The Relationship Between the Price of Gold and Inflation(CPI) in U.S.

Econ 515 Group 8
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FINE GOLD
NET WT 1000g

- Financial – safe-haven asset
  - Protect your portfolio

- Gold is widely used in the jewelry and art fields
  - gifts
  - decorative items
  - souvenirs

- Manufacturing Industry – high-tech fields
  - Gold has excellent electrical and thermal conductivity, so it is good to use in circuit boards and other electronic devices.

Gold has both **financial** and **commodity** properties, so there may be a dynamic relationship between the CPI and the gold price. There are many factors that determine the price of gold, and inflation is one of the most important factors.

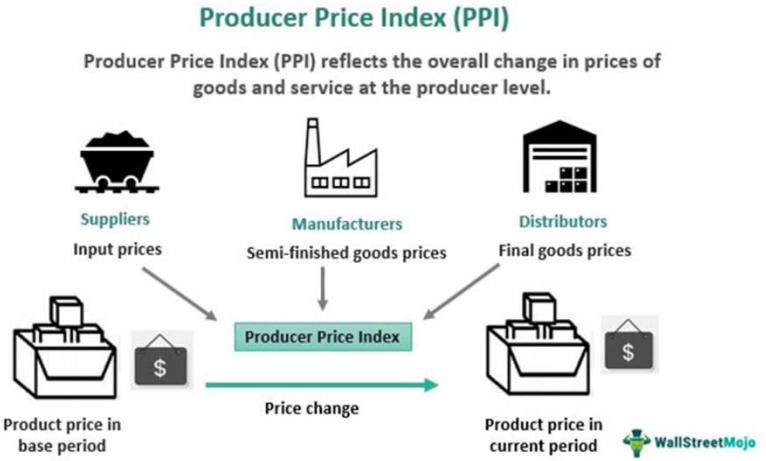
Consumer Price Index (CPI)

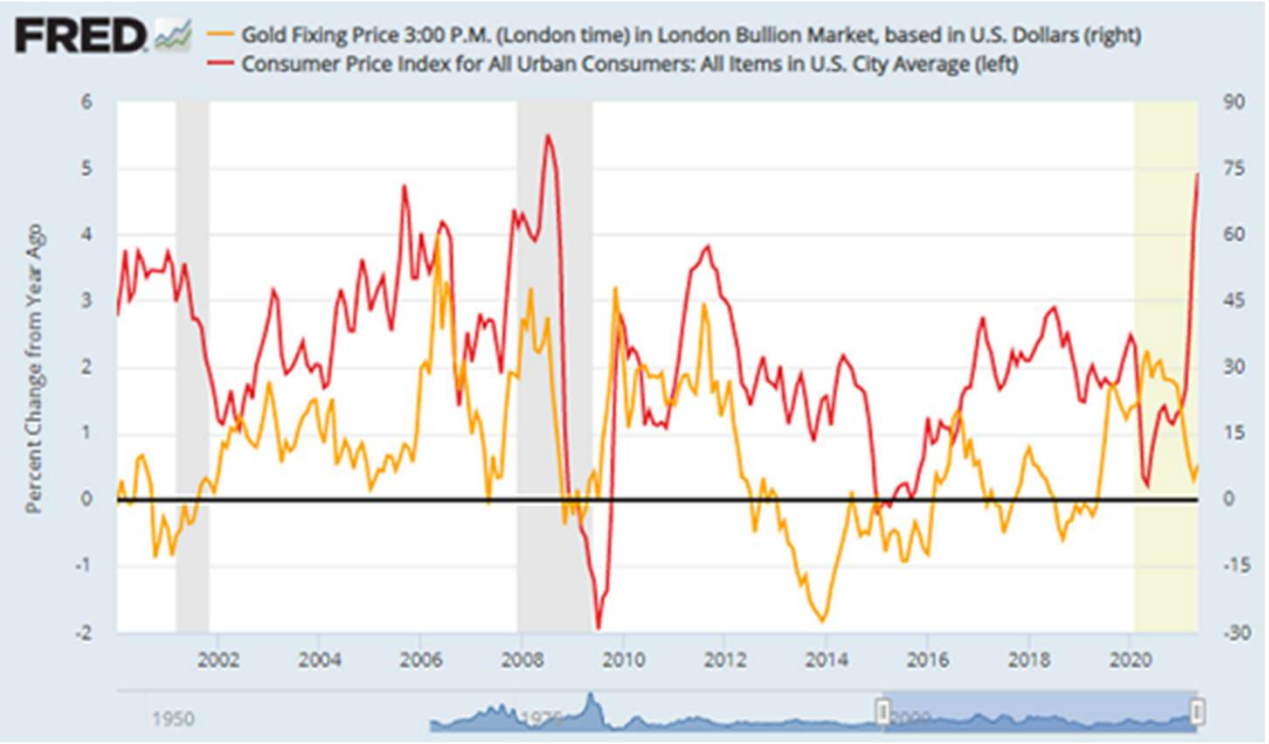
[kən-ˈsü-mər ˈprīs ˈin-ˌdeks]

An index that measures the monthly change in prices paid by U.S. consumers.

Inflation implies an inward depreciation of the currency and a decrease in purchasing power, as well as a shrinkage of financial assets.

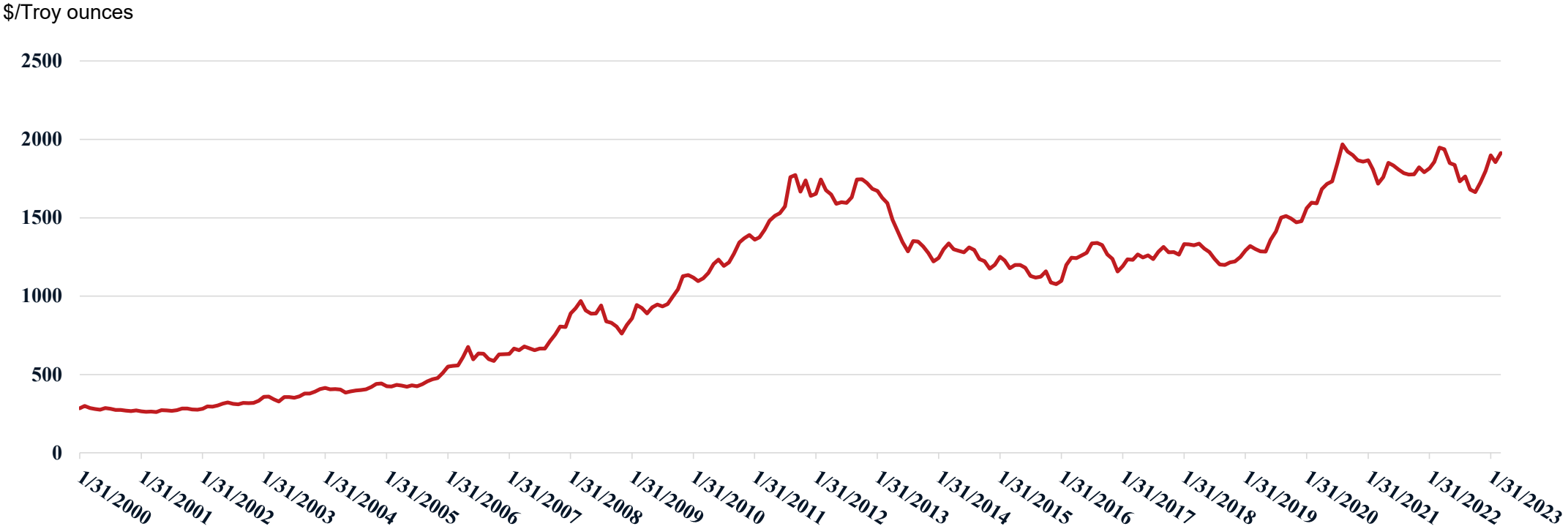
WHOLESALE PRICE INDEX



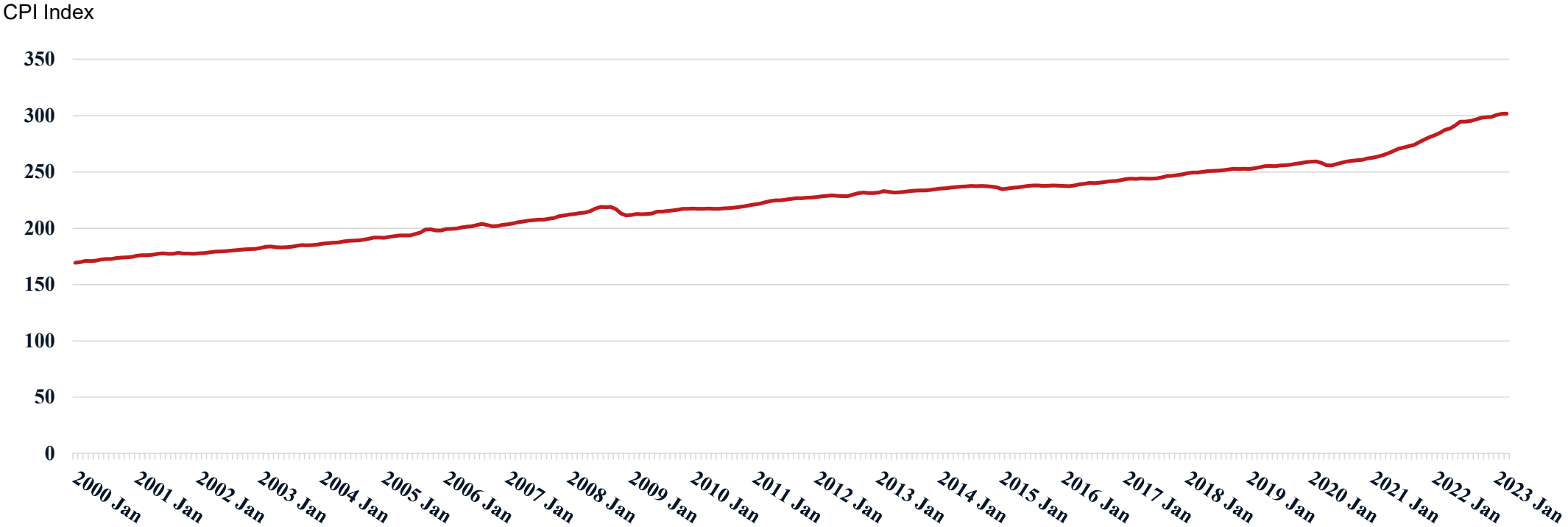


- When investment demand for gold increases, the price of gold rises
- Gold's commodity properties will also cause its price to rise in response to inflation
- In times of high inflation or strong inflationary expectations, gold is often favored by investors as a value preservation tool
- As an important raw material for production and consumption, the increase in the price of gold will also lead to higher production and consumption costs, which will cause price increases.

Gold price changes From 2000s



CPI changes From 2000s



Literature review

Levin and Wright (2006) using gold prices and inflation from 1835 to 2005 inflation data, conducted an empirical analysis, the results show that the price of gold and there is a long-run equilibrium relationship between inflation, which proves that the price of gold is a good tool to hedge against inflation. This is consistent with Wang's(2011) view, Focusing on the price of gold in contrast to a more general commodity price index, Wang et al. (2011) study the long run relationship between gold and inflation and augment the results with a linear cointegration test to examine the hedging ability of gold. The authors also suggest that changes in the price of gold reflect inflationary pressure.

Examining the macroeconomic drivers of the gold price, Baur(2013) finds that gold is driven by two categories of drivers; the first being traditional drivers such as inflation, the other one being new drivers like central bank demand. Apart from using the American CPI rate, the author also works with a Global CPI index.

Literature review

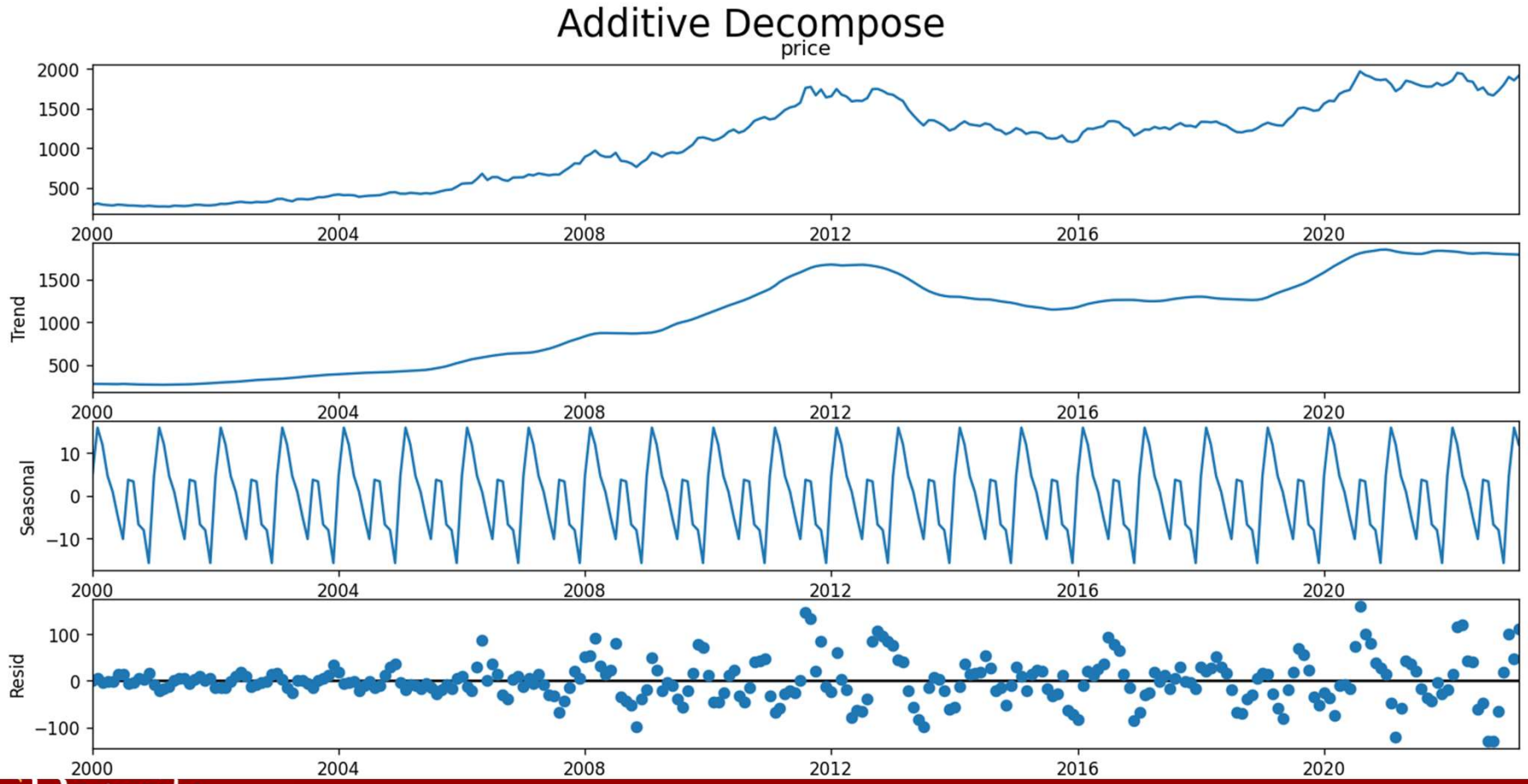
Ibrahim (2014) investigated the determinants of gold prices in Malaysia. Multiple Linear Regression Model was employed to determine the significant relationship between dependent and independent variables, covering data for 10-year period which are from 2003 until 2012. The price of gold was the dependent variable and crude oil prices, inflation rates and exchange rates were independent variables. The empirical results have revealed that there is negative and significant association between inflation rates and exchange rates on gold prices.

Laurence E. Blose(2010) holds that Gold prices do not change as a result of changes in expectations regarding future inflation. Articles in the financial press that tie changes in gold prices to changes in expectations regarding future inflation are mistaken.

Although the results of many studies are different, we wanted to study whether the level of inflation is one of factors affecting the fluctuation of gold prices

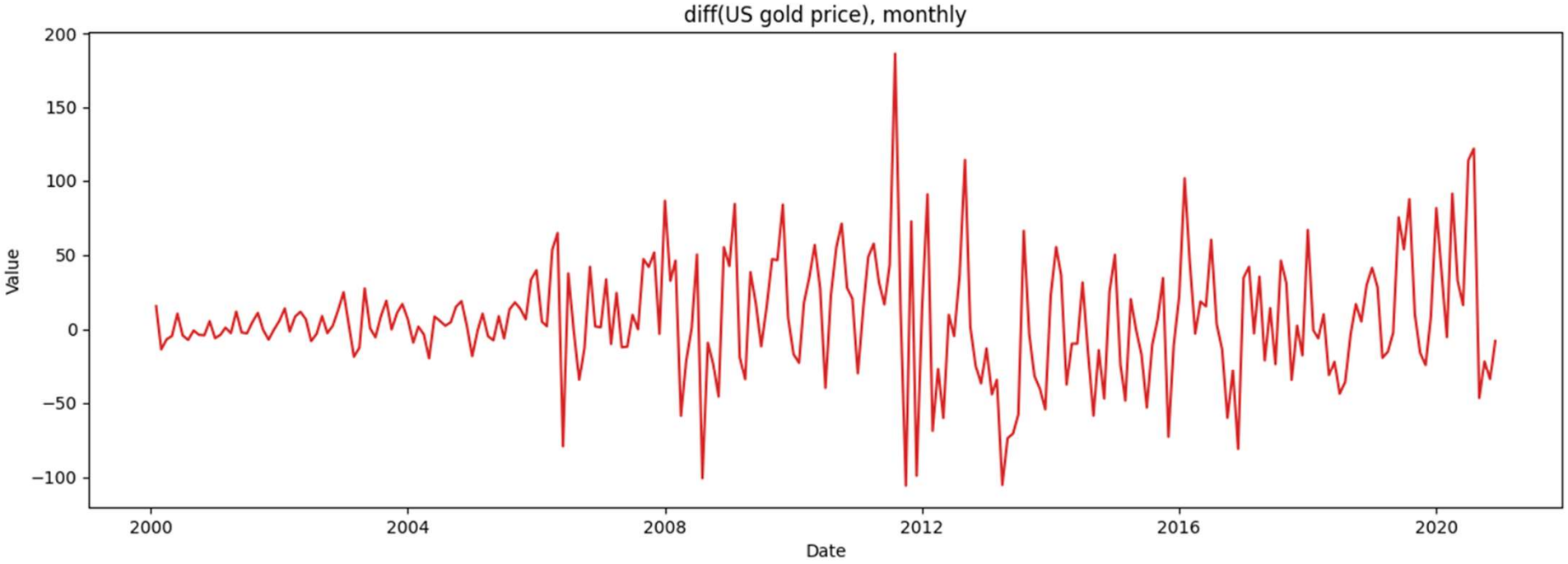
Plot the Data: Jan 2000 to Dec 2021, monthly

Additive Decompose

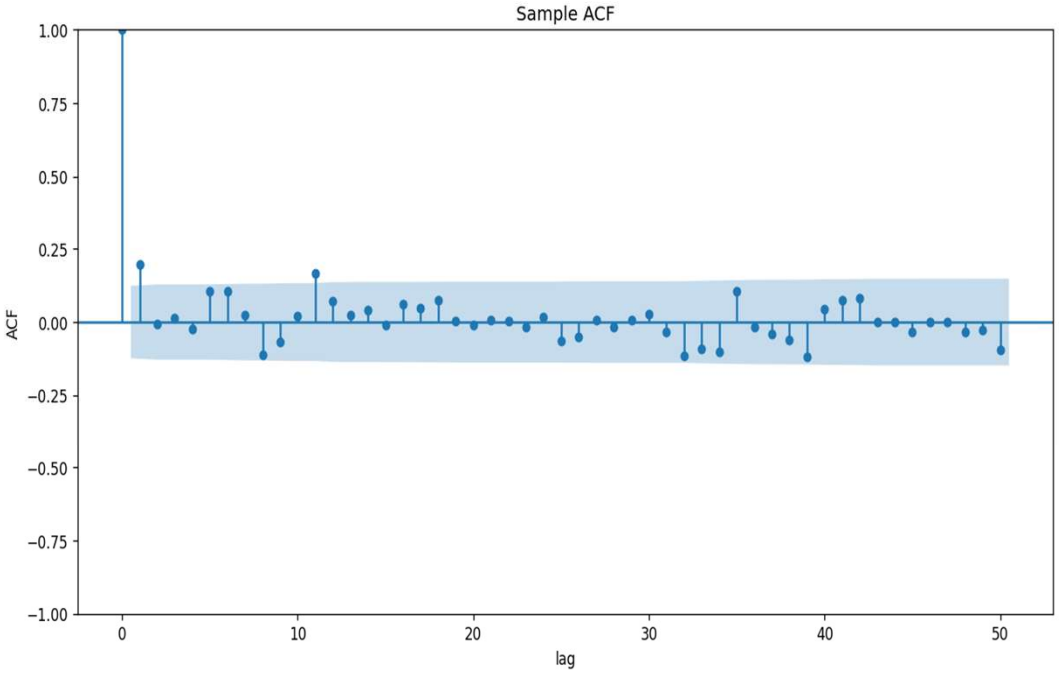


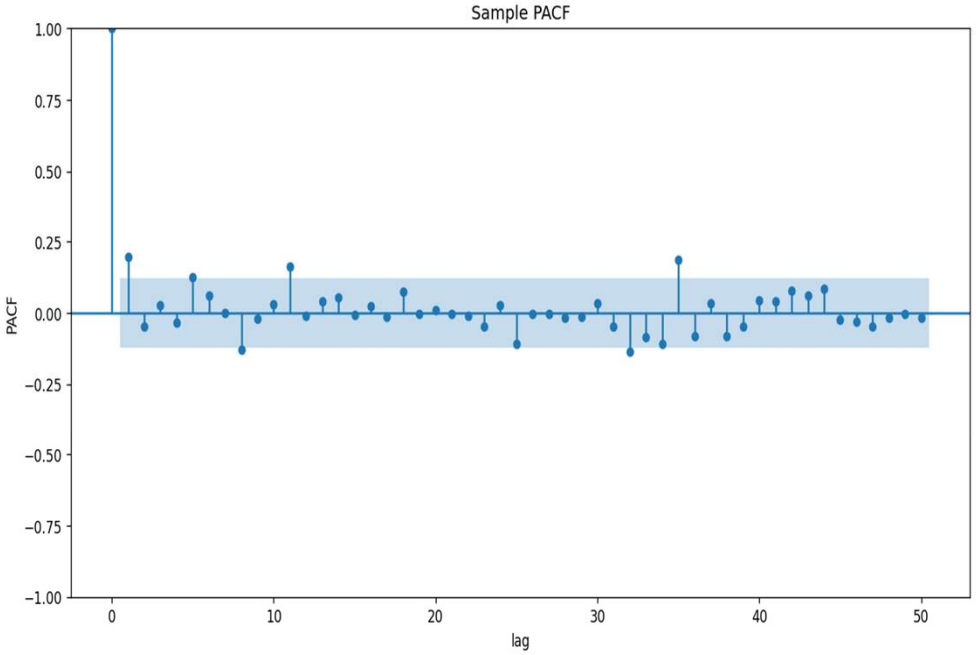
Stationary Checking: ADF test

	ADF test Statistic	p-value
Gold Price	-0.36307	0.91608
Diff(Gold Price)	-12.90420	4.18625*e-24

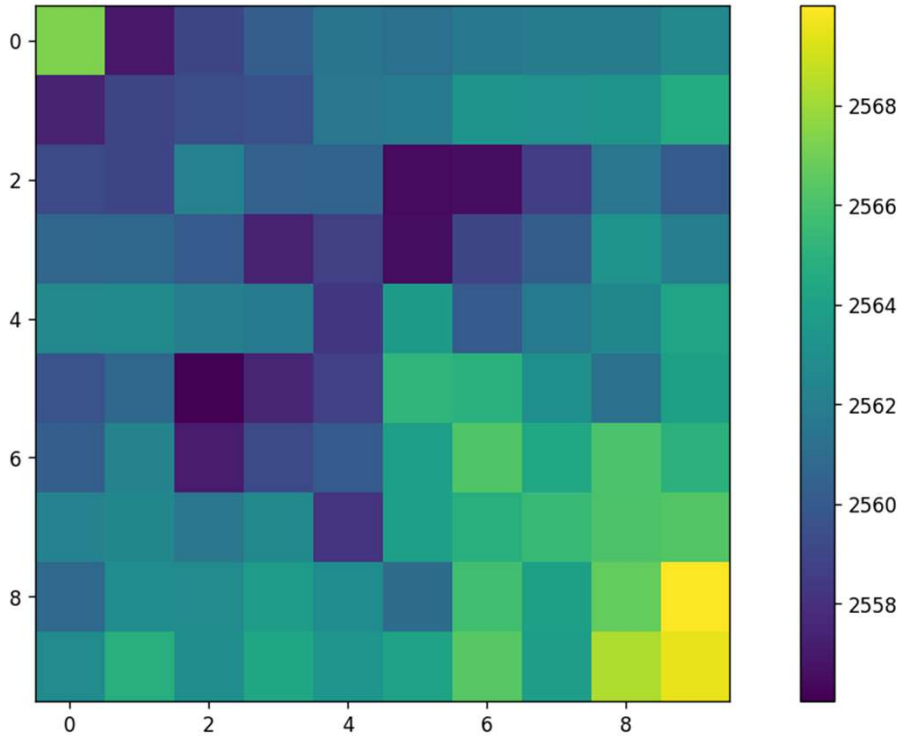


ACF&PACF


Sample ACF
ACF
lag
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75
−1.00
0
10
20
30
40
50


Sample PACF
PACF
lag
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75
−1.00
0
10
20
30
40
50

Model Specification using AIC



ARIMA(5,1,2)

SARIMAX Results

Dep. Variable:	price	No. Observations:	252
Model:	ARIMA(5, 1, 2)	Log Likelihood	-1270.024
Date:	Mon, 24 Apr 2023	AIC	2556.048
Time:	00:55:55	BIC	2584.252
Sample:	01-01-2000	HQIC	2567.398
	- 12-01-2020		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
ar.L1	1.1885	0.057	21.031	0.000	1.078	1.299
ar.L2	-1.1489	0.079	-14.602	0.000	-1.303	-0.995
ar.L3	0.2722	0.092	2.958	0.003	0.092	0.453
ar.L4	-0.0631	0.073	-0.871	0.384	-0.205	0.079
ar.L5	0.0956	0.048	1.975	0.048	0.001	0.191
ma.L1	-1.0022	0.040	-25.108	0.000	-1.080	-0.924
ma.L2	0.9445	0.045	21.087	0.000	0.857	1.032
sigma2	1386.6136	90.642	15.298	0.000	1208.959	1564.268

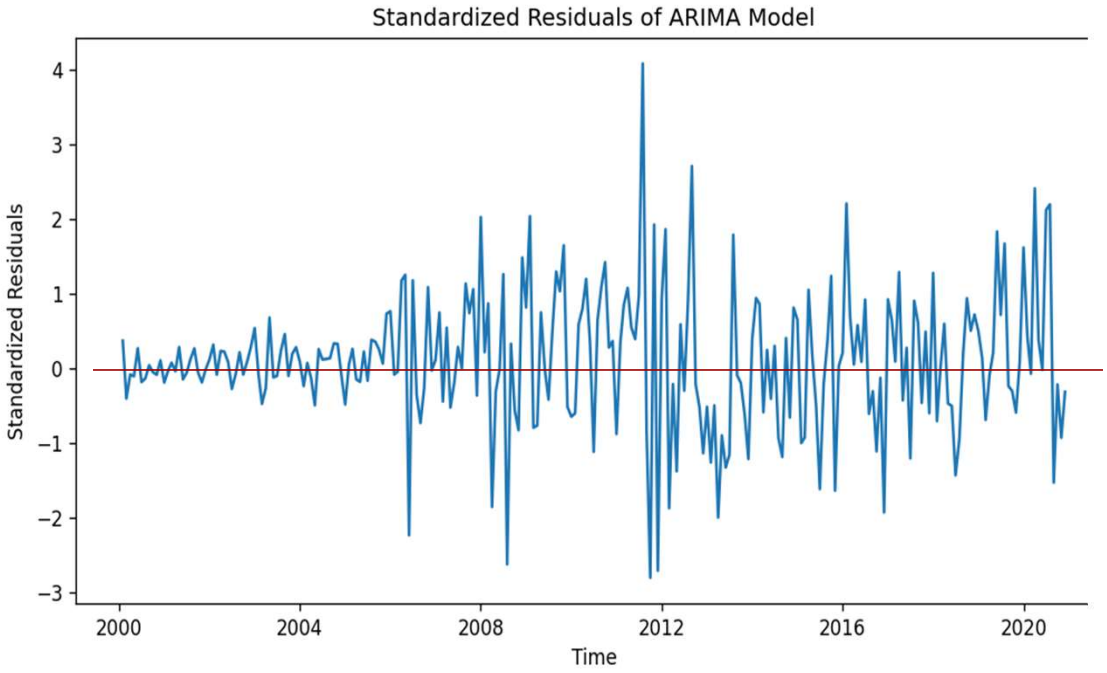
Ljung-Box (L1) (Q):	0.00	Jarque-Bera (JB):	43.64
Prob(Q):	0.98	Prob(JB):	0.00
Heteroskedasticity (H):	4.39	Skew:	0.15
Prob(H) (two-sided):	0.00	Kurtosis:	5.02

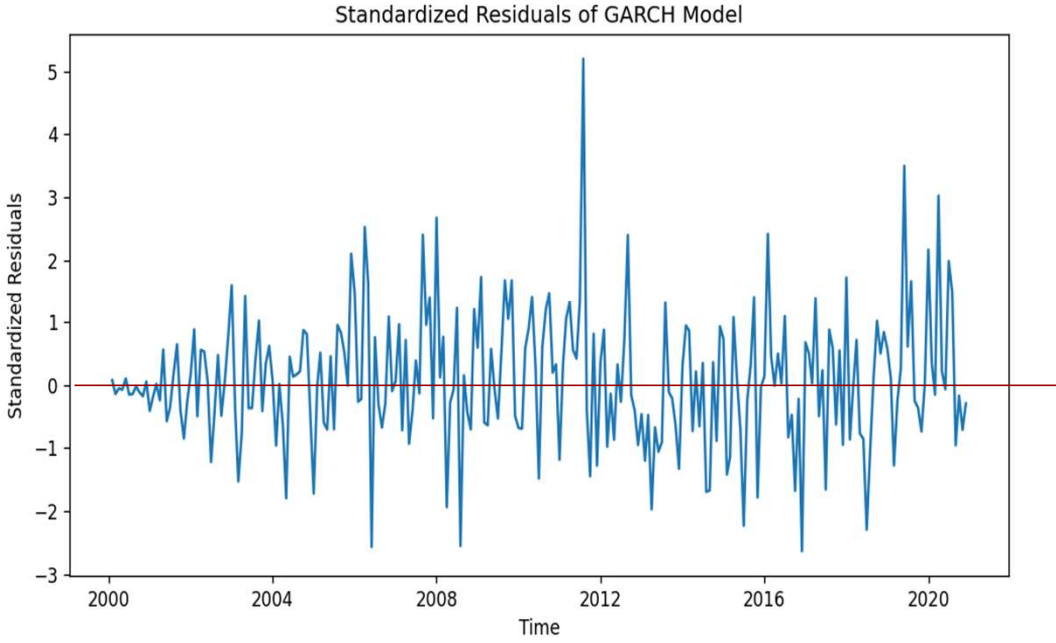
GARCH

```
                     Constant Mean - GARCH Model Results
==============================================================================
Dep. Variable:                    None   R-squared:                       0.000
Mean Model:             Constant Mean   Adj. R-squared:                  0.000
Vol Model:                      GARCH   Log-Likelihood:               -1255.02
Distribution:                  Normal   AIC:                           2518.04
Method:            Maximum Likelihood   BIC:                           2532.16
                                        No. Observations:                  252
Date:                Mon, Apr 24 2023   Df Residuals:                      251
Time:                        01:09:48   Df Model:                            1
                            Mean Model
==============================================================================
                 coef    std err          t      P>|t|      95.0% Conf. Int.
------------------------------------------------------------------------------
mu             2.8568      1.465      1.950  5.120e-02 [-1.493e-02,  5.729]
                          Volatility Model
==============================================================================
                 coef    std err          t      P>|t|  95.0% Conf. Int.
------------------------------------------------------------------------------
omega         29.8056     22.286      1.337      0.181 [-13.874, 73.485]
alpha[1]       0.2982  6.731e-02      4.430  9.409e-06 [  0.166,  0.430]
beta[1]        0.7018  5.478e-02     12.812  1.399e-37 [  0.594,  0.809]
==============================================================================

Covariance estimator: robust
```

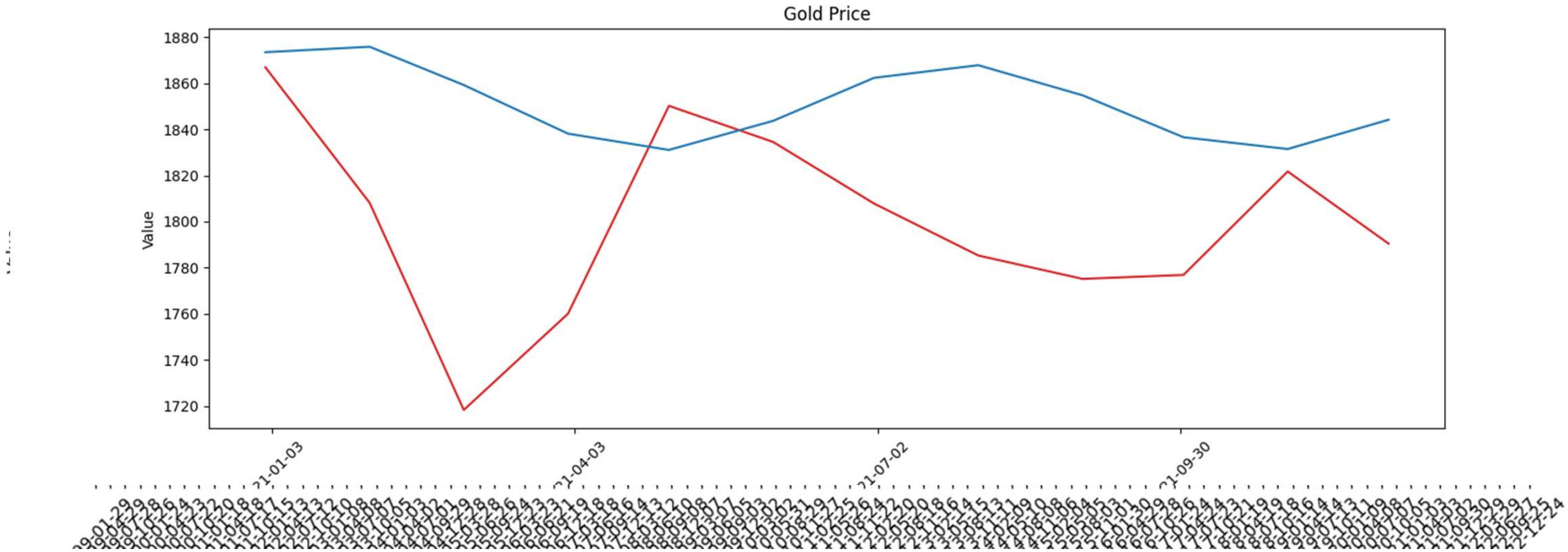
Residual Comparison



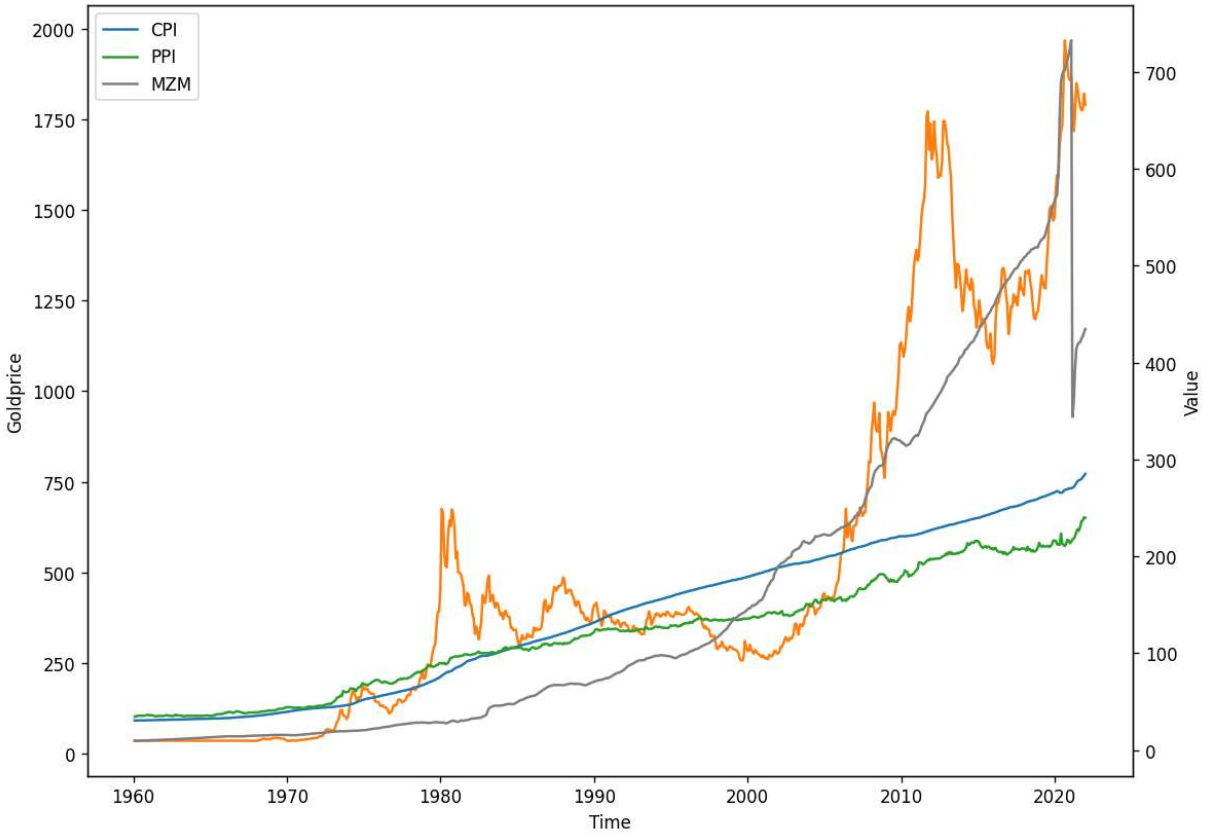


Forecasting

Test RMSE=41.62157



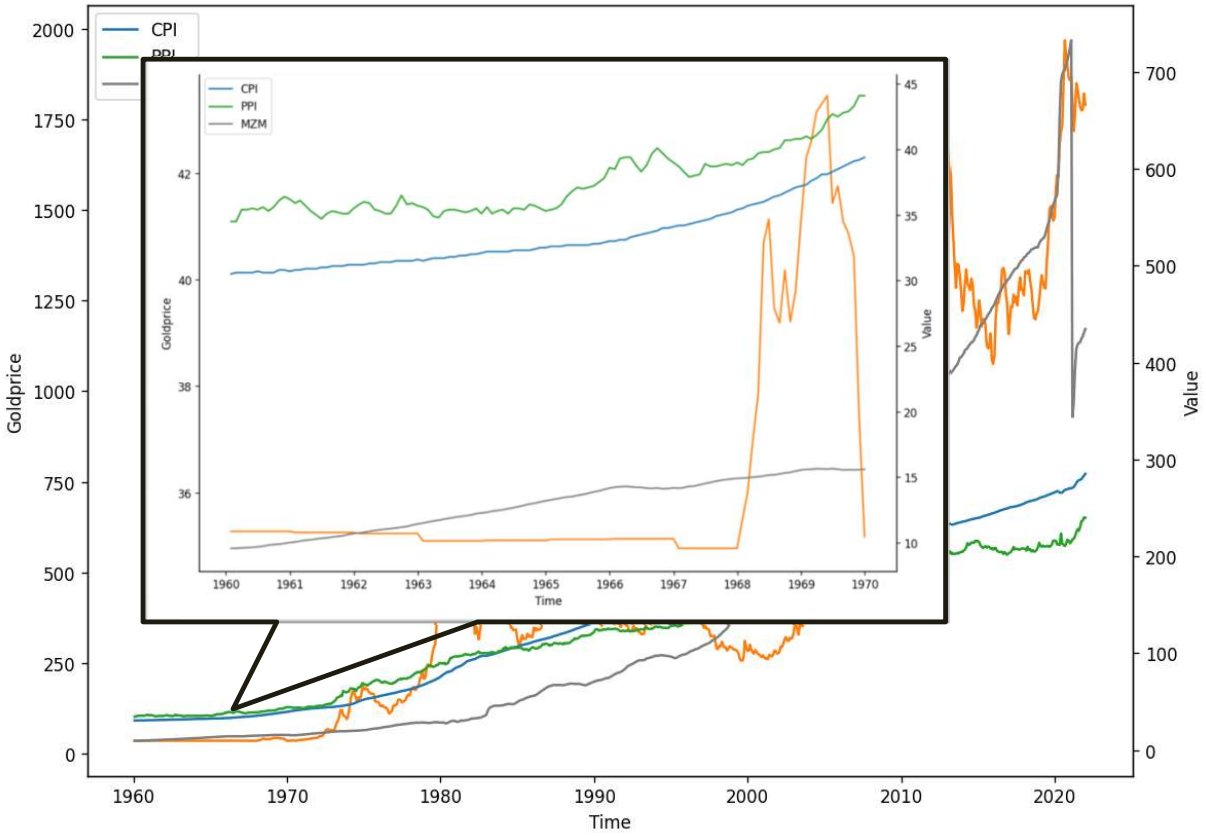
Data Visualization



- Data of Gold prices and Indicators representing US inflation.
- 1960 Jan – 2020 Dec, monthly data

- The indicators we usually use to represent inflation are Consumer Price Index, Producer Price Index and Money Zero Maturity.

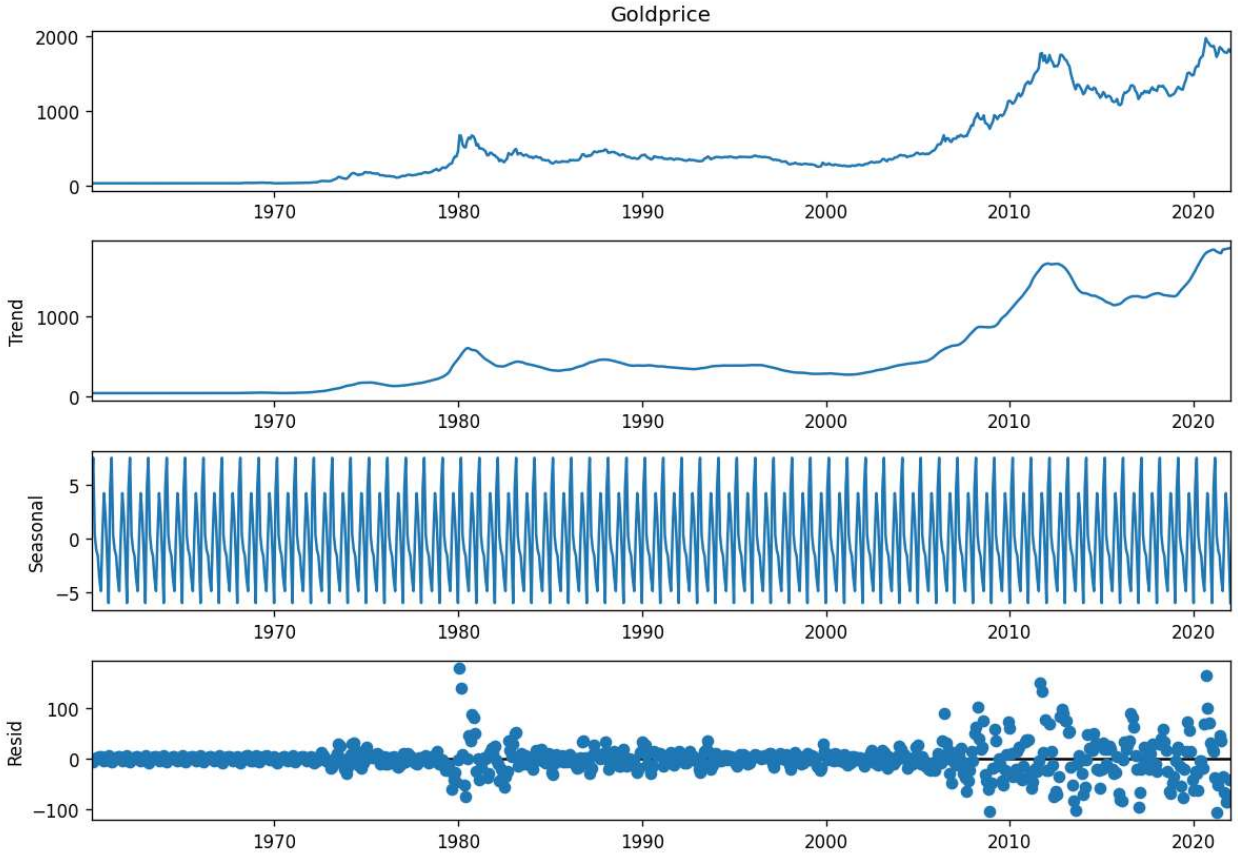
- There exists some special periods: 1960-1970, around 1980, around 2010.



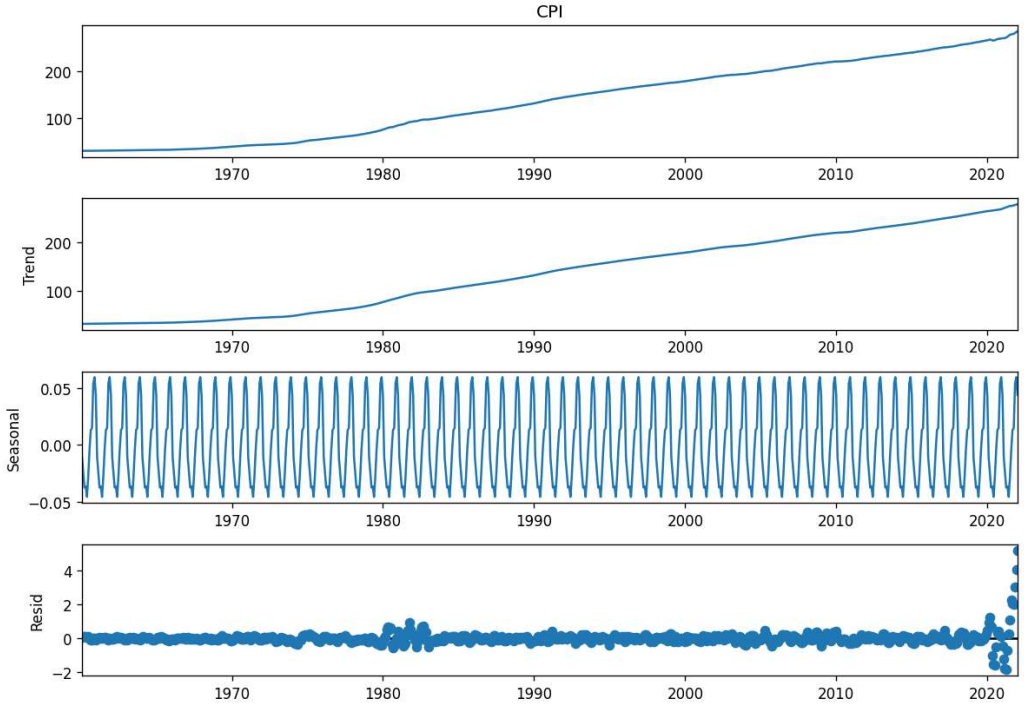
During the period of the Bretton Woods system from 1944-1970, member countries adopted a regulated system of fixed exchange rates, indirectly disciplined by a US dollar tied to gold—a system that relied on a regulated market economy with tight controls on the values of currencies.

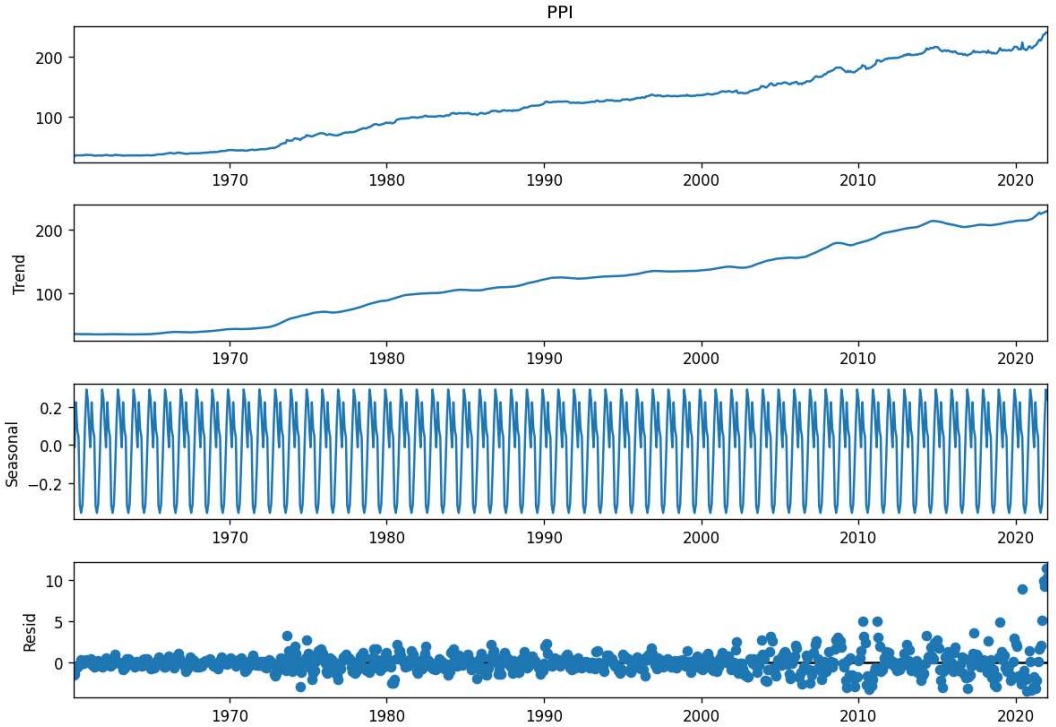
And from then until the collapse of the Bretton Woods system, the international price of gold remained stable at the official price of $35 per ounce.

Seasonal Decompose of Gold prices: 1960-2021

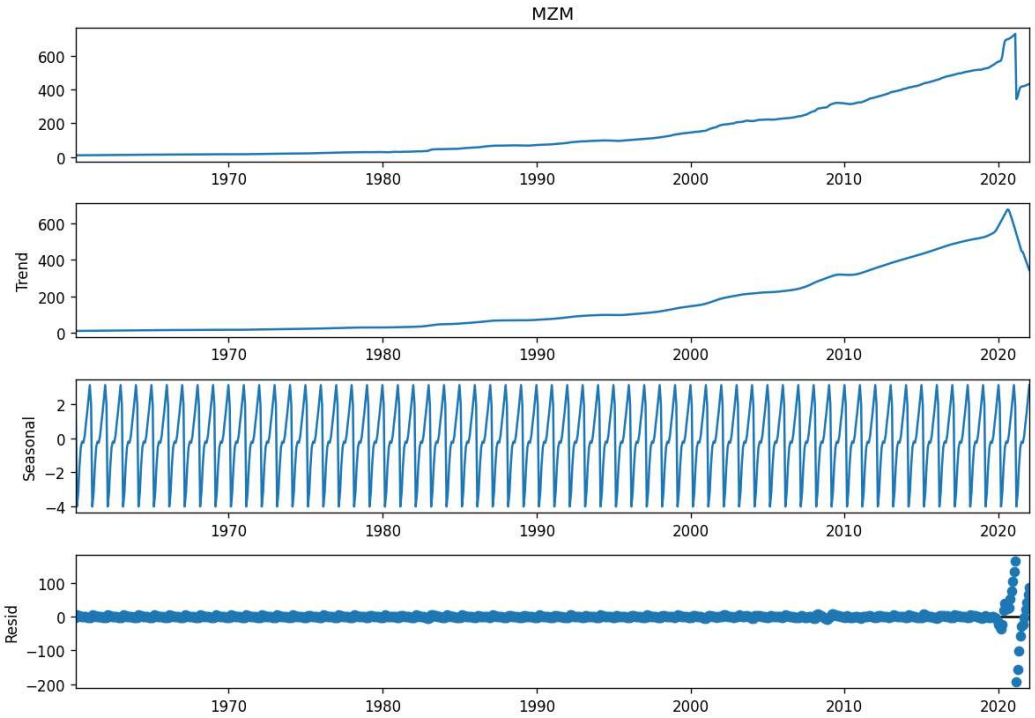


Seasonal Decompose of Other Indicators





Seasonal Decompose of Other Indicators (Continued)



Special periods:

Noises slightly increases around 1980

Noises increase after 2010

Huge noises and volatility in 2020

ADF test

	Test stat	p-value	Stationarity
Gold price	-1.1377	0.6998	Non-stationary
CPI	1.3347	0.9968	Non-stationary
PPI	-0.7066	0.845	Non-stationary
MZM	0.9747	0.994	Non-stationary
1st diff of Gold price	-12.7158	0.0	Stationary
1st diff of CPI	-7.3829	0.0	Stationary
1st diff of PPI	-8.4299	0.0	Stationary
1st diff of MZM	-5.2059	0.0	Stationary

Vector Autoregression Model

$$Y_t = \phi_0 + \phi_1 Y_{t-1} + \phi_2 Y_{t-2} + \cdots + \phi_p Y_{t-p} + u_t$$

Where Y_t is a vector of a set of endogenous variables which interact with each other.

Training set: 2000-01-2018-12
Testing set: 2019-01-2019-12

Gold-CPI

VAR Order Selection (* highlights the minimums)

	AIC	BIC	FPE	HQIC
0	3.775	3.806	43.60	3.788
1	3.707	3.800*	40.72	3.744*
2	3.701	3.857	40.48	3.764
3	3.734	3.952	41.83	3.822
4	3.723	4.003	41.37	3.836
5	3.681*	4.023	39.68*	3.819
6	3.691	4.096	40.10	3.855
7	3.726	4.193	41.52	3.914
8	3.708	4.238	40.80	3.922
9	3.742	4.333	42.20	3.981
10	3.750	4.404	42.56	4.014

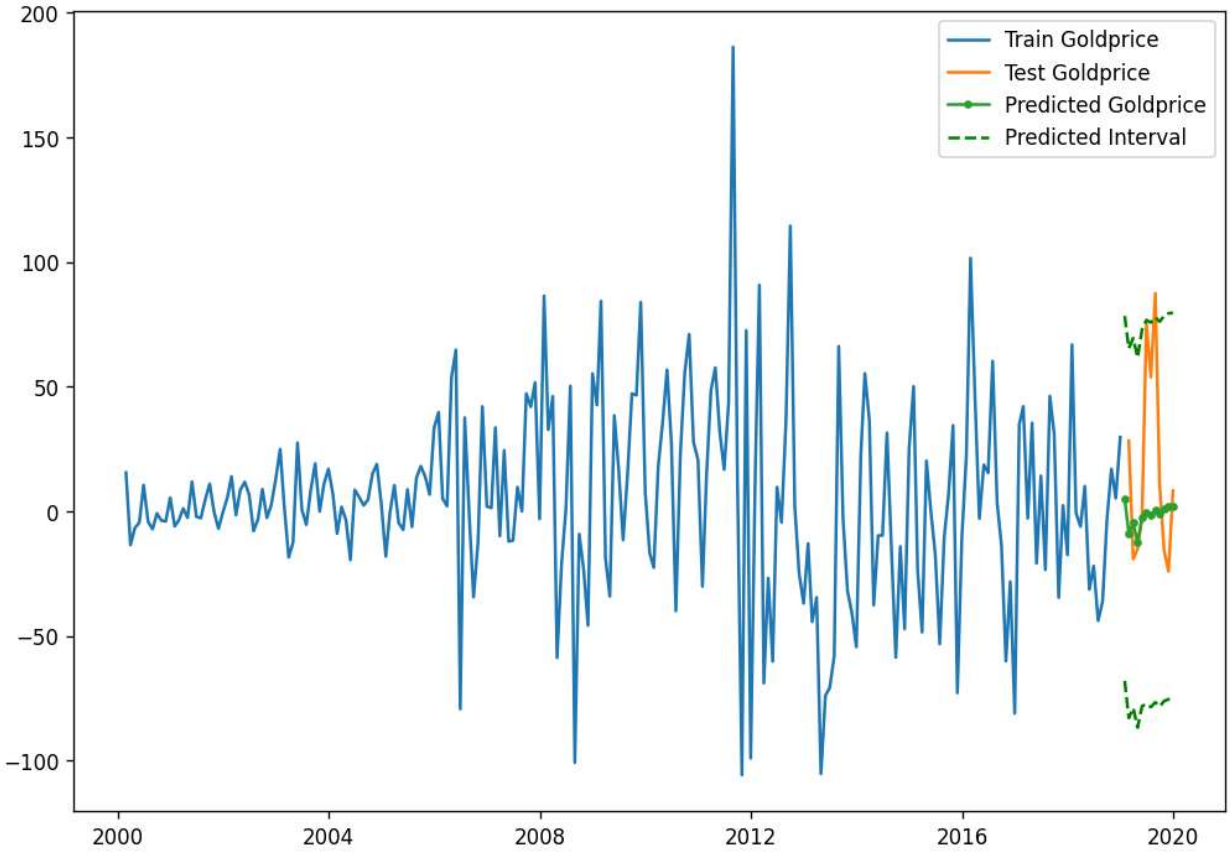
Summary of Regression Results

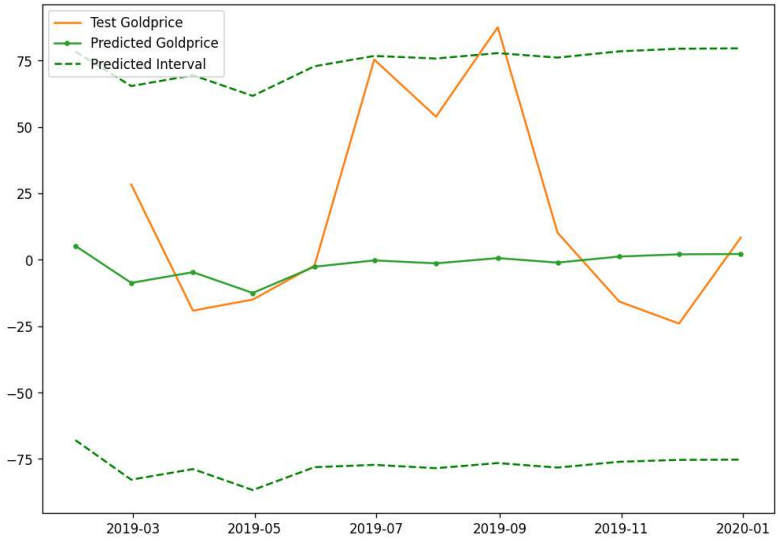
Model:	VAR		
Method:	OLS		
Date:	Sun, 23, Apr, 2023		
Time:	14:53:56		
No. of Equations:	2.00000	BIC:	3.97571
Nobs:	222.000	HQIC:	3.77465
Log likelihood:	-1011.88	FPE:	38.0412
AIC:	3.63851	Det(Omega_mle):	34.5341

Results for equation Goldprice

	coefficient	std. error	t-stat	prob
const	21.107886	9.414833	2.242	0.025
L1.Goldprice	0.140586	0.067978	2.068	0.039
L1.CPI	15.271290	16.002143	0.954	0.340
L2.Goldprice	-0.050601	0.067368	-0.751	0.453
L2.CPI	-1.138393	16.428986	-0.069	0.945
L3.Goldprice	0.031352	0.067579	0.464	0.643
L3.CPI	4.268237	16.683260	0.256	0.798
L4.Goldprice	-0.035470	0.067412	-0.526	0.599
L4.CPI	-46.006859	16.261776	-2.829	0.005
L5.Goldprice	0.150967	0.066585	2.267	0.023
L5.CPI	-22.751631	16.230227	-1.402	0.161

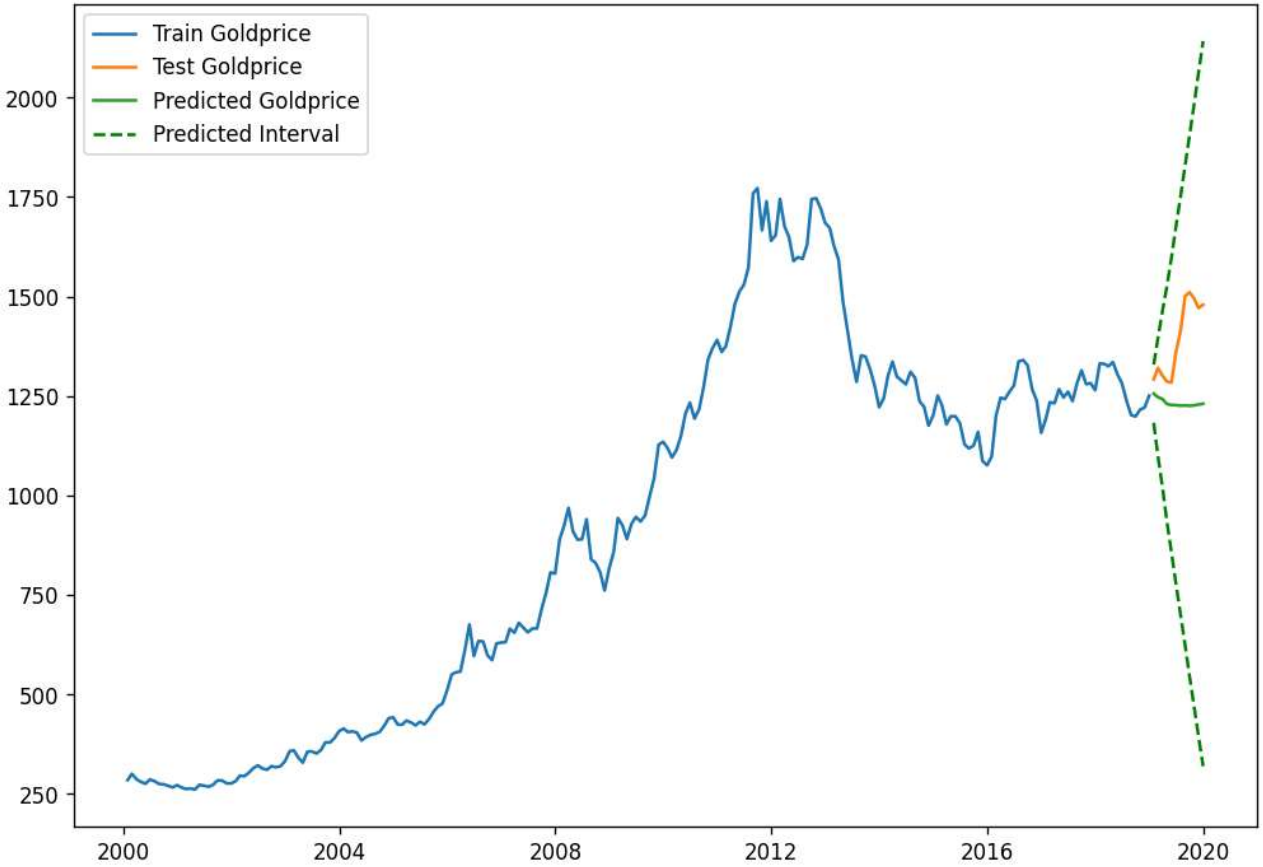
Forecast of 1st diff Gold price





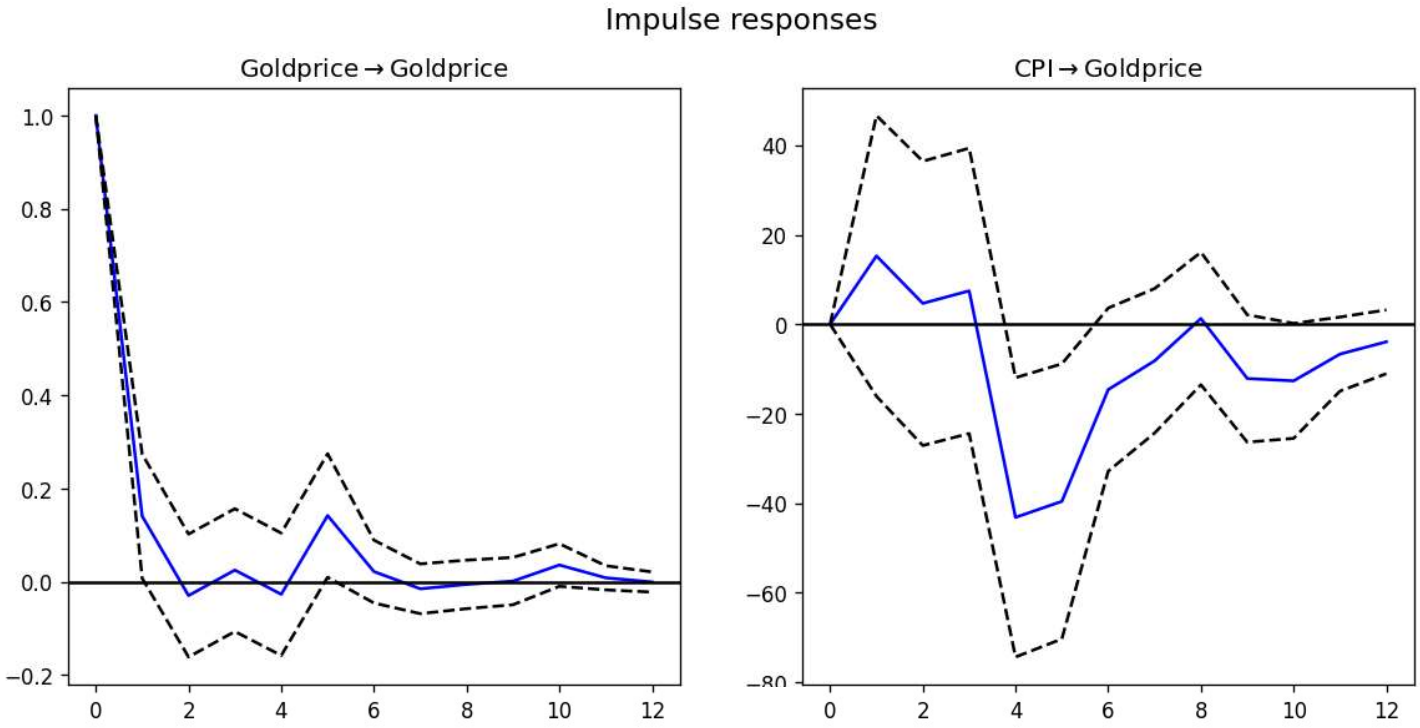
RMSE:41.17305995996232

Forecast of Gold price



RMSE:186.83114567391212

Impulse responses of CPI on Goldprice



Gold-Inf

VAR Order Selection (* highlights the minimums)

	AIC	BIC	FPE	HQIC
0	5.314	5.376	203.1	5.339
1	4.972	5.283*	144.3	5.098*
2	4.945*	5.505	140.4*	5.171
3	5.007	5.817	149.5	5.334
4	5.025	6.085	152.4	5.453
5	5.042	6.350	155.1	5.570
6	5.099	6.656	164.5	5.728
7	5.194	7.001	181.4	5.924
8	5.232	7.288	188.9	6.062
9	5.331	7.636	209.4	6.262
10	5.414	7.968	228.7	6.446

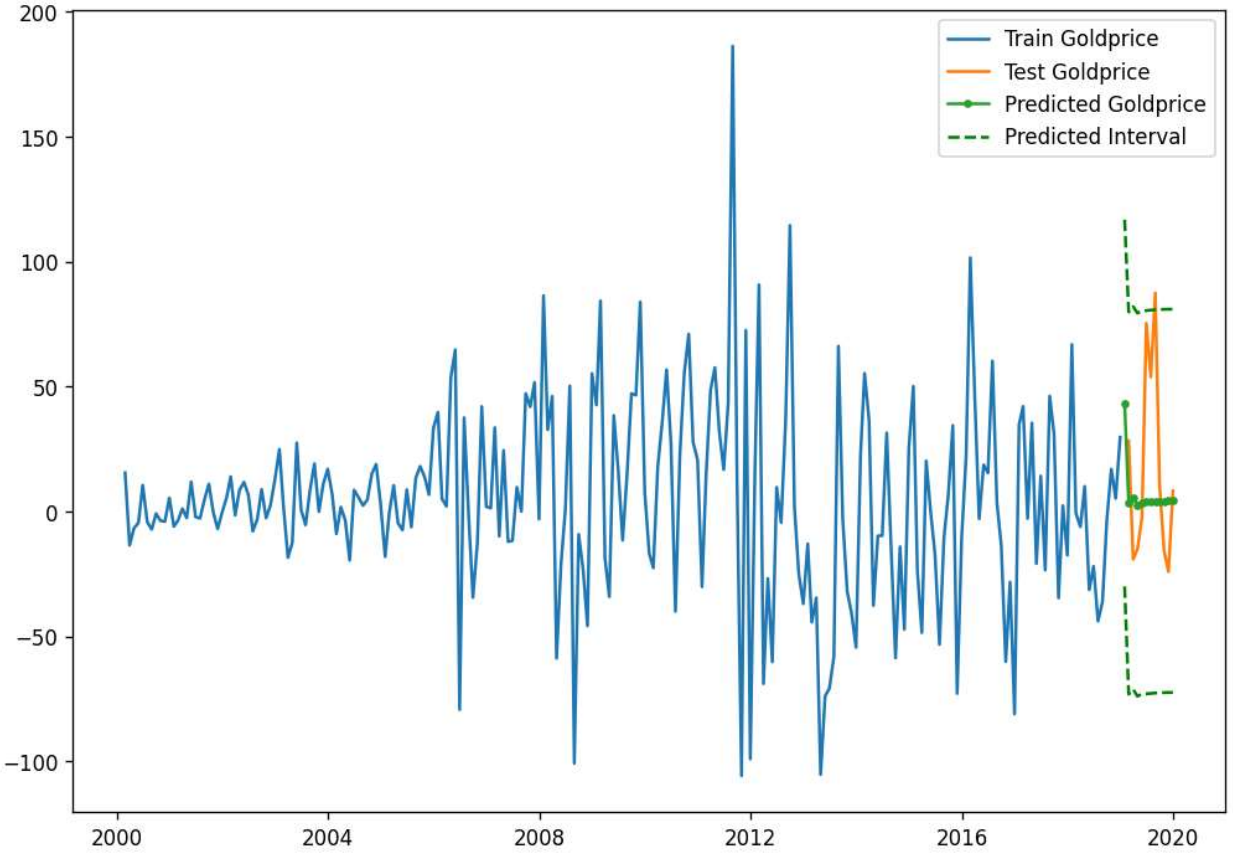
Summary of Regression Results

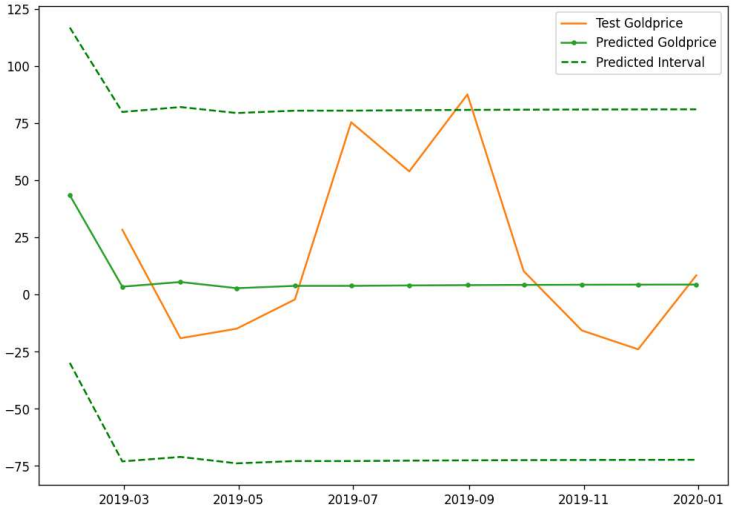
Model:	VAR		
Method:	OLS		
Date:	Sun, 23, Apr, 2023		
Time:	08:37:33		
No. of Equations:	4.00000	BIC:	5.37957
Nobs:	225.000	HQIC:	5.05360
Log likelihood:	-1784.76	FPE:	125.608
AIC:	4.83300	Det(Omega_mle):	107.371

Results for equation Goldprice

	coefficient	std. error	t-stat	prob
const	0.632848	7.589372	0.083	0.934
L1.Goldprice	0.152947	0.067461	2.267	0.023
L1.CPI	16.564023	15.891439	1.042	0.297
L1.PPI	3.226915	1.681451	1.919	0.055
L1.MZM	5.588237	2.158111	2.589	0.010
L2.Goldprice	-0.016592	0.066690	-0.249	0.804
L2.CPI	-12.809870	15.660785	-0.818	0.413
L2.PPI	-0.217739	1.713252	-0.127	0.899
L2.MZM	-5.135455	2.190666	-2.344	0.019

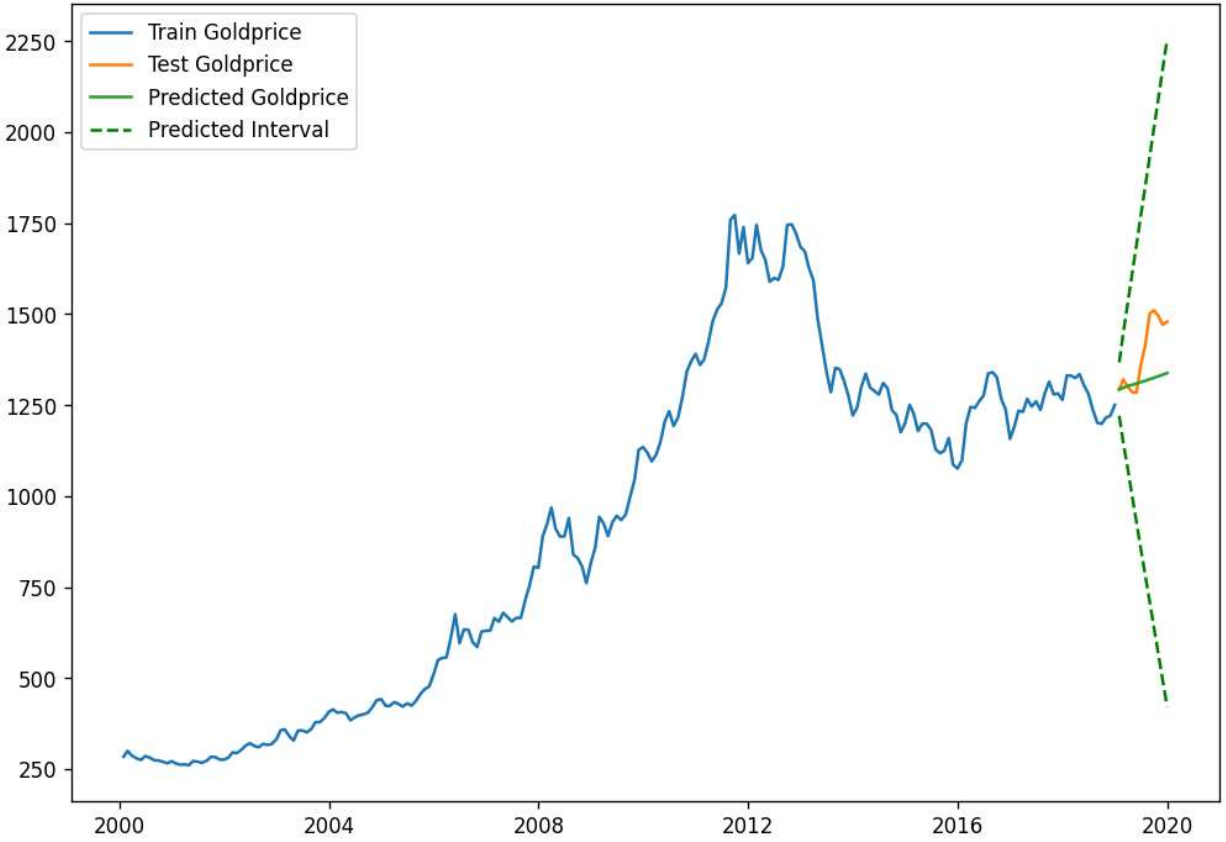
Forecast of 1st diff Gold price





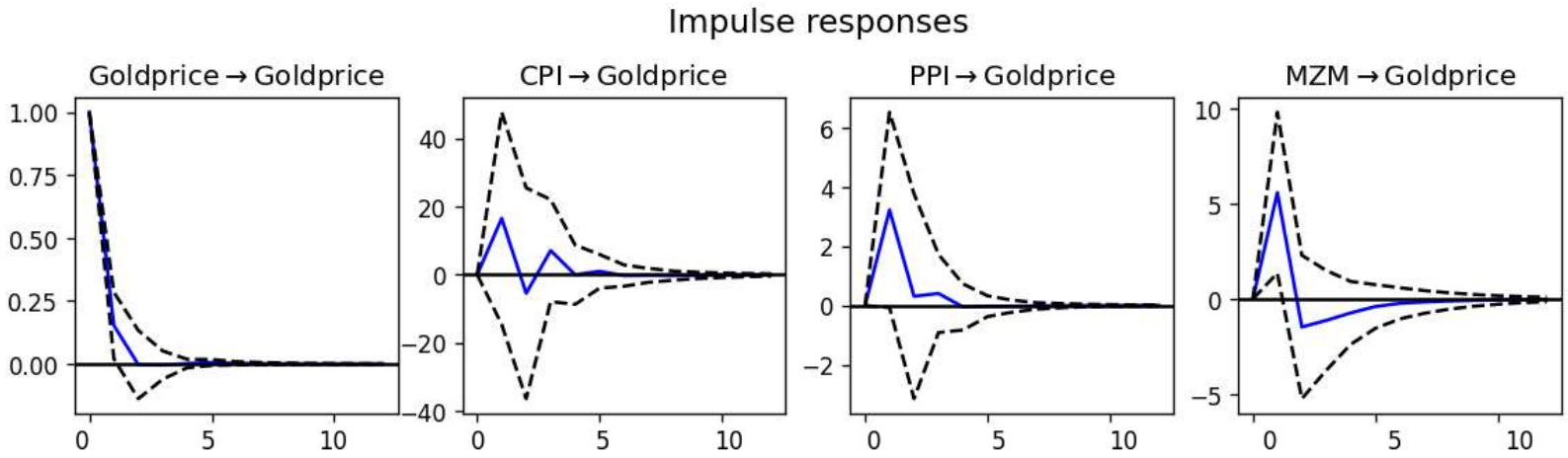
RMSE: 38.096660814852676

Forecast of Gold price



RMSE: 110.2198394907276

Impulse responses of inflation indicators on Goldprice



From the data of 2000-01 to 2019-12, we can derive from the model result that there exists inflation hedging effectiveness of gold.

Conclusion

Model	RMSE
ARIMA(5,1,2)	41.62157
VAR: Gold-CPI	186.83114567391212
VAR: Gold-Inflation	110.2198394907276

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