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The Effect of Money Supply on the Performance of the Stock Market

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"ALTERNATIVE HYPOTHESIS" TEAM

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Introduction

Monetary policy is one of the most powerful tools that the central bank controls. It affects the level of money supply and exchange rates, but it can also be used to induce desired magnitude of economic activities. When the central bank wants to stimulate the economy, it might increase the money supply or, on the contrary, decrease it if the market is overheated. When there is more money in circulation, interest rates fall, and consumers and businesses are more willing to spend. Therefore, consumers buy more products and services, whereas businesses expand operations and earn more. Growing earnings constitute an incentive towards investment and are almost always good for stock prices. The opposite happens when money supply is decreased. Interest rates increase, consumer and business spending falls, and consequently also the company earnings and stock prices decrease.

Economic theory confirms a relationship between changes in money supply and stock prices. Nevertheless, there are different assumptions regarding the nature and causality of this relation. The aim of our study is to analyze the relationship between US money supply and stock price index S&P 500 and to discover the direction of causality of this relation. The research questions in the study are as follows:

RQ1. Is M2 money supply a useful predictor of stock prices?

RQ2. At which frequency (weekly or monthly) the relationship is stronger?

RQ3. Which other predictors, except M2, play an important role in a predictive model?

1. Literature review

Economic literature has proven the influence of the money supply on the stock market prices. The relationship between money supply and stock prices is complex and it can influence through a variety of factors. According to Keynesian theory, change in the level of money supply might affect stock prices only if this change affects expectations about future monetary policy. Increase in the money supply results in people anticipating contractionary monetary policy, which leads to increase in bidding for bonds driving the current interest rate up. Consequently, discount rates are also increasing, and the present value of future earnings falls together with the stock prices. Furthermore, as interest rates increase the level of economic activity is decreasing which further depresses stock prices.

In contrast, the real activity theorists argue that the relationship between money supply and market stock prices is positive as positive money supply shock increases money demand in anticipation of the increase in economic activity. Consequently, the expected profitability is higher, which leads to increase in stock prices[1].

Bernanke and Kuttner believe that money supply affects stock prices through its effect on the interest rate. Decrease in the money supply raises the real interest rate leading to increase in the discount rate which results in lower stock value[2]. Theoretically, higher interest rate preclude demand for high-risk stocks which consequently leads to decrease in their values. Nevertheless, it highly depends on the efficiency with which market participants include the information on growing money supply into share prices. If the market is inefficient, investors can earn significantly higher rates of return than in normal circumstances. The supporters of the efficient market hypothesis argue that all available information is already reflected in the market value of the stock, thus expected changes in the money supply cannot affect the stock prices[3].

Gupta proved that money supply is a significant predictor of stock markets development. He found that 59% of the stock price indices can be forecasted with the use of the money supply[4]. This result was confirmed by Rapach, Wohar, and Rangvid

[1] E. H. Thabet, Examining the Long Run Relationship between the U.S. Money Supply (M2) and the Canadian Stock Market, International Journal of Economics and Finance, 2014, vol. 6, no. 10.

[2] B. S. Bernanke, K. N. Kuttner, What explains the stock market's reaction to Federal Reserve policy?, The Journal of Finance, 2005,

[3] C. J. Corrado, B. D. Jordan, Fundamentals of Investments: Valuation and Management, McGraw-Hill Education (ISE Editions), 1999.

[4] M. Gupta, Money supply and stock market: A probabilistic approach, Journal of Finance and Quantitative Analysis, 1974.

who discovered that the most reliable macroeconomic indicator for stock market anticipation is the interest rate that is mostly influenced by money supply[5]. Furthermore, Husain, Mahmood and Azid investigated the relationship between monetary expansion and stock returns using M1 and M2 money supply. They proved that changes in money supply affects stock prices both in the long run and short run indicating that stock market is not efficient with regard to the money supply[6]. Thabet analyzed the impact of changes in the US money supply on the Canadian stock market using Canadian S&P/TSX Composite Index, Canadian Consumer Price Index, and USD/CAD exchange rate. He found that money supply is the most exogenous variable that leads the Canadian stock price index[7].

Additionally, stock prices are influenced by a wide range of factors, except from money supply, macroeconomic indicators such as economic growth, unemployment rate, long term interest rate also has significant effects[8]. Empirically, the relationship between stock prices and output has been thoroughly researched. Growing output can indicate more demand, so this will increase cash flows and furthermore increase stock price. Fama found that there is a positive relationship between stock price and GDP growth[9]. Boyd suggested that depending on the economy employment data has an significant effect on stock prices[10]. Furthermore, it is said to be important to consider technical variables when determining stock prices. For example, higher trading volume of stock represents the sentiment of stock, and it has negative effect on stock price changes. Also researches include volatility variable in to their model.

2. Methodology

Vector Error Correction model (VECM) is widely applied to determine the relationship of multiple time series variables, that have common trend in long term. It is important to note that VECM should be applied when the variables are non-

[5] D. E. Rapach, M. E. Wohar, Rangvid J., Macro variables and international stock return probability, international journal of Forecasting, 2005.

[6] F. Husain, T. Mahmood, T. Azid, Monetary Expansion and Stock Returns in Pakistan, The Pakistan Development Review, 1999.

[7] E. H. Thabet, op. cit.

[8] T. Hudepohl, R. v. Lamoen, N. d. Vette., Quantitative easing and exuberance in stock markets: Evidence from the euro area, 2021. Journal of International Money and Finance, Volume 118.

[9] E. F. Fama,. Stock Returns, Real Activity, Inflation, and Money, 1981. The American Economic Review , Vol. 71.

[10] J. H. Boyd, J. HU, R. JAGANNATHAN., The Stock Market's Reaction to Unemployment News: Why Bad News Is Usually Good for Stocks, 2005.

stationary and when there is evidence of cointegration between the variables. The term cointegration is used when the linear combination between nonstationary variables becomes stationary. To create a VECM model, error correction model is added to the VAR model specification. The VECM approach is only used when there is evidence of a long-term cointegration among the variables.

VECM is employed when, $0 < r < K$, here r is the level of cointegration and it should be higher than 0 and lower than K, the number of variables. If it is the case that $r = 0$, and $r = K$, there is no long-term relationship between variables, and it is not suitable to use VECM.

VAR model with p-lags as shown in following equation:

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

Here, Y_t is a vector with K variable, A is matrix parameters and εt is error vector. Because of the linear cointegration relationship, VAR model will change to the VECM model by having first difference:

$$\Delta y_t = \Pi y_{t-1} + \sum_{i=1}^{k} \Gamma_i \, \Delta y_{t-i} + \varepsilon_t$$

Here $\prod$ is matrix of adjustment coefficients size pr with value of $-(1_k - A_i - \cdots - A_p)$, which suggests how strong the correction mechanism works. And Γi is matrix coefficient of size pp with value of $(A_{i+1} + \cdots + A_p)$, $i = 1, \ldots, p - 1$. r is the number of linear combinations of y_t elements which is only affected by the shock transistor. ε_t is error correction vector.

To check if the time series' are cointegrated, Engle-Granger and Johansen cointegration test is examined. In a case of time series data consist of 2 I(1) components, it is advised to use Engle-Granger test for cointegration. Aside from Engle-Granger test, the Johansen test is possible to be applied on multidimensional case, more than two variables jointly. The test is based on an idea that variables are non-stationary and cointegrated. It estimates the number of cointegrating vectors. When working with multidimensional time series, it is possible for more than one cointegrating relationship to exist. In other words, if we have K variables, then it is possible to have up to K-1 cointegrating relationships.

3. Empirical Model

Data preparation

Based on literature review, we selected the following independent variables. Also, we added some variables, and we can classify them into 2 types, technical indicators, and fundamental indicators. Fundamental Indicator includes economic indicators related to United stated of America. Technical indicators include mathematical indicators related to S&P500 price. We chose Adjusted Close price as dependent variable and we used open, high, low prices of S&P500 for calculating volatility. We used 4 periods of pervious weekly data to estimate volatility, and 3 periods for monthly volatility. S&P500 index price and money supply M2, data was provided in a frequency of weekly and monthly. All the other variables were collected from website (https://research.stlouisfed.org/).

Table 1. Variables

Variable	Type		Desc
Dependent	-	SP500 Adj_Close weekly	S&P 500 index's adjusted close price of end of weekly
	-	SP500 Adj_Close Monthly	S&P 500 index's adjusted close price of end of monthly
Independent	Fundamental Indicators	UnEmp	Unemployment rate (%)
		CPI	Consumer price index
		IntRate	Federal Rate (%)
		M2SL	Monthly M2 (billions of dollars)
		WM2NS	Weekly M2 (billions of dollars)
		GDP	Gross Domestic Product (billions of dollars)
		Bond10	Long-Term Government Bond Yields: 10 years
		XAUUSD	Gold price
		INDPRO	Industrial Production: Total Index
		CIVPART	Labor Force Participation Rate (%)
	Technical Indicators	Volatility*	Volatility of S&P500 price
		Volume*	Total number of shares that have been bought or sold in specific period

* Due to non-stationarity technical variables are excluded from further analysis

Some indicators are monthly frequency, and some are weekly frequency. So, we had to convert them into fitting time frequency.

Table 2. Frequency convert

	Convert	How
UnEmp	Monthly to weekly	every week is same during a month
CPI	Monthly to weekly	every week is same during a month
IntRate	Daily to weekly/Monthly	median of days in every week or a month
GDP	Monthly to weekly	every week is same during a month
Bond10	Monthly to weekly	every week is same during a month
XAUUSD	Weekly to monthly	mean of weeks in month
INDPRO	Monthly to weekly	every week is same during month
CIVPART	Monthly to weekly	every week is same during month

Generally, our all variables are the same but different time frequency. So, the correlation of weekly and monthly are almost same. From following table, S&P500 price is strongly and positively correlation with M2, and GDP. But SP500 price is a strong negative correlation with Labor Force participating rate. One of our main goal is to determine the relation between S&P500 and M2. As you see, they are a positive correlation. But we must check this assumption using a more appropriate model.

Table 3. Weekly Correlation table

	Characteristics	1	2	3	4	5	6	7	8	9	10
1	Adj_Close	1									
2	WM2NS	0.95	1								
3	IntRate	-0.18	-0.4	1							
4	CPI	0.55	0.45	0.27	1						
5	UnEmp	-0.34	-0.13	-0.54	-0.52	1					
6	GDP	0.88	0.95	-0.38	0.37	-0.2	1				
7	Bond10	-0.56	-0.73	0.76	0.05	-0.27	-0.75	1			
8	XAUUSD	0.69	0.84	-0.58	0.18	0.23	0.85	-0.85	1		
9	INDPRO	0.58	0.55	0.03	0.39	-0.54	0.71	-0.37	0.48	1	
10	CIVPART	-0.78	-0.9	0.6	-0.18	-0.05	-0.9	0.87	-0.89	-0.56	1

Based on literature reviews, economic theories, and above correlation table, we expect following hypothesizes about how our chosen independent variables effect on S&P500 price. $r \neq 0$ so we have to estimate VECM.

Table 4. Research hypothesis

Variable	Description
M2SL/WM2N	+/- We expect to have positive correlation between M2 and stock price in long run and negative in shorter period.
IntRate	- We expect to have negative correlation
CPI	+ We expect to have positive correlation

UnEmp	- We expect to have negative correlation
GDP	+ We expect to have positive correlation
Bond10	- We expect to have negative correlation
XAUUSD	+ We expect to have positive correlation
INDPRO	+ We expect to have positive correlation
CIVPART	-/+ Expectation is unclear

VECM model in weekly:

1) ADF test:

The first step to take when we would like to estimate VECM, according to the methodology we need to check if the original time series variables are non-stationary, and their first differences are stationary. Stationarity can be tested Augmented Dickey Fuller unit root test. From ADF test, we expect that the p-value of the original variables are higher than 5%, indicating that the series are non-stationary, and the p-value of the first difference series was below 5% significance level, meaning the series is stationary. Below table shows, that all variables, except for the GDP variable, fulfill this requirement. Therefore, the GDP variable is not included in the further steps of weekly analysis.

Table 5. ADF test

	(-) - non stationary, (+) - stationary	
differences	0	1
Adj_Close	-	+
WM2NS	-	+
IntRate	-	+
CPI	-	+
UnEmp	-	+
GDP	+	+
Bond10	-	+
XAUUSD	-	+
INDPRO	-	+
COVPART	-	+

2) Optimal lag

Next step to consider when doing VECM analysis. We need to determine the optimal lag. We used VARselect() function to get optimal lag and we assume that the highest lag order is 7 and set the type to "trend", because we can clearly see that we have trend in our dependent variable. Test result show that, AIC and FPE values are smallest in the 6th lag, while HQ and SC values are smallest in 1st lag. But optimum lag must be at least 2. So, we chose $lag^* = 6$. And k = lag^*- 1 =5.

Table 6. Optimal lag critea

	1	2	3	4	5	6	7
AIC(n)	3.47	3.36	3.28	3.19	3.02	**2.95***	2.95
HQ(n)	**3.62***	3.66	3.72	3.77	3.75	3.81	3.96
SC(n)	**3.88***	4.15	4.44	4.72	4.93	5.23	5.61
FPE(n)	32.04	28.70	26.56	24.22	20.58	**19.09***	19.18

3) Johansen Cointegration Test

Next, in order to check if the variables are jointly cointegrated we use Johansen Cointegration test. Two types of Johansen test can be used and we used the type Eigen. When r is equal to 4, critical value is higher than the test statistic at the 5% level. It means that there are at least 4 cointegration relationship exists in our model. As mentioned above in the Methodology section, we have 8 time series variables in our model. So that we can have such number of cointegrating relationships.

Table 7. Cointegration

	test statistic	critical values		
		10%	5%	1%
r<=5	19	29.12	31.46	36.65
r<=4	**29.48***	34.75	37.52	42.36
r<=3	49.39	40.91	43.97	49.51
r<=2	71.44	46.32	49.42	54.71
r<=1	94.5	52.16	55.5	62.46
r=0	141.27	57.87	61.29	67.88

4) VECM estimation

Our weekly model fulfills initial requirements. Therefore, we can proceed with estimating VECM model. We have more than 1 cointegration relation in our model, so we use Maximum likelihood method.

Table 8. Cointegration vectors

		r1	r2	r3	r4
Cointegrating vector (estimated by ML):	Adj_Close	1.00	-0.00	0.00	-0.00
	WM2NS	-0.00	1.00	-0.00	0.00
	bond10	-0.00	-	1.00	-
	XAUUSD	-0.00	-0.00	0.00	1.00
	INDPRO	12.69	178.68	-0.04	-8.50
	UnEmp	86.64	-570.89	0.26	-198.55
	IntRate	77.60	-375.66	0.15	-60.44
	CPI	- 74.86	-1,482.54	-0.40	-190.15
	CIVPART	129.22	1,399.01	-0.70	346.96

Above table shows long term relationship of variables. We can't clearly see long term money supply effect on stock prices. All the variables except for CIVPART, labor force participation rate variable influences negatively in the long run.

Table 9. VECM output

	ECT1	ECT2	ECT3	ECT4
Adj_Close	0.0006	0.0009	5.7743	-0.0028
	(0.0069)	(0.0016)	(4.0720)	(0.0072)
WM2NS	0.0510	-0.0085	-22.7467	-0.0441
	(0.0076)***	(0.0018)***	(4.4738)***	(0.0079)***
bond10	3.8e-05	-9.7e-06	-0.0315	-3.0e-05
	(1.4e-05)**	(3.3e-06)**	(0.0082)***	(1.4e-05)*
XAUUSD	0.0009	-0.0002	0.9100	-0.0039
	(0.0036)	(0.0009)	(2.1198)	(0.0037)
INDPRO	0.0003	-6.8e-05	-0.0635	-0.0004
	(6.4e-05)***	(1.5e-05)***	(0.0379).	(6.7e-05)***
UnEmp	-0.0002	4.7e-05	0.0866	0.0003
	(3.6e-05)***	(8.5e-06)***	(0.0212)***	(3.7e-05)***
IntRate	-0.0001	2.6e-05	0.0553	-2.9e-05
	(1.8e-05)***	(4.2e-06)***	(0.0105)***	(1.8e-05)
CPI	5.6e-05	1.4e-05	0.0373	0.0001
	(5.1e-05)	(1.2e-05)	(0.0303)	(5.3e-05)**
CIVPART	2.4e-05	-6.9e-06	-0.0126	-6.3e-05
	(1.3e-05).	(3.1e-06)*	(0.0076).	(1.3e-05)***

Below table shows the short-term relation of stock price and other variables. In the short term, we can see that money supply has positve effect on stock prices. On weekly dataset bond yield and gold price variables has negative impact. In contrast, industrial production and Interest rate has positive impact.

Table 10. VECM output

	Lag 1	Lag 2	Lag 3	Lag 4	Lag 5
Adj_Close	-0.0725	0.0075	-0.0906	-0.0747	-0.1215
	(0.0317)*	(0.0322)	(0.0327)**	(0.0332)*	(0.0334)***
WM2NS	0.0098	0.0938	0.0625	0.0994	0.0233
	(0.0283)	(0.0280)***	(0.0289)*	(0.0284)***	(0.0292)
bond10	3.6579	24.6431	12.2766	-41.3298	-20.9815
	(15.6837)	(15.6020)	(15.4865)	(15.5854)**	(15.7529)
XAUUSD	0.0187	-0.1564	0.0965	-0.0369	-0.0142
	(0.0600)	(0.0600)**	(0.0604)	(0.0610)	(0.0611)
INDPRO	-0.4605	10.7975	-1.3514	-3.9848	11.2078
	(4.7255)	(4.7003)*	(4.6437)	(4.7370)	(4.7402)*
UnEmp	-3.8440	8.4467	-0.9843	-12.7842	8.9270
	(9.3202)	(9.16	(9.0124)	(9.0062)	(8.9166)
IntRate	34.2365	10.0971	6.6005	1.6809	6.3205
	(11.9612)**	(12.7147)	(12.8216)	(12.8090)	(12.1765)
CPI	-4.7730	0.5862	2.8021	1.8154	3.0565
	(4.3671)	(4.2256)	(4.1621)	(4.1914)	(4.2213)

CIVPART	38.7320 (21.5743).	0.5225 (21.1234)	17.3787 (21.1197)	-12.4167 (21.2266)	-30.7277 (21.3210)

5) Diagnostic Test:

- Autocorrelation

After VECM model, we have to check autocorrelation. You can see we have autocorrelation. Because pvalue is lower than 0.05. And we reject H0.

```
        Portmanteau Test (asymptotic)

data:  Residuals of VAR object Model1VAR
Chi-squared = 1635.3, df = 819, p-value < 2.2e-16
```

- Heteroscedastic

After VECM model, we have to check heterescedastic. You can see we have heterescedastic. Because pvalue is lower than 0.05. And we reject H0.

```
        ARCH (multivariate)

data:  Residuals of VAR object Model1VAR
Chi-squared = 32283, df = 24300, p-value < 2.2e-16
```

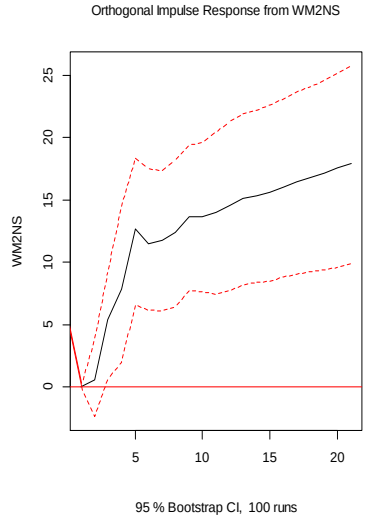
- Residual normality

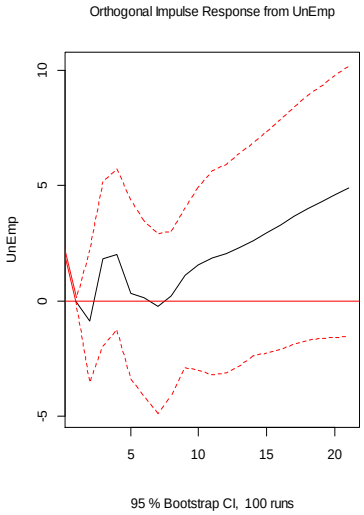
After VECM model, we have to check residual's normality. P value is lower than 0.05, we can reject H0. And residual is not normal distribution.

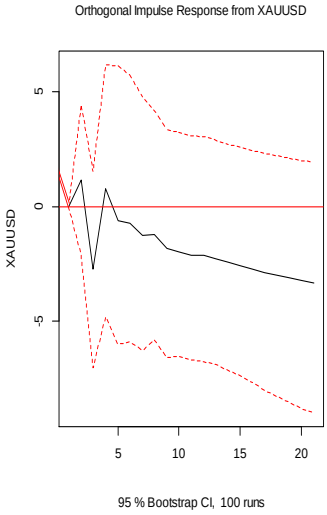
```
$JB

        JB-Test (multivariate)

data:  Residuals of VAR object Model1VAR
Chi-squared = 1100627, df = 18, p-value < 2.2e-16


$Skewness

        Skewness only (multivariate)

data:  Residuals of VAR object Model1VAR
Chi-squared = 9939.1, df = 9, p-value < 2.2e-16


$Kurtosis

        Kurtosis only (multivariate)

data:  Residuals of VAR object Model1VAR
Chi-squared = 1090688, df = 9, p-value < 2.2e-16
```

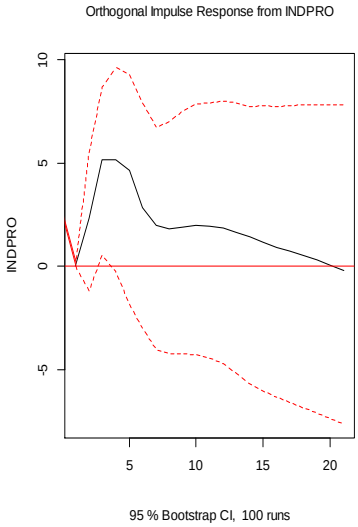
6) Impulse Response Function & Variance Decomposition

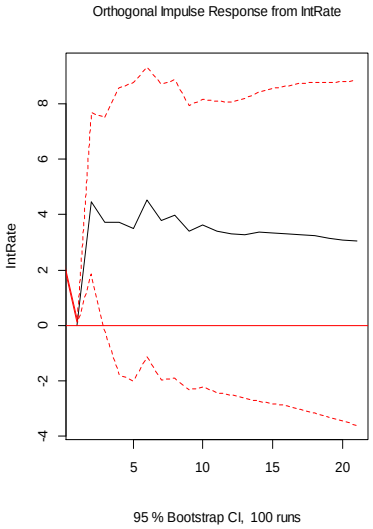
We can see following result from Impulse response function. M2's shock strongly affects on SP500 until 5 period and after that, shock's impact will decrease. Shock in unemployment rate affect slightly in shorter period. As time pass it will increase stock price. In contrast gold have negative impact on stock price. Industrial production and CIVPART increases stock price in short time and it's shock will gradually decrease. Interest rate shock increases the stock price and its effect kept longer. CPI's shock will effect strongly negative on stock price.

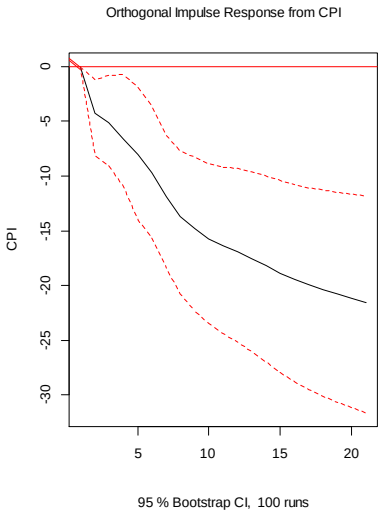

Orthogonal Impulse Response from WM2NS
WM2NS
95 % Bootstrap CI, 100 runs


Orthogonal Impulse Response from UnEmp
UnEmp
95 % Bootstrap CI, 100 runs


Orthogonal Impulse Response from XAUUSD
XAUUSD
95 % Bootstrap CI, 100 runs


Orthogonal Impulse Response from INDPRO
INDPRO
95 % Bootstrap CI, 100 runs


Orthogonal Impulse Response from IntRate
IntRate
95 % Bootstrap CI, 100 runs


Orthogonal Impulse Response from CPI
CPI
95 % Bootstrap CI, 100 runs

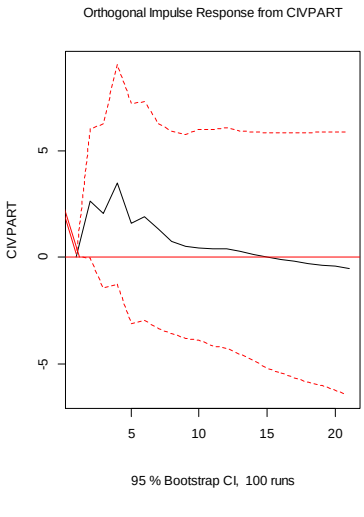
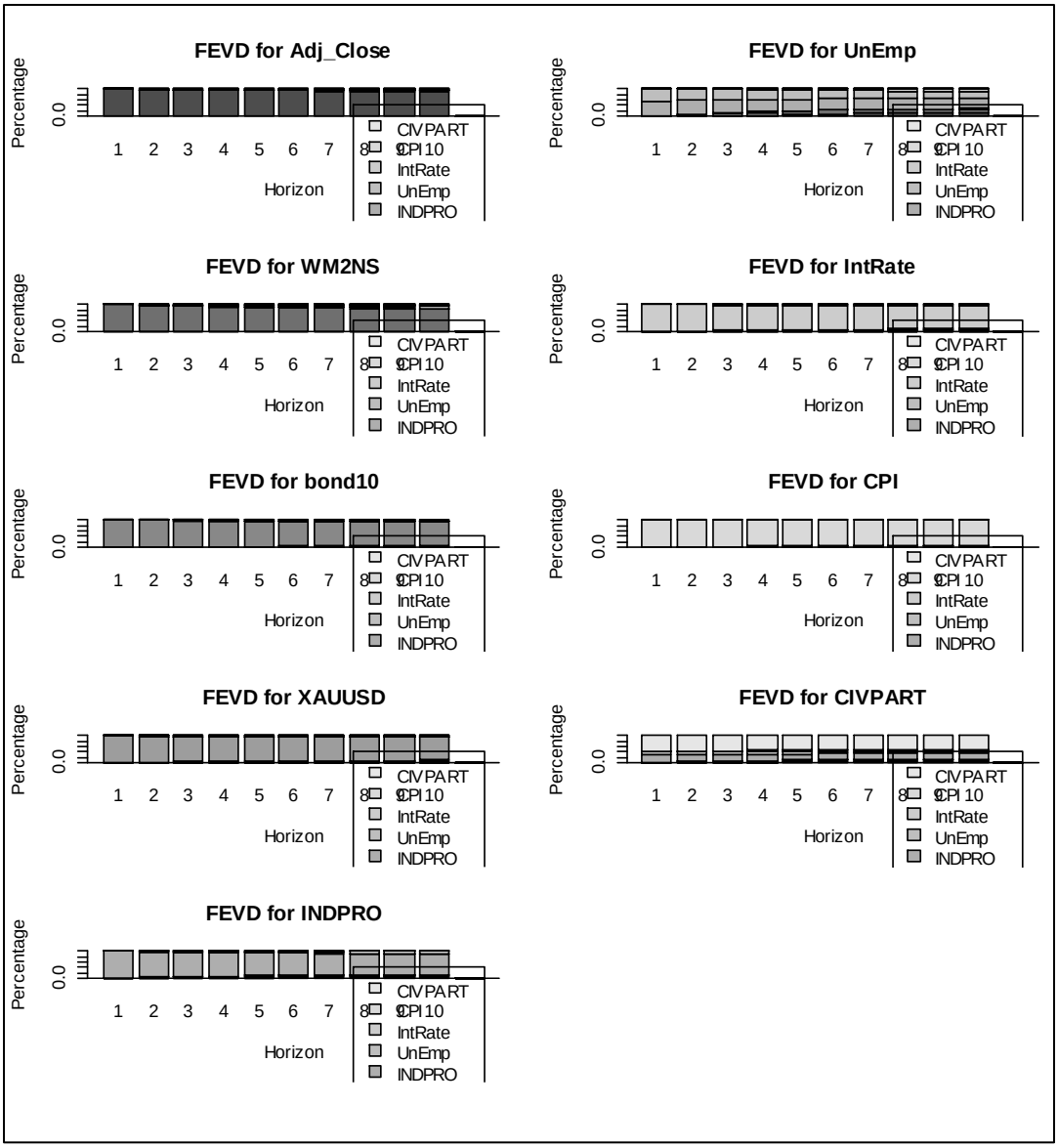
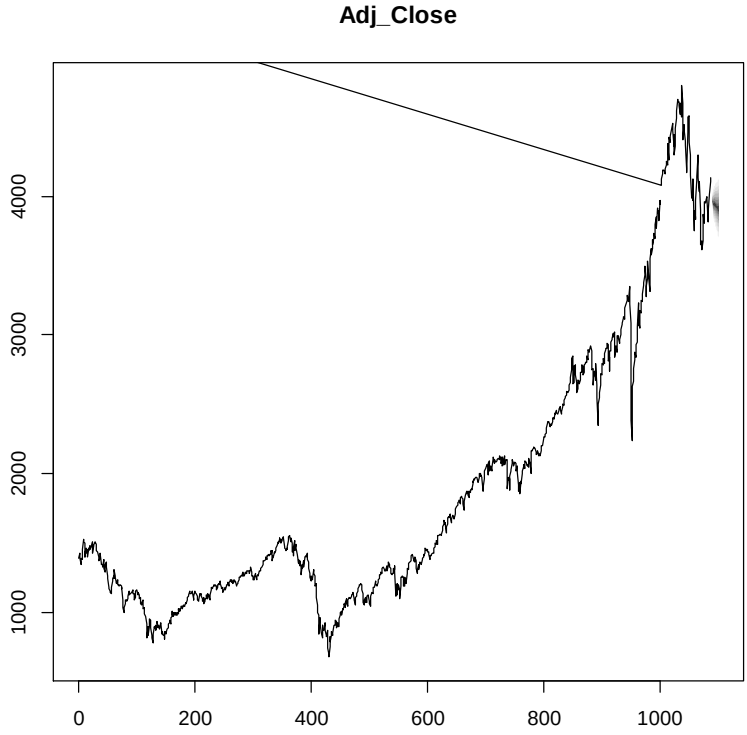

Orthogonal Impulse Response from CIVPART
CIVPART
95 % Bootstrap CI, 100 runs

Figure 1. Variance Decomposition



7) Forecasting

Now using above model, let's forecast next 3 month(a.head=12) of SP500 close price on 95 % confidence.



VECM model in monthly:

1) ADF test

Firstly, according to ADF test results, that all variables, including the GDP variable, fulfill non-stationarity in original and stationary in first difference.

Table 11. ADF test

	(-) - non stationary, (+) - stationary	
differences	0	1
Adj_Close	-	+
M2SL	-	+
IntRate	-	+
CPI	-	+
UnEmp	-	+
GDP	-	+
x10	-	+
XAUUSD	-	+
INDPRO	-	+
CIVPART	-	+

2) Optimal lag

Secondly, for optimal lag we assume that the highest lag order is 7 and also set the type to "trend". Test result show that, AIC and FPE values are smallest in the 7th lag, while HQ suggests 2nd and SC values are smallest in 1st lag. Since 7 lag was suggested by 2 criteria, we chose $lag^* = 7$. And k = lag^*-1 =6.

Table 12. Optimal lag criterea

	1	2	3	4	5	6	7	8	9	10	11	12
AIC(n)	20.87	19.53	19.48	19.52	19.59	19.46	**19.29***	19.39	19.49	19.43	19.38	19.53
HQ(n)	21.47	**20.67***	21.17	21.75	22.36	22.78	23.16	23.80	24.44	24.93	25.42	26.11
SC(n)	**22.36***	22.37	23.68	25.07	26.50	27.73	28.91	30.36	31.81	33.11	34.41	35.91
FPE(n)	1,161.4 M	303.19 M	291.66 M	306.76 M	337.55 M	308.62 M	**273.84 M***	322.52 M	390.45 M	414.25 M	453.58 M	630.71M

3) Johansen Cointegration Test

Then, to check if the variables are jointly cointegrated we use Johansen Cointegration test. We used the type Eigen type out of 2 types. Based on the Johansen test output in below table, we see that we have r=1, cointegrating relationship in out monthly model.

Table 13. Cointegration

	test	critical values		
	statistic	10%	5%	1%
r<=9	11	10.5	12.3	16.3
r<=8	14.4	16.9	19	23.7
r<=7	17.8	23.1	25.5	30.3
r<=6	18.1	29.1	31.5	36.7
r<=5	25.2	34.8	37.5	42.4
r<=4	50.6	40.9	44	49.5
r<=3	54	46.3	49.4	54.7
r<=2	56.2	52.2	55.5	62.5
r<=1	**61.1***	57.9	61.3	67.9
r=0	110	63.2	66.2	73.7

4) VECM estimation

Our monthly model also fulfills initial requirements. Therefore, we can proceed with estimating VECM model. Below table result support the Keynesian economic assumptions of negative impact of money supply on stock price in the long run. Furthermore, bond, Gold price, Industrial Production, and Interest Rate, LFP has negative impact on SP500 price in the long term. On the other hand, GDP, CPI, Unemployment has a positive impact on SP500 price in the long term.

Table 14. VECM output

		r1
Cointegrating vector (estimated by ML):	Adj_Close	1
	M2SL	-0.68812
	bond10	-204.893
	XAUUSD	-1.26808
	INDPRO	-103.078
	UnEmp	298.919
	IntRate	-115.36
	CPI	601.3712
	CIVPART	-271.15
	GDP	1.091024

As you see from following table, 0.6% changes in money supply will be corrected in 151 periods. However, it is insignificant. We can also see that 2% changes caused by gold price will be corrected in 50 periods. Unemployment rate and interest rate has also some effect but it's effect will be erased in very long periods.

Table 15. VECM output

	ECT
Adj_Close	-0.0306(0.0215)
M2SL	-0.0066(0.0127)
bond10	2.8e-05(4.9e-05)
XAUUSD	0.0200(0.0092)*
INDPRO	0.0004(0.0002)*
UnEmp	-0.0002(0.0001)
IntRate	0.0001(3.7e-05)***
CPI	-0.0004(0.0002)*
CIVPART	2.6e-06(4.4e-05)
GDP	-0.0261(0.0330)

Below result shows the shorter-term impacts of variables on S&P500 price index. It is suggested that money supply has a positive effect on stock prices in the short run. And interest rate has positive impact on stock price. More over LFP rate has short term negative effect on stock price. And lastly GDP has positive impact on S&P500 index.

Table 16. VECM output

	Lag 1	Lag 2	Lag 3	Lag 4	Lag 5	Lag 6
Adj_Close	-0.2644 (0.0723)**	-0.1100 (0.0796)	-0.0346 (0.0811)	-0.0197 (0.0825)	0.0712 (0.0841)	-0.2074 (0.0852)*
M2SL	0.2505 (0.1720)	**0.3190** (0.1848).	0.2119 (0.1811)	-0.0342 (0.1871)	-0.2238 (0.1951)	-0.2056 (0.1532)
bond10	8.3571 (33.8691)	-10.7460 (35.7786)	38.1518 (37.0691)	- 28.5981(35.4325	-33.0396 (34.6235	-25.8075 (32.4511)
XAUUSD	-0.1438 (0.1697)	-0.0669 (0.1781)	0.0524 (0.1805)	0.0886 (0.1774)	0.1718 (0.1683)	-0.0954 (0.1648)
INDPRO	4.6195 (10.8225)	-2.8840 (11.3285)	-6.0112 (11.0853)	-0.5266 (11.0652)	11.9726 (11.4237)	-39.2667 (11.2967)**

	11.1876	22.0067	-18.5306	2.6333	12.6932	-2.7519
UnEmp	(22.9374)	(25.2270)	(24.9248)	(23.8790)	(23.9072)	(21.6534)
	-6.4637	-36.9862	**101.8369**	19.6974	78.0088	-48.0195
IntRate	(43.0921)	(43.9517)	(45.2837)*	(45.8063)	(44.4911).	(44.6328)
	11.9396	13.2575	1.0436	-10.8505	-4.1469	-3.5961
CPI	(13.8101)	(13.8061)	(13.1572)	(12.2056)	(11.1748)	(9.2139)
	-77.8118	**-80.1390**	-36.1495	-27.1805	-40.8141	21.9627
CIVPART	(47.0912).	(47.1678).	(46.5433)	(46.9477)	(46.1343)	(43.6085)
	0.1020	**0.3156**	0.2071	0.0619	0.1063	0.1898
GDP	(0.0803)	(0.0908)***	(0.0886)*	(0.0882)	(0.0865)	(0.0782)*

5) Diagnostic Test

- Autocorrelation:

VECM model with monthly frequency data has autocorrelation.

```
        Portmanteau Test (asymptotic)

data:  Residuals of VAR object Model2
Chi-squared = 1635.3, df = 819, p-value < 2.2e-16
```

- Heteroscedastic

VECM model with monthly frequency data has heteroscedastic problem.

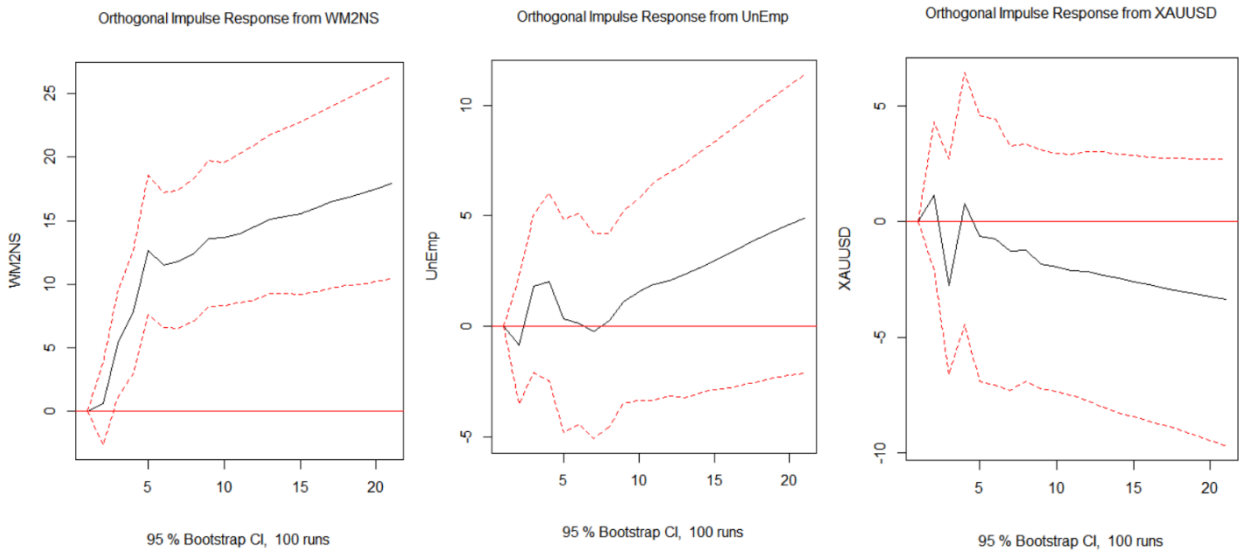
```
        ARCH (multivariate)

data:  Residuals of VAR object Model2
Chi-squared = 32283, df = 24300, p-value < 2.2e-16
```

- Residual normality

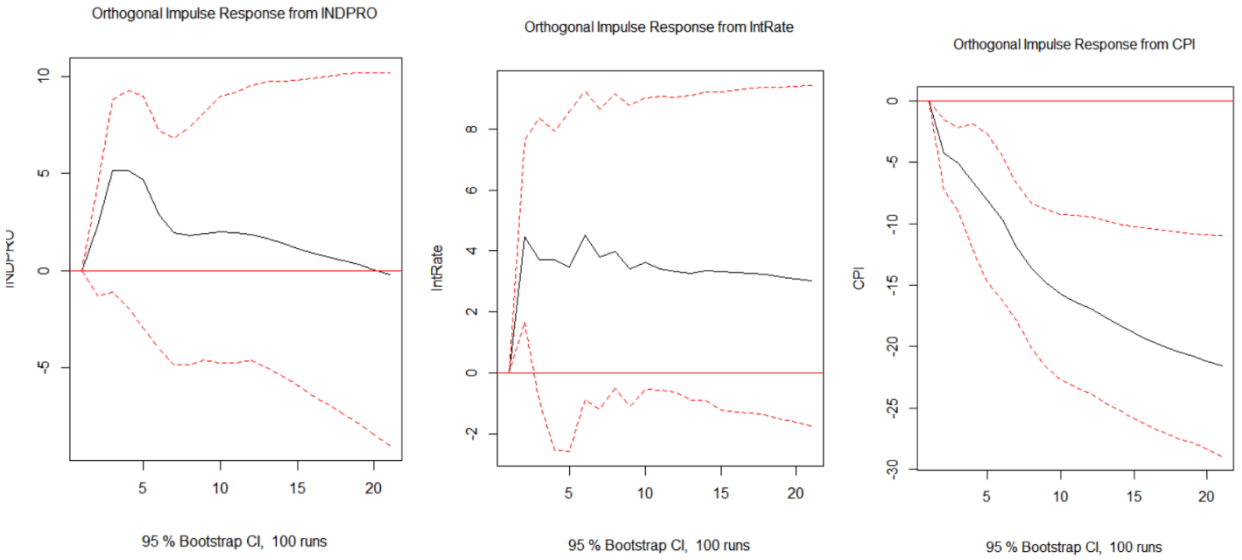
Residual of VECM model with monthly frequency data is not normal distribution.

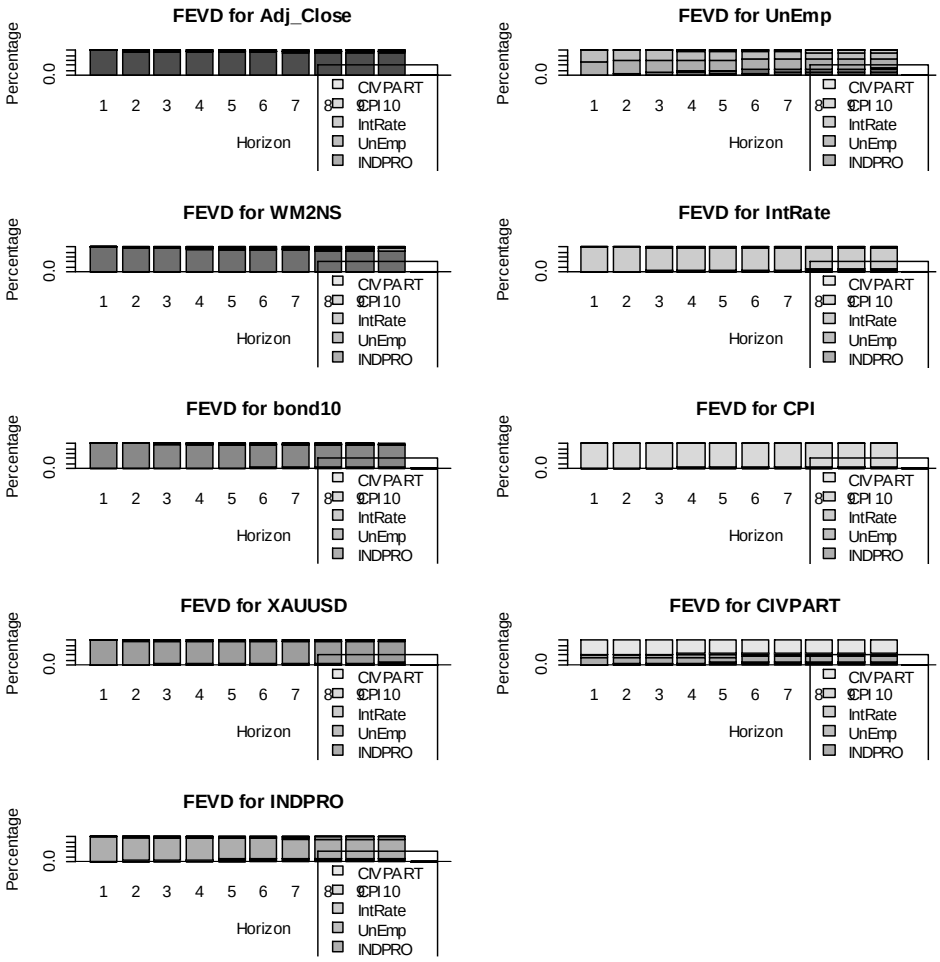
```
$JB

        JB-Test (multivariate)

data:  Residuals of VAR object Model2
Chi-squared = 1100627, df = 18, p-value < 2.2e-16


$Skewness

        Skewness only (multivariate)

data:  Residuals of VAR object Model2
Chi-squared = 9939.1, df = 9, p-value < 2.2e-16


$Kurtosis

        Kurtosis only (multivariate)

data:  Residuals of VAR object Model2
Chi-squared = 1090688, df = 9, p-value < 2.2e-16
```

6) Impulse Response Function



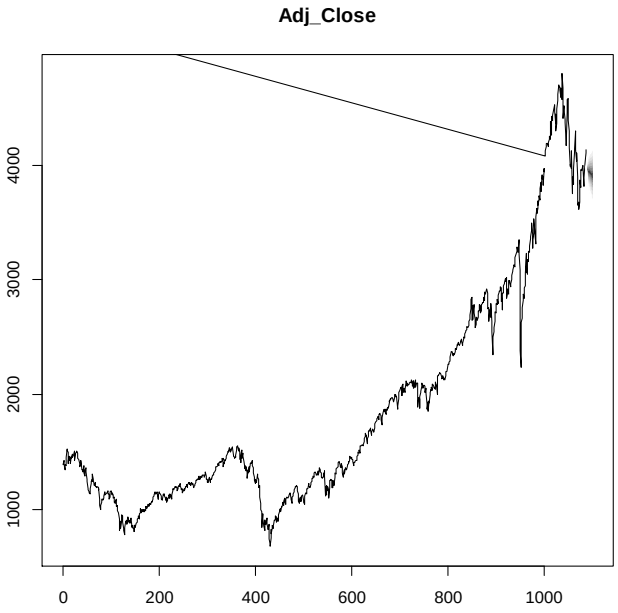
Impulse response output shows similar effect compared to weekly data.





7) Forecasting

Using above VECM model with monthly frequency forecastin SP500 price index's next 1 year



4. Conclusion

The relationship between money supply and stock prices is complex. We tried to estimate the VEC model to have an insight of how money supply and other macroeconomic indicators and technical variables could influence stock price, S&P500 in the both long and short term. We estimated the VECM on weekly and monthly frequency time series. VECM model expects to work on originally non-stationary time series. Due to some original data was stationary before first difference, we couldn't include some variables we want to get to know the impact on stock price. However, after removing some variables, both datasets fulfilled the initial assumptions required to analyze VECM model.

Diagnostic analysis of the VECM model in both weekly and monthly frequency shows that these models have underlying problems, such as autocorrelation and heteroskedasticity, and non normality residuals. So due to not fullfilling the diagnostic tests, we consider these models are not great. However, the results show us the insights of macroeconomic variables on stock prices.

For weekly variable, we could't clearly see effect from money supply and all the variables except for CIVPART, labor force participation rate variable, they influences negatively in the long run. In short-term, we observed that money supply has positve effect on stock prices. On weekly dataset bond yield and gold price variables has negative impact. In contrast, industrial production and Interest rate has positive impact.

Monthly VECM model results suggest that in the short run money supply has a positive correlation to stock prices. However, it impacts stock price negatively in the long run. Most of the variables except for CPI and GDP, were negatively impacting stock price in the long run. For shorter term, interest rate and GDP impacts stock price positively and CIVPART, labor force participation rate variable was impacting negatively.

We can conclude that money supply could be an important factor for explainint stock price changes in both long and shorter term. However, from our results we can say that monthly frequency model shows long term relation clearly. So that is better to use monthly data if one wants to predict for a longer period. And if one wants to do shorter period, we could recommend using weekly frequency.

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6. Appendix

Descriptive analysis

Table 17. Weekly

	DATE	WM2NS	Close	Adj_Close	Volume	IntRate	CPI
Min	2000.01.31	4634.70	676.53	676.53	439.67	0.04	-0.29
Max	2023.02.27	22052.30	4796.56	4796.56	8570.51	7.03	8.46
Mean		10581.24	1882.78	1882.78	3129.14	1.65	2.69
Media		9387.60	1433.37	1433.37	3226.37	1.02	2.46
Stdev		4723.15	974.67	974.67	1448.35	1.87	1.37

Table 18. Weekly continue

	UnEmp	GDP	Bond10	XAUUSD	INDPRO	CIVPART	Volatility
Min	3.40	12870.00	0.62	257.95	84.60	60.10	0.03
Max	14.70	20310.00	6.66	2031.69	104.12	67.30	0.61
Mean	5.86	16333.79	3.20	1051.59	96.82	64.37	0.12
Media	5.40	15940.00	2.98	1191.96	98.19	64.10	0.10
Stdev	1.95	2011.56	1.32	521.91	4.95	1.77	0.08

Table 19. Monthly

	Date	Close	Adj_Clos	Volume	M2NS	M2SL	CPI
Min	2000.03.01	735.09	735.09	19089.10	4732.30	4710.20	-0.29
Max	2023.02.01	4766.18	4766.18	162185.38	21855.90	21703.20	8.46
Mean		1894.42	1894.42	69573.55	10639.01	10639.42	2.72
Media		1433.67	1433.67	73315.47	9481.05	9517.95	2.47
Stdev		981.23	981.23	29454.40	4748.33	4749.06	1.40

Table 20. Monthly continue

	UnEmp	IntRate	GDP	Bond10	XAUUSD	INDPRO	CIVPART	volatility
Min	3.4	0.05	13000.00	0.62	261.11	84.60	60.10	0.28
Max	14.7	6.51	20310.00	6.44	1970.18	104.12	67.30	2.88
Mean	5.85	1.64	16358.99	3.19	1057.93	96.86	64.35	0.75
Media	5.4	1.00	15945.00	2.99	1199.03	98.20	64.10	0.61
Stdev	1.96	1.85	2010.04	1.30	521.92	4.93	1.77	0.44