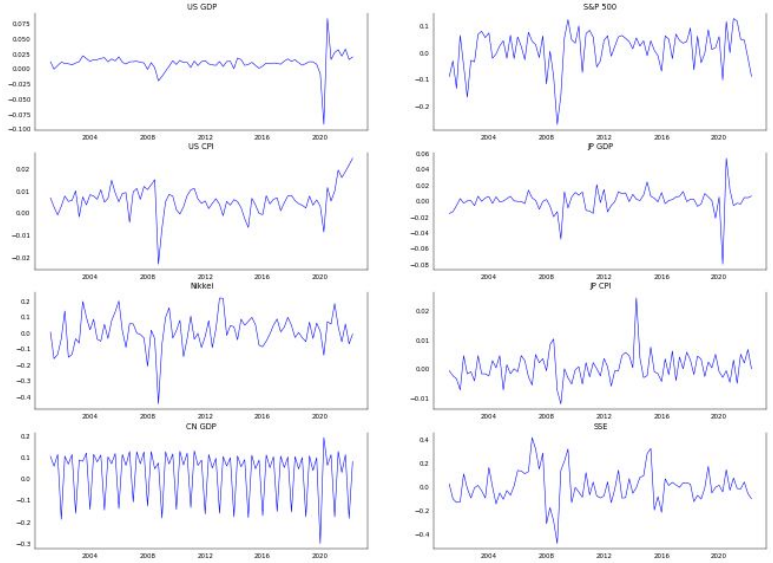
The original time series dataset are all non-stationary data, after logarithmic transformation, the sequence data are all stationary.

If p-value of ADF test <0.05 ⇒ data is stationary

Original data



Processed data



Granger Causality Test

- A statistical concept that measures whether one time series is useful in forecasting another.
- Designed to determine whether one time series is useful in predicting another time series.
- Based on the idea that if a time series X "Granger-causes" another time series Y.
- Granger Causality Test doesn’t actualy prove a true cause and effect chain.

Formula: $$y_t = a_0 + a_1 y_{t-1} + a_2 y_{t-2} + \cdots + a_m y_{t-m} + b_p x_{t-p} + \cdots + b_q x_{t-q} + \text{error}_t\,.$$

Granger Causality Test

US CPI and stock

Pairwise Granger Causality Tests
Date: 11/20/22 Time: 17:21
Sample: 2001Q1 2022Q2
Lags: 3

Null Hypothesis:	Obs	F-Statistic	Prob.
S_P does not Granger Cause USCPI	83	3.69264	0.0154
USCPI does not Granger Cause S_P		4.62711	0.0050

JP CPI and stock

Pairwise Granger Causality Tests
Date: 11/20/22 Time: 17:22
Sample: 2001Q1 2022Q2
Lags: 3

Null Hypothesis:	Obs	F-Statistic	Prob.
JPCPI does not Granger Cause NIKKEI	83	2.29571	0.0845
NIKKEI does not Granger Cause JPCPI		4.96039	0.0034

CN CPI and stock

Pairwise Granger Causality Tests
Date: 11/20/22 Time: 17:23
Sample: 2001Q1 2022Q2
Lags: 3

Null Hypothesis:	Obs	F-Statistic	Prob.
CNCPI does not Granger Cause SSE	83	2.35304	0.0788
SSE does not Granger Cause CNCPI		3.55028	0.0183

US GDP and stock

Pairwise Granger Causality Tests
Date: 11/20/22 Time: 17:18
Sample: 2001Q1 2022Q2
Lags: 3

Null Hypothesis:	Obs	F-Statistic	Prob.
S_P does not Granger Cause USGDP	83	3.53511	0.0186
USGDP does not Granger Cause S_P		1.23216	0.3039

JP GDP and stock

Pairwise Granger Causality Tests
Date: 11/20/22 Time: 17:22
Sample: 2001Q1 2022Q2
Lags: 3

Null Hypothesis:	Obs	F-Statistic	Prob.
JPGDP does not Granger Cause NIKKEI	83	2.55999	0.0612
NIKKEI does not Granger Cause JPGDP		1.59980	0.1964

CN CPI and stock

Pairwise Granger Causality Tests
Date: 11/20/22 Time: 17:23
Sample: 2001Q1 2022Q2
Lags: 3

Null Hypothesis:	Obs	F-Statistic	Prob.
SSE does not Granger Cause CNGDP	83	0.53603	0.6590
CNGDP does not Granger Cause SSE		1.56122	0.2057

When P-value is less than 5%, we could conclude that a variable is Granger Cause with another series. According to the above results. The P-value of key results (e.g., SSE does not Granger Cause CNCPI is 0.0183) is all less than 5%. Therefore, we could determine all-time series pass the Granger Causality Test.

Cointegration Test

- Statistical tests used to determine whether two or more time series are cointegrated, meaning they share a common long-run trend.
- Cointegration is a useful concept in econometrics because it allows researchers to model the long-term relationship between variables even if they appear to be unrelated in the short run.
- Note that cointegration does not imply causation between the time series, and that additional analysis is required to establish any causal relationship between them.

Cointegration Test

```
Name    ::  Test Stat > C(95%)    =>   Signif
 --------------------------------------------
US GDP ::  41.57      > 24.2761   =>   True
US CPI ::  14.23      > 12.3212   =>   True
S&P 500 ::  0.04       > 4.1296    =>   False

Name    ::  Test Stat > C(95%)    =>   Signif
 --------------------------------------------
JP GDP ::  50.39      > 24.2761   =>   True
JP CPI ::  26.86      > 12.3212   =>   True
Nikkei ::  8.5        > 4.1296    =>   True

Name    ::  Test Stat > C(95%)    =>   Signif
 --------------------------------------------
CN GDP ::  45.4       > 24.2761   =>   True
CN CPI ::  14.52      > 12.3212   =>   True
SSE    ::  1.33       > 4.1296    =>   False
```

The S&P 500 may not exist a long-run equilibrium relationship between the S&P 500 and the other two series - CPI & GDP.

Japanese GDP, CPI, and Nikkei stock index exists a long-run equilibrium relationship between the three series.

The SSE may not exist a long-run equilibrium relationship between the SSE and the other two series - CPI & GDP.

VAR Model

- Introduction
- Model fitting
- Durbin Watson Test
- Forcasting
- Preformance
- Impulse response

VAR model

- A risk management estimate the potential loss of an investment or portfolio at a certain time horizon.
- Using statistical like historical simulation, Monte Carlo simulation, or parametric modeling.
- Widely used in financial institutions such as banks, insurance companies, and investment firms to measure and manage the risk of their investments.
- VaR is a measure of risk, not a guarantee.

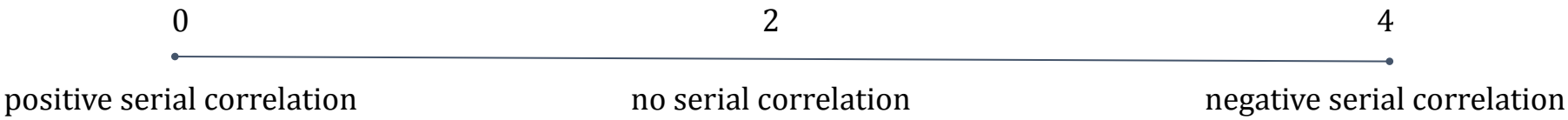
Model fitting :

- Splitting the dataset into training and test data.
- The VAR model was used to forecast the last 2 observations (2 season). These forecasts will be compared against the actuals present in test data.
- To do the comparisons, we will use multiple forecast accuracy metrics.

Durbin Watson Test

Check for Serial Correlation of Residuals (Errors) using Durbin Watson Statistic

The value of this statistic is between 0 and 4.

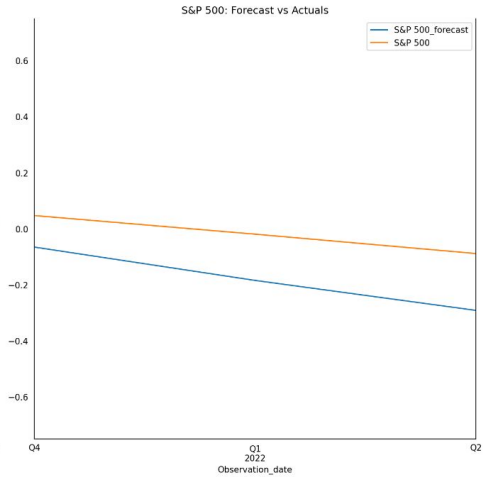


If there is any correlation in the residuals, then some pattern in the time series still needs to be explained by the model. In such cases, the typical approach is to either increase the order of the model, introduce more predictors into the system, or find a different algorithm to model the time series.

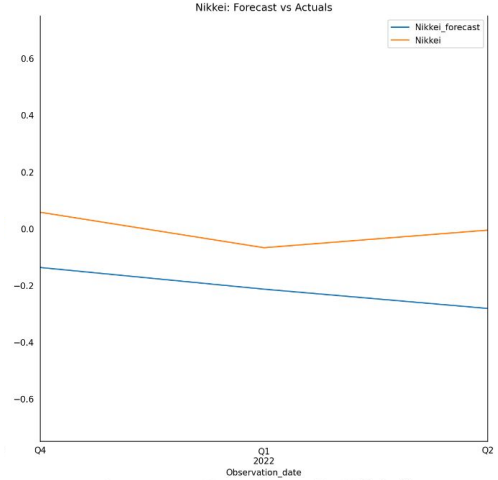
```
US GDP : 2.01
US CPI : 1.89
S&P 500 : 2.1
JP GDP : 2.02
JP CPI : 2.05
Nikkei : 2.02
CN GDP : 2.13
CN CPI : 1.99
SSE : 1.85
```

The serial correlation seems to be fine.

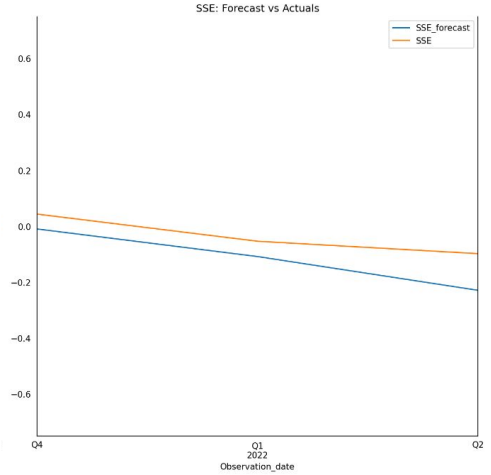
Preformance



Forecast Accuracy of: S&P 500
mape : 4.3579
me : −0.1601
mae : 0.1601
mpe : 2.7512
rmse : 0.1644
corr : 0.9991
minmax : −2.7512



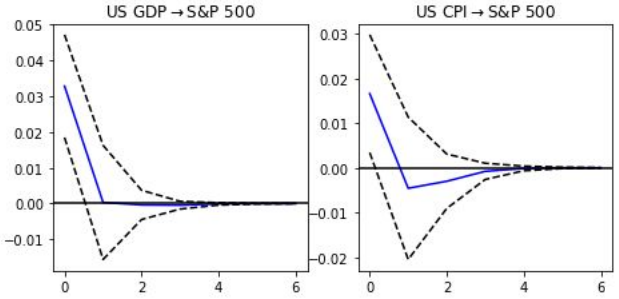
Forecast Accuracy of: Nikkei
mape : 17.9264
me : −0.2056
mae : 0.2056
mpe : 15.6617
rmse : 0.2124
corr : 0.533
minmax : −15.6617

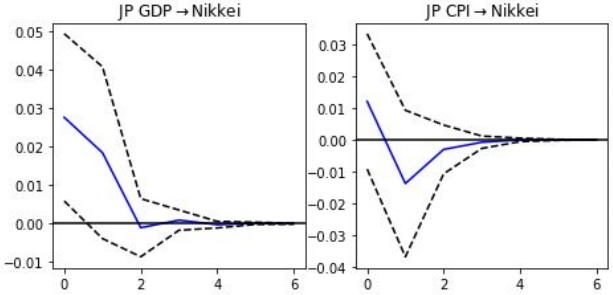


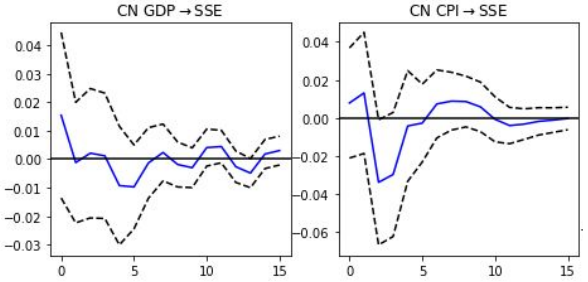
Forecast Accuracy of: SSE
mape : 1.1941
me : −0.0797
mae : 0.0797
mpe : 0.3737
rmse : 0.0875
corr : 0.9638
minmax : −0.3737

- The RMSE around 0.0875 to 0.2124 is also relatively low, indicating that the model's forecasts are generally **close to the actual values**.
- The correlation coefficient of S&P500 & SSE is around 0.96-0.99 is high, indicating a **strong positive relationship between the predicted and actual values**.
- Overall, the model's performance is decent, but the **high MAPE (1.19-17.92) suggests that there may be room for improvement.**

Impulse response







➔ Overall, stock prices respond more strongly to CPI than GDP, and Japan and China respond more strongly than the United States.

Conclusion

In conclusion, GDP and CPI are useful in predicting the stock market since they have Granger Causality. Generally, GDP and CPI are cointegrated, they share a common long-run trend. But the stock market and CPI are not always cointegrated, they are not always share a common long-run trend.

The US, China and Japanese stock markets have a high correlation with GDP and CPI. Generally, Stock prices respond more strongly to CPI than GDP, and Japan and China respond more strongly than the United States. CPI are useful in predicting the stock market than GDP.

In our study, Japan and China stock market respond to CPI more strongly than the US.