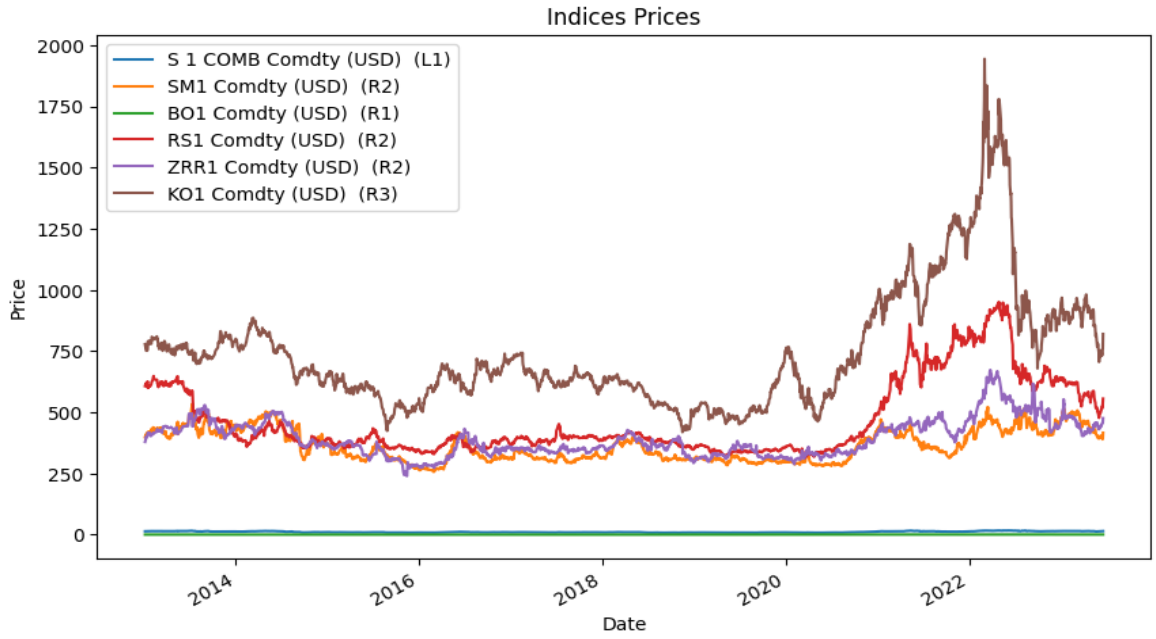
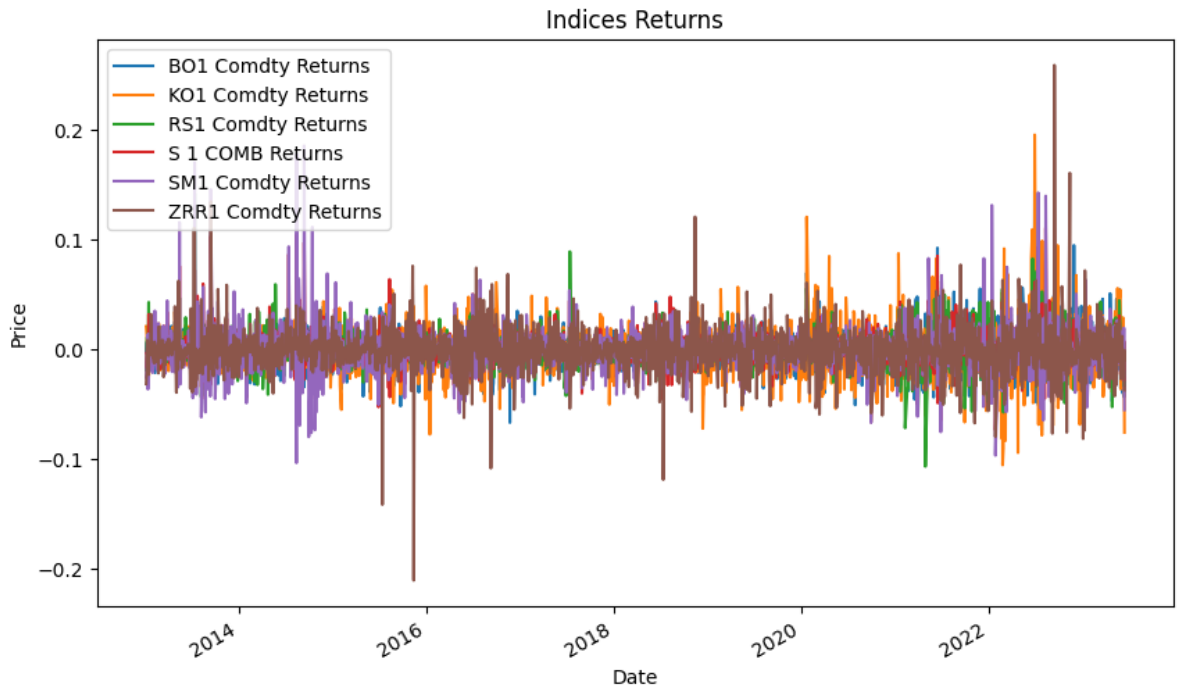
Work done in Data Processing

Given on sheet 2 were the prices of 8 indices, the first and foremost job was to clean the data and only consider those dates for which we have prices for all eight indices. We have prices for IJA Comdty (R2) and PKR1 Comdty (L2) from 6/16/2023 to 1/29/2021. So for analysis, I've not taken these two price indexes. The cleaned dataset of six commodity price indexes from 2023-06-16 to 2013-01-04 is here [Link].



The returns of all these six indexes can be found here[Link]



Further descriptive statistics of all the vegetable oil containing the following Obs. needs to be done.

- **Mean**
- **Maximum**
- **Minimum**
- **Standard deviation**
- **Skewness Kurtosis**
- **Jarque-Bera**
- **Q (5)**
- **Q (10)**
- **Q (20)**
- **ARCH (5)**
- **ARCH (10)**
- **ARCH (20)**
- **ADF**
- **P-P**

Also, the TVP-VAR analysis needs to be done with the external effects of the US Economic Policy Uncertainty Index, Dollar Index Spot Currency and Generic 1st 'CL.' Future Commodity

Descriptive statistics of the return of six commodity indexes.

	vars	n	mean	sd	median	trimmed	mad	min	max	range	skew	kurtosis	se
BO1 Comdty Returns	1	2288	0	0.02	0	0	0.01	-0.07	0.14	0.22	0.50	4.89	0
KO1 Comdty Returns	2	2288	0	0.02	0	0	0.02	-0.11	0.20	0.30	0.62	7.79	0
RS1 Comdty Returns	3	2288	0	0.01	0	0	0.01	-0.11	0.14	0.25	0.54	7.64	0
S 1 COMB Returns	4	2288	0	0.01	0	0	0.01	-0.07	0.11	0.18	1.06	7.41	0
SM1 Comdty Returns	5	2288	0	0.02	0	0	0.01	-0.10	0.19	0.29	1.63	15.70	0
ZRR1 Comdty Returns	6	2288	0	0.02	0	0	0.01	-0.21	0.26	0.47	0.74	27.12	0

The TVP-VAR analysis

```
Finished MCMC after 10.19 secs.
>
> # Print the model results
> print(tvp_var)
Bayesian VAR consisting of 2287 observations, 6 variables and 1 lags.
Time spent calculating: 10.19 secs
Hyperparameters: lambda
Hyperparameter values after optimisation: 3.84748
Iterations (burnt / thinning): 10000 (5000 / 1)
Accepted draws (rate): 5000 (1)
```

The analysis of US Economic Policy Uncertainty Index is [Link to Google Colab]

Summary of ARIMA(2,1,2) Model

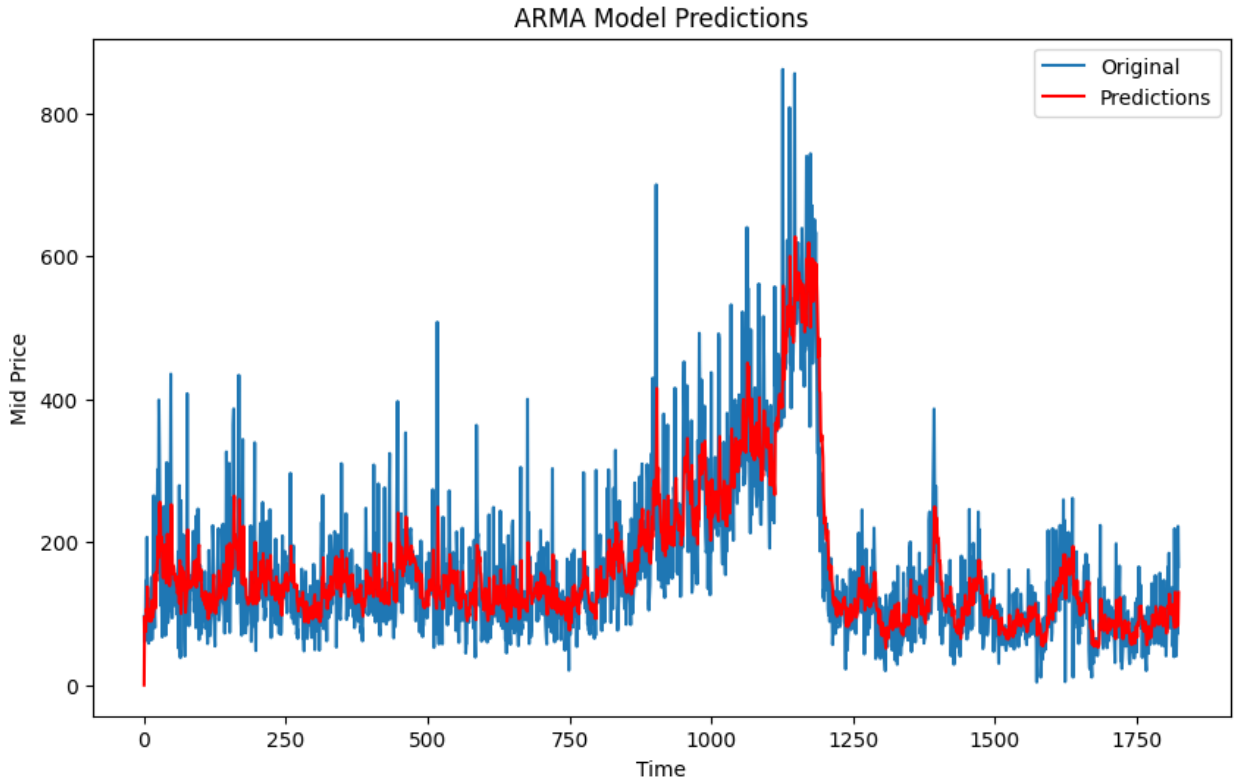
SARIMAX Results

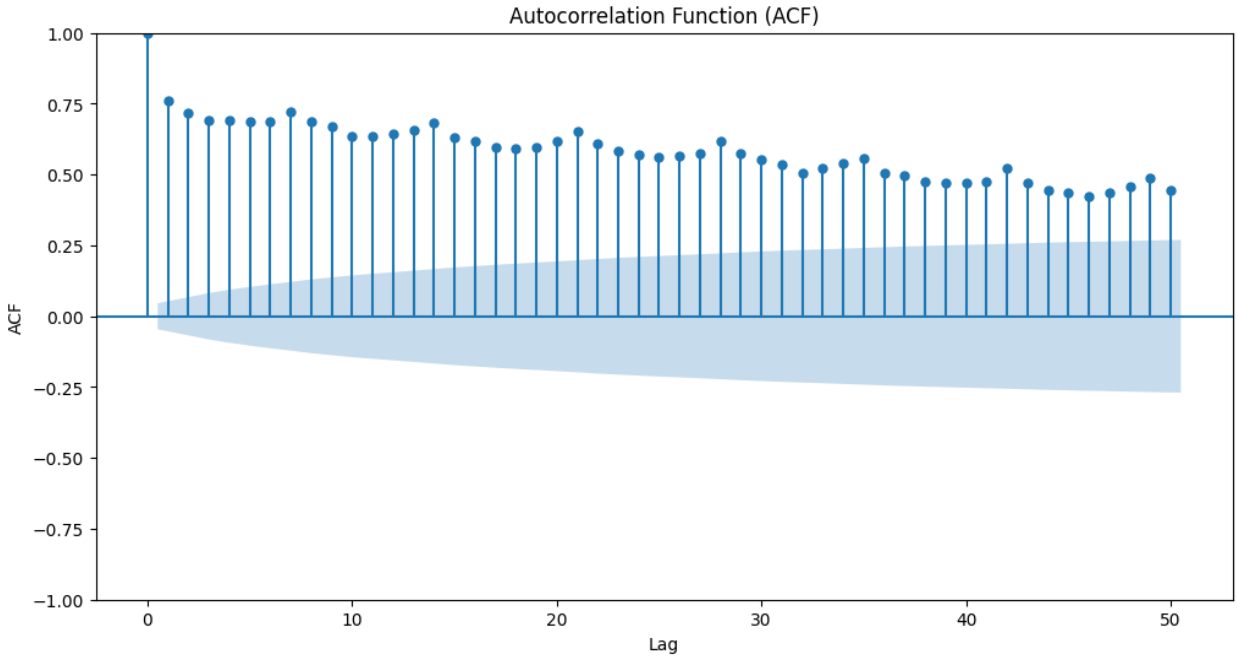
Dep. Variable:	Mid Price	No. Observations:	1825
Model:	ARIMA(2, 1, 2)	Log Likelihood	-10224.515
Date:	Sun, 25 Jun 2023	AIC	20459.030
Time:	12:38:36	BIC	20486.574
Sample:	0	HQIC	20469.191
	- 1825		
Covariance Type:	opg		

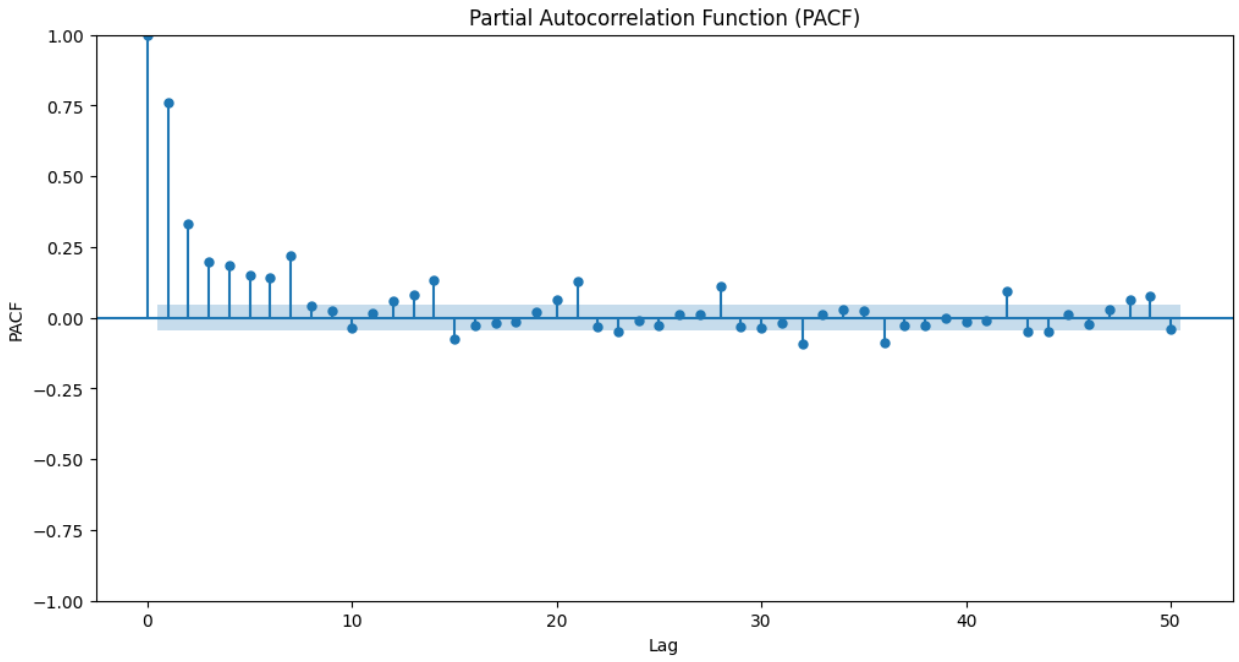
	coef	std err	z	P>|z|	[0.025	0.975]
ar.L1	-0.2603	0.593	-0.439	0.661	-1.423	0.903
ar.L2	0.1023	0.096	1.065	0.287	-0.086	0.290
ma.L1	-0.4196	0.595	-0.706	0.480	-1.585	0.746
ma.L2	-0.3706	0.503	-0.737	0.461	-1.356	0.615
sigma2	4327.4563	80.918	53.480	0.000	4168.861	4486.052

Ljung-Box (L1) (Q):	0.01	Jarque-Bera (JB):	1953.49
Prob(Q):	0.94	Prob(JB):	0.00
Heteroskedasticity (H):	0.45	Skew:	1.16
Prob(H) (two-sided):	0.00	Kurtosis:	7.51

Warnings:
[1] Covariance matrix calculated using the outer product of gradients (complex-step).


ARMA Model Predictions
Original
Predictions
Mid Price
Time
0
200
400
600
800
0
250
500
750
1000
1250
1500
1750


Autocorrelation Function (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



ADF Statistics

ADF Statistic: -2.7129590059669355
p-value: 0.07182251516198512
Critical Values:
1%: -3.4339840952648695
5%: -2.8631452508003057
10%: -2.567624583142913

Based on the ADF test results, we do not have sufficient evidence to conclude that the time series is stationary. The data may exhibit some degree of non-stationarity. However, the results are not definitive, and further analysis or exploration of the data may be necessary to determine its stationarity.

On Applying the Moving Average Smoothing technique, the new ADF Statistics we get are:

ADF Statistic: -2.9056001212886695
p-value: 0.044700644401516075
Critical Values:
1%: -3.434002362895342
5%: -2.863153315036348
10%: -2.5676288771043367

Now the series is stationary.

Later using the AIC criterion to get the best-fitting model, we get the following table

	(p, d, q)	AIC
0	(7, 1, 7)	20287.032907
1	(7, 1, 5)	20295.519637
2	(7, 1, 6)	20295.774217
3	(6, 1, 5)	20297.747802
4	(4, 1, 5)	20311.139954
...	...	...
59	(4, 1, 0)	20576.307078
60	(3, 1, 0)	20627.737892
61	(2, 1, 0)	20711.444622
62	(1, 1, 0)	20819.961076
63	(0, 1, 0)	21156.712295

64 rows × 2 columns

Therefore, this suggests are ARIMA model with an AR(7) process and a MA(7) process.

Now, we can print a summary of the best model, which an ARIMA (7,1,7).

```
                               SARIMAX Results
==============================================================================
Dep. Variable:              Mid Price   No. Observations:                 1825
Model:                 ARIMA(7, 1, 7)   Log Likelihood              -10128.516
Date:                Sun, 25 Jun 2023   AIC                         20287.033
Time:                        12:42:38   BIC                         20369.665
Sample:                             0   HQIC                        20317.515
                                 - 1825
Covariance Type:                  opg
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
ar.L1         -0.6162      0.128     -4.827      0.000      -0.866      -0.366
ar.L2         -0.5855      0.126     -4.654      0.000      -0.832      -0.339
ar.L3         -0.8299      0.048    -17.291      0.000      -0.924      -0.736
ar.L4         -0.7639      0.086     -8.898      0.000      -0.932      -0.596
ar.L5         -0.5464      0.139     -3.944      0.000      -0.818      -0.275
ar.L6         -0.6966      0.092     -7.578      0.000      -0.877      -0.516
ar.L7          0.1236      0.036      3.431      0.001       0.053       0.194
ma.L1         -0.0776      0.125     -0.621      0.535      -0.323       0.168
ma.L2          0.0672      0.096      0.697      0.486      -0.122       0.256
ma.L3          0.3732      0.083      4.520      0.000       0.211       0.535
ma.L4          0.1693      0.098      1.721      0.085      -0.023       0.362
ma.L5         -0.0945      0.111     -0.855      0.393      -0.311       0.122
ma.L6          0.2253      0.086      2.628      0.009       0.057       0.393
ma.L7         -0.5778      0.081     -7.139      0.000      -0.736      -0.419
sigma2      4036.7515     91.244     44.241      0.000    3857.916    4215.586
===================================================================================
Ljung-Box (L1) (Q):                   0.03   Jarque-Bera (JB):              1687.57
Prob(Q):                              0.87   Prob(JB):                         0.00
Heteroskedasticity (H):               0.44   Skew:                             1.01
Prob(H) (two-sided):                  0.00   Kurtosis:                         7.26
```

The analysis of Dollar Index Spot Currency [Link to Google Colab]

Summary of ARIMA(2,1,2) model

SARIMAX Results

Dep. Variable:	Mid Price	No. Observations:	1825
Model:	ARIMA(7, 1, 7)	Log Likelihood	-10128.516
Date:	Sun, 25 Jun 2023	AIC	20287.033
Time:	12:42:38	BIC	20369.665
Sample:	0	HQIC	20317.515
	- 1825		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
ar.L1	-0.6162	0.128	-4.827	0.000	-0.866	-0.366
ar.L2	-0.5855	0.126	-4.654	0.000	-0.832	-0.339
ar.L3	-0.8299	0.048	-17.291	0.000	-0.924	-0.736
ar.L4	-0.7639	0.086	-8.898	0.000	-0.932	-0.596
ar.L5	-0.5464	0.139	-3.944	0.000	-0.818	-0.275
ar.L6	-0.6966	0.092	-7.578	0.000	-0.877	-0.516
ar.L7	0.1236	0.036	3.431	0.001	0.053	0.194
ma.L1	-0.0776	0.125	-0.621	0.535	-0.323	0.168
ma.L2	0.0672	0.096	0.697	0.486	-0.122	0.256
ma.L3	0.3732	0.083	4.520	0.000	0.211	0.535
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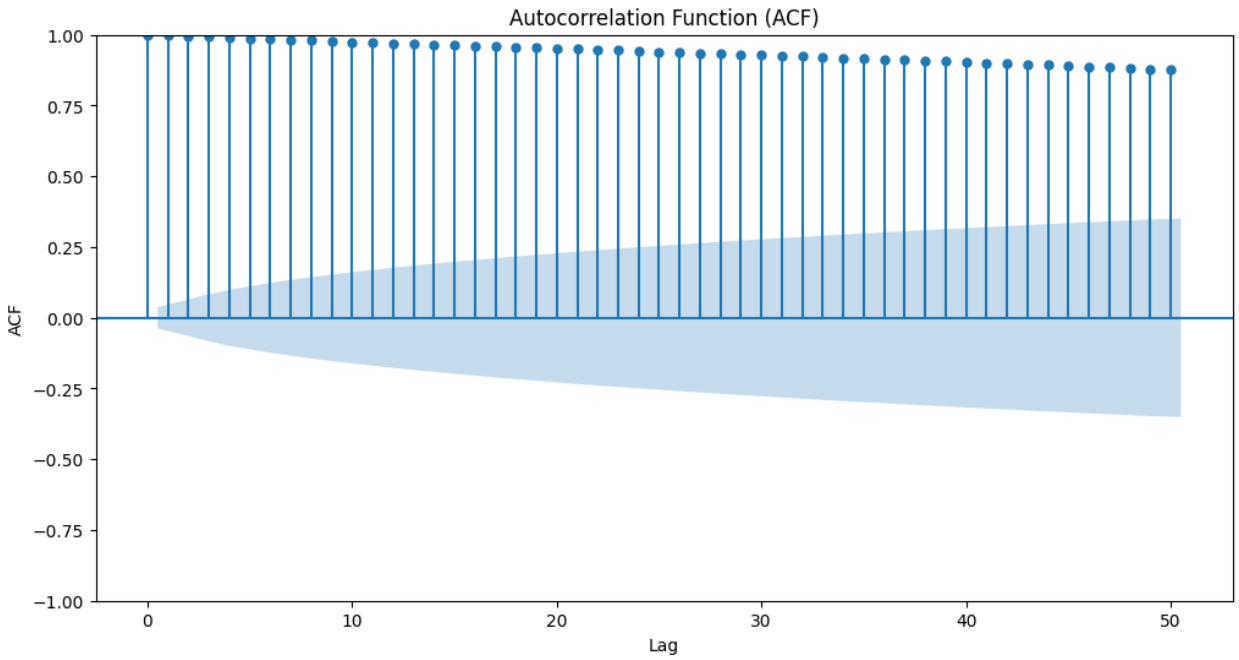
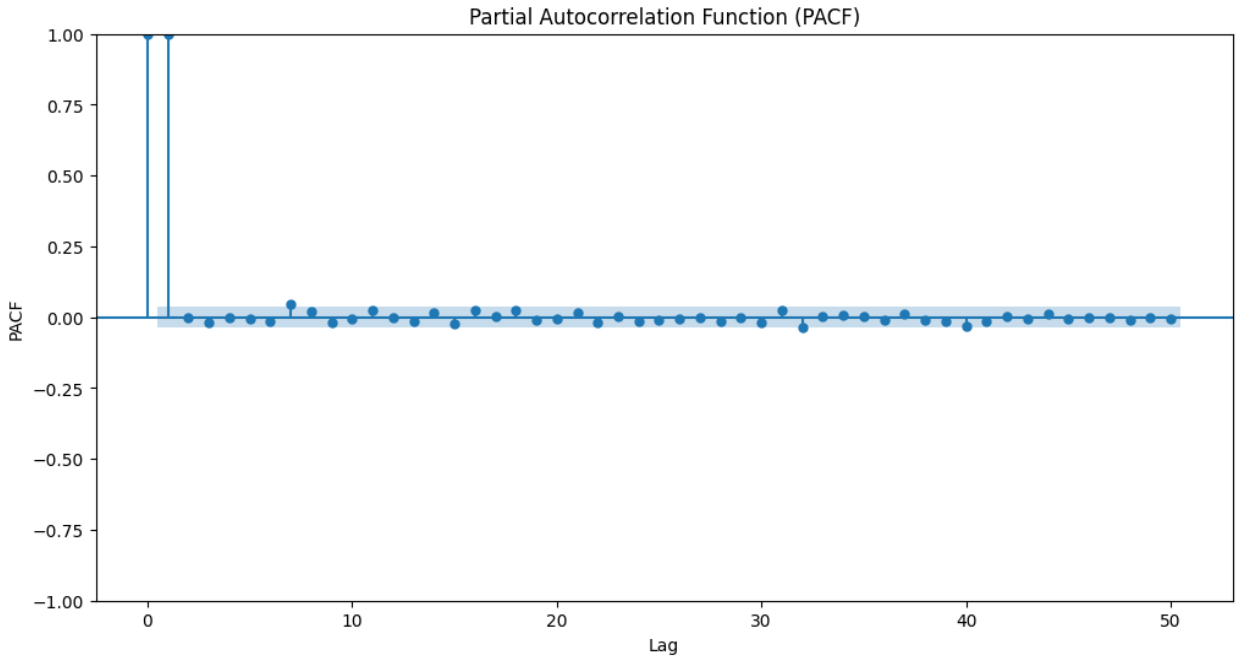
ma.L5	-0.0945	0.111	-0.855	0.393	-0.311	0.122
ma.L6	0.2253	0.086	2.628	0.009	0.057	0.393
ma.L7	-0.5778	0.081	-7.139	0.000	-0.736	-0.419
sigma2	4036.7515	91.244	44.241	0.000	3857.916	4215.586

Ljung-Box (L1) (Q):	0.03	Jarque-Bera (JB):	1687.57
Prob(Q):	0.87	Prob(JB):	0.00
Heteroskedasticity (H):	0.44	Skew:	1.01
Prob(H) (two-sided):	0.00	Kurtosis:	7.26





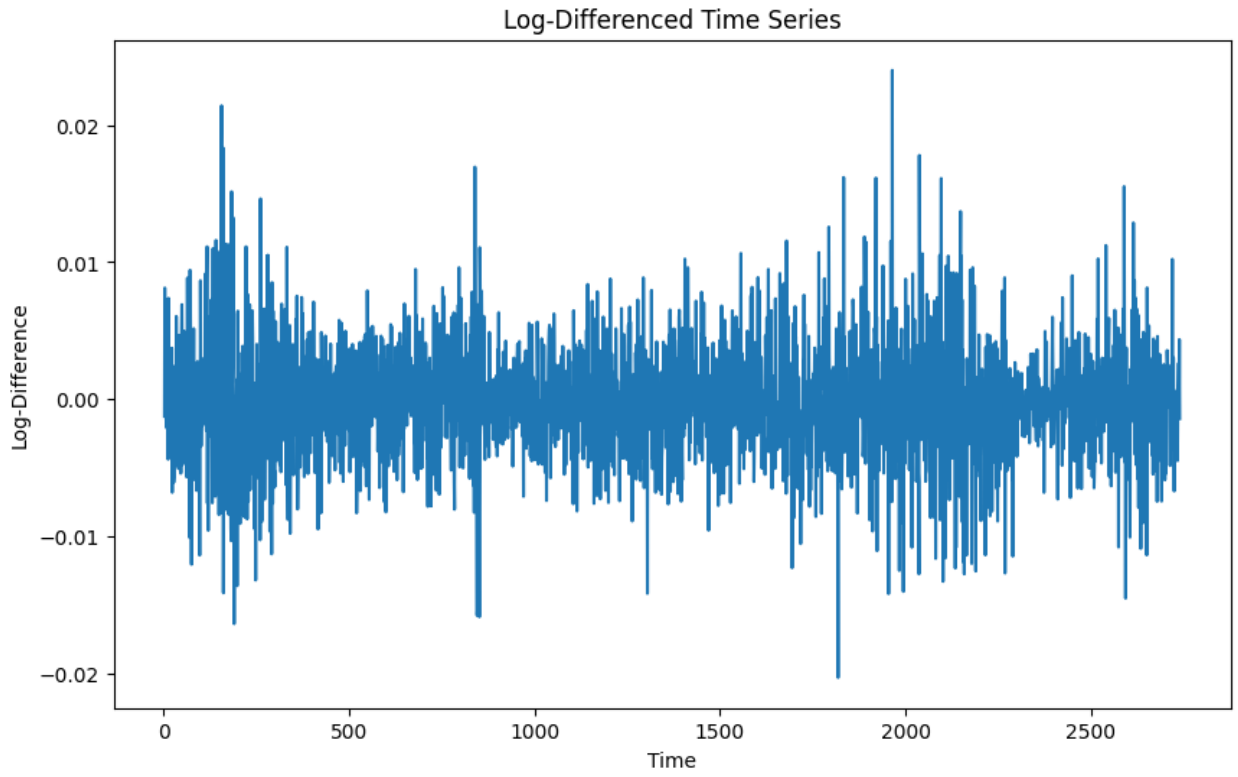
The ADF Statistics of the given time series

ADF Statistic: -1.0493752063996695
p-value: 0.7348328267904379
Critical Values:
1%: -3.43274059216515
5%: -2.8625961912802333

10%: -2.567332244679086

The critical values at different significance levels (1%, 5%, and 10%) are provided for comparison with the ADF statistic. If the ADF statistic is more negative (smaller in magnitude) than these critical values, it provides stronger evidence in favor of stationarity. In this case, the ADF statistic does not exceed the critical values significantly. Based on these results, we can infer that the time series is likely non-stationary and may contain a unit root. Further analysis or transformation may be required to achieve stationarity in the data.

Applying log difference for stationarity
ADF Statistic: -21.24440353107157
p-value: 0.0
Critical Values:
1%: -3.4327467254180486
5%: -2.8625988999327463
10%: -2.567333686767106



Since this dataset was small, AIC criterion was not applied.

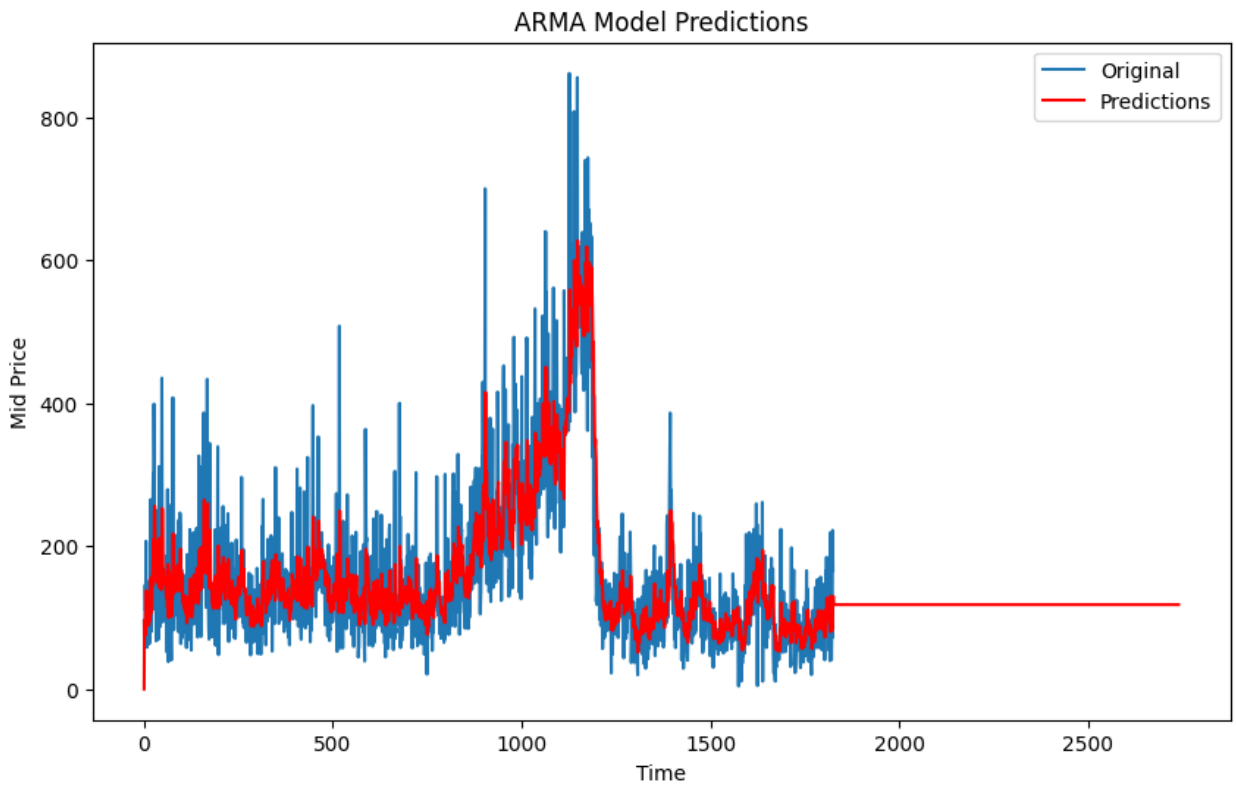
The analysis of Generic 1st 'CL' Futures [Link to Google Colab]
Summary of ARIMA(2,1,2) Model

SARIMAX Results

Dep. Variable:	Mid Price	No. Observations:	1825
Model:	ARIMA(7, 1, 7)	Log Likelihood	-10128.516
Date:	Sun, 25 Jun 2023	AIC	20287.033
Time:	12:42:38	BIC	20369.665
Sample:	0	HQIC	20317.515
	- 1825		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
ar.L1	-0.6162	0.128	-4.827	0.000	-0.866	-0.366
ar.L2	-0.5855	0.126	-4.654	0.000	-0.832	-0.339
ar.L3	-0.8299	0.048	-17.291	0.000	-0.924	-0.736
ar.L4	-0.7639	0.086	-8.898	0.000	-0.932	-0.596
ar.L5	-0.5464	0.139	-3.944	0.000	-0.818	-0.275
ar.L6	-0.6966	0.092	-7.578	0.000	-0.877	-0.516
ar.L7	0.1236	0.036	3.431	0.001	0.053	0.194
ma.L1	-0.0776	0.125	-0.621	0.535	-0.323	0.168
ma.L2	0.0672	0.096	0.697	0.486	-0.122	0.256
ma.L3	0.3732	0.083	4.520	0.000	0.211	0.535
ma.L4	0.1693	0.098	1.721	0.085	-0.023	0.362
ma.L5	-0.0945	0.111	-0.855	0.393	-0.311	0.122
ma.L6	0.2253	0.086	2.628	0.009	0.057	0.393
ma.L7	-0.5778	0.081	-7.139	0.000	-0.736	-0.419
sigma2	4036.7515	91.244	44.241	0.000	3857.916	4215.586

Ljung-Box (L1) (Q):	0.03	Jarque-Bera (JB):	1687.57
Prob(Q):	0.87	Prob(JB):	0.00
Heteroskedasticity (H):	0.44	Skew:	1.01
Prob(H) (two-sided):	0.00	Kurtosis:	7.26



The ADF Statistics of the time series:
ADF Statistic: -3.113222352376439
p-value: 0.025590024112739685
Critical Values:
1%: -3.432764423688327
5%: -2.8626067160580204
10%: -2.567337848081528

In summary, based on the ADF test results, we can conclude that the time series is likely stationary. This implies that the series does not exhibit a unit root and has a stable mean and covariance structure, making it suitable for certain time series analysis techniques and modeling approaches.

Applying AIC criterion to find the best model, we get

	(p, d, q)	AIC
0	(2, 1, 5)	11325.908264
1	(1, 1, 1)	11329.617687
2	(0, 1, 3)	11330.406411
3	(0, 1, 2)	11330.435204
4	(2, 1, 1)	11330.668329
...	...	...
59	(4, 1, 7)	11345.860219
60	(1, 1, 0)	11347.079730
61	(5, 1, 7)	11347.837227
62	(7, 1, 5)	11347.844436
63	(0, 1, 0)	11467.309902

64 rows × 2 columns

Once the function is done running, you should see that the order associated with the lowest AIC is (2,1,5). Therefore, this suggests are ARIMA model with an AR(2) process and a MA(5) process.

Now, we can print a summary of the best model, which an ARIMA (2,1,5).

SARIMAX Results

Dep. Variable:	Mid Price	No. Observations:	2740
Model:	ARIMA(2, 1, 5)	Log Likelihood	-10221.620
Date:	Tue, 27 Jun 2023	AIC	20459.241
Time:	12:09:06	BIC	20506.563
Sample:	0	HQIC	20476.341
	- 2740		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
ar.L1	-0.4305	0.390	-1.105	0.269	-1.194	0.333
ar.L2	0.3023	0.408	0.741	0.459	-0.498	1.102
ma.L1	-0.2469	0.391	-0.631	0.528	-1.014	0.520
ma.L2	-0.6972	0.292	-2.386	0.017	-1.270	-0.124
ma.L3	0.0974	0.311	0.313	0.754	-0.512	0.706
ma.L4	0.0064	0.055	0.116	0.908	-0.102	0.115
ma.L5	0.0607	0.023	2.619	0.009	0.015	0.106
sigma2	4318.2955	81.730	52.836	0.000	4158.109	4478.482

Ljung-Box (L1) (Q):	0.00	Jarque-Bera (JB):	8617.48
Prob(Q):	0.97	Prob(JB):	0.00
Heteroskedasticity (H):	0.00	Skew:	1.40
Prob(H) (two-sided):	0.00	Kurtosis:	11.23