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COMMODITY FUTURES:

WHAT DRIVES ASSET PRICES?

CAUSALITY AND COINTEGRATION

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1 Introduction

This paper aims to investigate the causal relationships and long-term equilibrium dynamics among a set of commodity futures through the lens of cointegration analysis and Granger causality testing.

2 Literature Review

Studies have shown that many economic time series follow a stochastic process and can be classified as non-stationary. The methods for the analysis of regression models and hypothesis tests require the use of stationary time series. If this requirement is ignored and non-stationary time series are used, there is a risk of spurious regressions (Winker, 2017, pp. 268-269). A common method for testing the null hypothesis of non-stationarity is the Augmented Dickey-Fuller unit root test (Winker, 2017, pp. 273-275; Acikalin & Basci, 2016, p. 569).

To avoid the difficulties resulting from spurious correlations, non-stationary time series can be differenced to make them stationary. A disadvantage of the analysis of differences is that information about long term dependencies get lost (Gerhards, 1994, p. 73).

It is often of interest to determine whether there are certain dependencies between non-stationary time series (Gerhards, 1994, p. 73). Cointegration occurs when two or more non-stationary variables exhibit a common long-term trend and do not drift away from each other (Kirchgässner, Wolters, & Hassler, 2023, p. 209). The time series therefore develop in parallel in the long term and the difference between the two time series remains the same over time, although both time series individually have a trend (Gerhards, 1994, p. 74).

The Granger Causality Test is used to find out whether a Time Series can help to predict another Time Series. It states that a variable X is Granger-causal for Y if, for a given amount of information up to time t-1, variable Y can be predicted better at time t than without the inclusion of variable X. The Granger causality test can apply in one direction or in both directions. The Times Series must also be stationary for Granger Causality (Granger, 1969, pp. 431-436)

This means that in case of non-stationary data, as described above, the time series must first be differentiated.

3 Methodology

For the analysis, 20 different commodity futures are analyzed and tested for causality and cointegration. As reference of the commodity futures, the first generic commodity future will be used. The analysis will be done mainly by using Python and SQL is used as support. The raw data for this is obtained from Refinitiv. For an additional control of the data, the data will be pulled via Excel on the one hand and directly via Python API interface on the other hand. Afterwards, the data has to be cleaned due to missing values. Then an SQL database is created for further processing. In this way, the data can be processed more easily and efficiently.

The first step of the main analysis is to test the stationarity of all time series in level and first difference. Thereafter, each asset is tested against each other for cointegration and granger causality. Both analyses are performed in Python using a loop to test all possible combinations. The respective results are saved and added to this work as a table.

4 Data and Sources

4.1 Data Retrieval

The data used in this paper is obtained from Refinitiv and covers a period of ten years, from 02.05.2013 to 01.05.2023. We focus on analyzing the daily closing prices of the 1st generic commodity futures for twenty different instruments.

```
(   Instrument                                     Instrument Description
 0        CLc1  NYMEX Light Sweet Crude Oil (WTI) Electronic Energy Future Continuation 1
 1         Cc1                                 CBoT Corn Composite Commodity Future
 2        GCc1                      COMEX Gold Composite Commodity Future Continuation 1
 3        LCc1                CME Live Cattle Electronic Commodity Future Continuation 1
 4        NGc1        NYMEX Henry Hub Natural Gas Electronic Energy Future Continuation 1
 5        OJc1           ICE-US FCOJ-A Futures Electronic Commodity Future Continuation 1
 6        PAc1              NYMEX Palladium Electronic Commodity Future Continuation 1
 7        PLc1               NYMEX Platinum Electronic Commodity Future Continuation 1
 8        SIc1                               COMEX Silver Composite Commodity Future
 9         Wc1                     CBoT Wheat Composite Commodity Future Continuation 1
 10       SOYc1       Johannesburg Stock Exchange Soybean Commodity Future Continuation 1
 11        HGc1                    COMEX Copper Composite Commodity Future Continuation 1
 12       SFSc1    ICE-US Sugar No. 16 Futures Electronic Commodity Future Continuation 1
 13       LCCc1                ICE Europe London Cocoa Commodity Future Continuation 1
 14       LCOc1                        ICE Europe Brent Crude Electronic Energy Future
 15        RBc1              NYMEX RBOB Gasoline Electronic Energy Future Continuation 1
 16        HOc1             NYMEX NY Harbor ULSD Electronic Energy Future Continuation 1
 17       SAFc1                          SHFE Aluminium Commodity Future Continuation 1
 18       SZNc1                               SHFE Zinc Commodity Future Continuation 1
 19       CUUc1    NYMEX Chicago Ethanol (Platts) Electronic Energy Future Continuation 1,
 None)
```

Figure 1: Selected Instruments

To gather the data, two methods were employed: the Formula Builder in the Excel Add-in and the Eikon API. Both approaches utilized the same parameters, including the asset keys, daily intervals, and the "CLOSE" field for the specified time horizon as defined above.

During the comparison of the two datasets, we observed that the data obtained through the Eikon API did not contain any NaN values as those dates were excluded. For that reason, we dropped the NaN values in the excel data to enable comparability. By employing the method .info() in pandas we identified that the data format in the two data differs in some asset classes. However, by utilizing the method .describe() in pandas, we confirmed that the values were identical (see Appendix 1).

4.2 Verifying and Cleaning of Data

4.2.1 Missing Data

In the data cleaning process, we initially examined the samples (plots see Appendix 2) and observed a significant number of days with more than 50% missing values, which coincided with public holidays in the USA. Additionally, we identified missing values for assets traded in Shanghai due to public holidays in China. Consequently, we proceeded by excluding these data points. As a result of the cleaning process, the initial sample, consisting of 2601 trading days, was reduced to 2357 trading days for each asset.

Furthermore, we encountered additional randomly missing dates across certain asset classes. To address this issue, we applied the method .ffill() in pandas. This method allowed us to replace the NaN values in each selected row with the values from the previous row, ensuring a consistent and continuous dataset.

4.2.2 Outliers

To identify and address outliers, we employed a methodology that involved calculating the moving average and standard deviation for each asset class. Any data points that fell outside a certain threshold were identified as outliers. Subsequently, these outliers were replaced with the corresponding moving average value, effectively smoothing the data and reducing the impact of extreme values. The plots of clean data are found in the Appendix 3.

4.3 Description of Data

4.3.1 Subsamples

After cleaning the data, we divided the set into five subsamples, each representing a two-year interval. To gain insights into the data distribution within each subsample, we employed the method .describe() to generate descriptive statistics.

Price 1st generic Commodity Future		Full Sample 013-05-02 - 2023-05-02				2013-05-02 - 2015-05-01	2015-05-02 - 2017-05-01	2017-05-02 - 2019-05-01	2019-05-02 - 2021-05-01	2021-05-02 - 2023-05-02
		Mean	Std.	Min	Max	Mean	Mean	Mean	Mean	
CLc1	NYMEX Light Sweet Crude Oil (WTI) Electronic Energy Future Continuation 1	64,81	22,27	10,01	123,70	88,34	46,38	58,69	48,63	84,05
Cc1	CBoT Corn Composite Commodity Future	439,04	121,19	301,50	818,25	445,37	364,51	364,28	404,94	653,24
GCc1	COMEX Gold Composite Commodity Future Continuation 1	1431,65	258,81	1050,80	2051,50	1275,75	1206,63	1273,13	1663,46	1820,55
LCc1	CME Live Cattle Electronic Commodity Future Continuation 1	126,09	17,35	84,80	171,00	144,01	126,60	117,12	109,08	139,96
NGc1	NYMEX Henry Hub Natural Gas Electronic Energy Future Continuation 1	3,41	1,42	1,55	9,68	3,84	2,64	3,01	2,31	5,11
OJc1	ICE-US FCOJ-A Futures Electronic Commodity Future Continuation 1	140,46	27,49	91,25	232,85	140,98	155,36	142,79	109,39	171,25
PAc1	NYMEX Palladium Electronic Commodity Future Continuation 1	1309,27	681,94	469,90	2979,90	773,89	650,81	1051,34	2029,60	2083,85
PLc1	NYMEX Platinum Electronic Commodity Future Continuation 1	1036,86	200,31	595,90	1543,60	1369,81	988,77	891,75	931,57	997,70
SIc1	COMEX Silver Composite Commodity Future	18,88	3,67	11,74	29,40	19,42	16,55	15,98	20,20	22,96
Wc1	CBoT Wheat Composite Commodity Future Continuation 1	573,94	151,27	361,00	1425,25	601,72	457,32	473,52	550,26	811,49
SOYc1	Johannesburg Stock Exchange Soybean Commodity Future Continuation 1	6233,50	1557,62	4145,00	11113,00	5468,11	6049,08	4638,26	6871,59	8643,40
HGc1	COMEX Copper Composite Commodity Future Continuation 1	3,05	0,67	1,94	4,93	3,09	2,34	2,90	2,95	4,14
SFSc1	ICE-US Sugar No. 16 Futures Electronic Commodity Future Continuation 1	27,49	4,39	18,48	38,62	22,89	27,05	26,04	27,21	36,05
LCCc1	ICE Europe London Cocoa Commodity Future Continuation 1	1821,37	233,42	1326,00	2577,00	1835,32	2097,31	1615,22	1793,24	1812,44
LCOc1	ICE Europe Brent Crude Electronic Energy Future	69,67	23,38	19,33	127,98	95,31	49,01	64,95	53,08	88,16
RBc1	NYMEX RBOB Gasoline Electronic Energy Future Continuation 1	1,97	0,64	0,41	4,28	2,53	1,51	1,79	1,48	2,65
HOc1	NYMEX NY Harbor ULSD Electronic Energy Future Continuation 1	2,10	0,75	0,61	5,14	2,69	1,48	1,94	1,56	2,98
SAFc1	SHFE Aluminium Commodity Future Continuation 1	14829,72	2723,04	9825,00	24330,00	13747,36	12386,82	14394,23	14518,16	19745,88
SZNc1	SHFE Zinc Commodity Future Continuation 1	19680,96	3990,79	12275,00	28690,00	15539,48	16914,90	23457,48	19054,90	23979,61
CUUc1	NYMEX Chicago Ethanol (Platts) Electronic Energy Future Continuation 1	1,76	0,49	0,83	3,45	2,10	1,52	1,39	1,42	2,47
# of data points		2282				**472**	**471**	**475**	**472**	**467**

Scale Std. LOWEST HIGHEST **Scale Rows** LOWEST HIGHEST

Figure 2: Descriptive Statistics of Subsamples

Following the analysis, the data was exported to Excel and consolidated, as depicted in Table 2 above.

This table provides information on the number of observations, mean, standard deviation, minimum, and maximum price for each asset throughout the entire period. Additionally, it presents the average market price of each asset during different time periods. The standard deviations of each asset within the entire sample were visualized using a colour scale, ranging from green (indicating the lowest standard deviation) to red (representing the highest standard deviation). Additionally, the means of each asset in every subsample were also color-coded, with lighter shades denoting lower prices and darker shades indicating higher prices.

It becomes evident that the commodities Soybean, Aluminium and Zinc show the highest standard deviation in the full sample. This might result from lower volumes in this asset classes. Furthermore, once can notice that the prices in the last subsample are almost without exception the highest. From May 2015 till May 2019 the prices were usually the lowest. This downward pressure on commodity prices might be connected to several factors such as oversupply, reduced demand from emerging economies, and a stronger US Dollar.

4.3.2 Stationarity

Variables of economic time series are often non-stationary, they follow a trend and have cycles. A method to make variables of time series stationary is a first difference change.

We analyzed whether the time series are stationary or not. In a first step, we plotted the cleaned data (see appendix 2). At first glance, it seems that the time series have a unit root. Afterwards, we performed the Augmented Dickey-Fuller (ADF) test with a null and alternative hypothesis to test if the time series are stationary:

H_0: Nonstationary time series

H_1: Stationary time series

The null hypothesis can be rejected if the p-value is less than α. We use a 95% confidence interval, which means that the alpha is 5%. We tested stationary of commodity futures on both level and first differences, using up to 2 lags.

The ADF tests computed with one and two lags at price level show in both cases high p-values over 20% (see appendix 4). The null hypothesis can't be rejected. Therefore, it can be assumed that the time series have a unit root at price level.

The ADF test computed with one and two lags at first differences (absolute returns) show in both cases p-values of 0% (see appendix 4) The null hypothesis can be rejected. It can be assumed that the time series at first differences are stationary.

4.3.3 Normality Test

Normality tests check if a dataset follows a normal distribution and calculate the probability of the underlying random variable being normally distributed.

To tests if the data is normal distributed we are using to different types of normality test:

- Visual method – Box Plots
- Visual method - Histogram
- Statistical method – Shapiro-Wilk test

4.3.3.1 Box Plots

The shape of a box plot can indicate whether a statistical dataset is normally distributed or skewed. If the median is positioned in the middle of the box and the whiskers are approximately equal on both sides of the box, it indicates a symmetric distribution.

In the table below 6 examples are shown, the others can be seen in the appendix 5. In most cases a non-symmetrical distribution can be recognized. In the case of LCc1, for example, one would have to look more closely. For this reason, another visual method will be used in the next chapter.

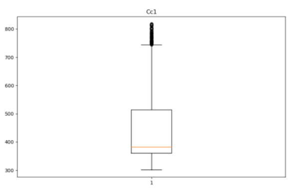
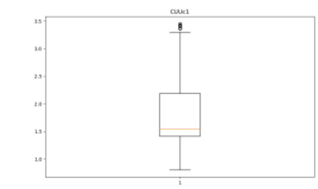
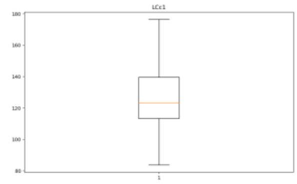
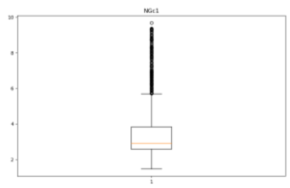
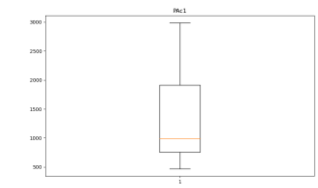
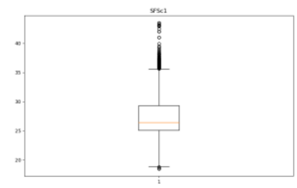
Cc1 	CUUc1 	LCc1 
NGc1 	PAc1 	SFSc1  i

Figure 3: Box Plots

4.3.3.2 Histogram

The histogram is used to represent frequency distributions for statistical data. In a normal distribution, the distribution is Bell-shaped.

We again created a histogram for all assets and manually checked for a normal distribution. All histograms have been archived in the appendix 6. As in the previous chapter, most of the time series can be classified as not normally distributed. This time one can also guess at LCCc1 that it is not normally distributed. But to be sure, we apply a statistical method for the control.

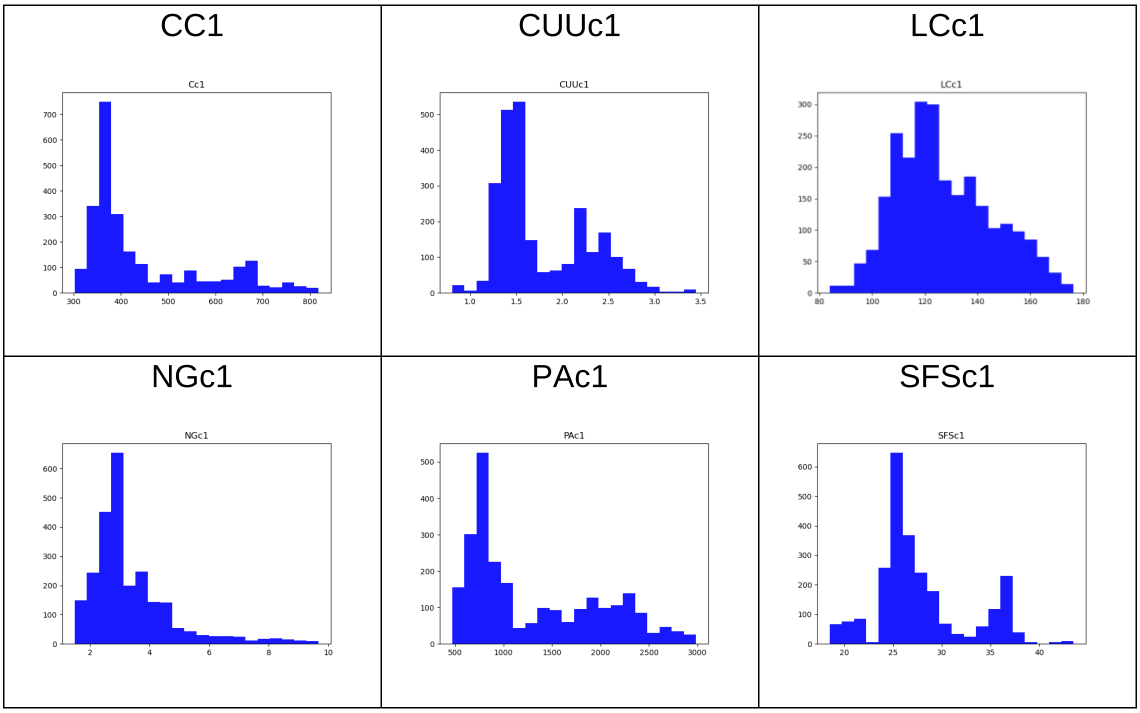


Figure 4: Histogram

4.3.3.3 Shapiro-Wilk Test

The Shapiro-Wilk test is a statistical Method for checking if Data is normal distributed. This is being done by testing the zero hypothesis that data is normally distributed.

For the Shapiro-Wilk test, we formulate following two hypotheses:

H_0: The sample comes from a normal distribution

H_1: The sample is not coming from a normal distribution

To test the hypothesis, we use a 95% confidence interval, which means that the alpha is 5%.

The Shapiro-Wilk test confirms our finding from the Box Plots and the Histograms as all p-values are smaller than 5%. Therefore, the zero hypothesis can be rejected, meaning that data is not normal distributed.

This was to be expected since stock market prices are usually not normally distributed. Performance figures are excluded from this statement.

4.4 Database Setup

As a database allows simple handling and a clear structuring of the data, the clean data is loaded into a database in SQLite. We established a connection between Python and SQLite and created a table named ASSET_PRICES using a timestamp as the primary key and the different asset classes as columns with data type FLOAT. Afterwards we imported the data exported by Refinitiv via Excel into the SQL database.

	mytimestamp	CLc1	Cc1	GCc1	LCc1	NGc1	OJc1	PAc1	PLc1	SIc1	Wc1	SOYc1	HGc1	SFSc1	LCCc1	LCOc1	RBc1	HOc1	SAFc1	SZNc1	CUUc1
	Filtern	Filtern	Filtern	Filtern	Filtern	Filtern	Filtern	Filtern	Filtern	Filtern	Filtern	Filtern	Filtern	Filtern	Filtern	Filtern	Filtern	Filtern	Filtern	Filtern	Filtern
1	2013-05-02 00:00:00	93.99	697.5	1467.7	123.65	4.025	145.05	692.2	1500.7	23.79	718.75	4900.0	3.1045	19.67	1565.0	102.85	2.7806	2.8555	14430.0	14290.0	2.6029
2	2013-05-03 00:00:00	95.61	699.5	1464.3	121.825	4.041	146.95	692.2	1501.7	23.975	711.25	4900.0	3.3135	19.25	1563.0	104.19	2.8254	2.8844	14450.0	14325.0	2.6471
3	2013-05-06 00:00:00	96.16	678.75	1468.1	121.3	4.011	143.45	696.0	1508.2	23.918	693.0	4900.0	3.31	19.63	1563.0	105.46	2.8657	2.9202	14530.0	14550.0	2.5978
4	2013-05-07 00:00:00	95.62	676.5	1449.0	120.825	3.92	141.6	679.5	1481.7	23.771	699.5	4900.0	3.3005	19.8	1563.0	104.4	2.8334	2.9277	14525.0	14565.0	2.6222
5	2013-05-08 00:00:00	96.62	675.0	1473.9	120.2	3.978	147.35	697.15	1505.4	23.892	696.75	4900.0	3.371	19.58	1556.0	104.34	2.8538	2.9147	14525.0	14560.0	2.6462
6	2013-05-09 00:00:00	96.39	694.5	1468.8	120.55	3.983	147.8	713.65	1516.5	23.879	716.25	4900.0	3.3415	19.5	1554.0	104.47	2.8851	2.9366	14540.0	14565.0	2.6625
7	2013-05-10 00:00:00	96.04	687.75	1436.8	120.45	3.91	148.2	704.6	1486.0	23.632	696.75	4900.0	3.356	19.49	1541.0	103.91	2.8603	2.9062	14545.0	14515.0	2.6593
8	2013-05-13 00:00:00	95.17	718.0	1434.5	120.575	3.925	148.15	717.95	1484.5	23.67	701.5	4900.0	3.362	19.55	1580.0	102.82	2.821	2.891	14535.0	14525.0	2.6908
9	2013-05-14 00:00:00	94.21	706.75	1424.7	120.775	4.024	148.65	726.4	1501.9	23.355	701.5	4900.0	3.2905	19.58	1597.0	102.6	2.8376	2.873	14525.0	14490.0	2.6787
10	2013-05-15 00:00:00	94.3	650.75	1396.5	120.0	4.07	146.45	728.3	1490.7	22.643	693.75	4900.0	3.267	19.55	1569.0	103.68	2.867	2.8801	14525.0	14400.0	2.6698
11	2013-05-16 00:00:00	95.16	641.5	1387.1	119.9	3.932	144.3	740.0	1485.6	22.643	687.75	4900.0	3.292	19.6	1529.0	103.8	2.8822	2.9087	14520.0	14320.0	2.6662
12	2013-05-17 00:00:00	96.02	652.75	1364.9	119.4	4.055	142.0	739.5	1468.0	22.339	683.25	4900.0	3.321	19.42	1549.0	104.64	2.9069	2.937	14550.0	14365.0	2.6714
13	2013-05-20 00:00:00	96.71	649.5	1384.3	120.125	4.09	143.8	750.0	1484.6	22.568	685.25	4900.0	3.357	19.45	1538.0	104.8	2.9056	2.9508	14555.0	14325.0	2.6675
14	2013-05-21 00:00:00	96.16	640.0	1377.8	121.1	4.192	143.05	747.7	1458.4	22.442	680.5	4900.0	3.339	19.45	1569.0	103.91	2.8458	2.929	14585.0	14415.0	2.6645
15	2013-05-22 00:00:00	94.28	658.5	1367.6	120.0	4.186	146.0	751.75	1469.2	22.458	688.5	4900.0	3.3775	19.41	1562.0	102.6	2.8194	2.8736	14630.0	14475.0	2.6696
16	2013-05-23 00:00:00	94.25	662.0	1392.0	119.125	4.261	148.4	738.25	1457.2	22.494	703.25	4900.0	3.2995	19.58	1537.0	102.44	2.8281	2.86	14645.0	14405.0	2.6696
17	2013-05-24 00:00:00	94.15	657.25	1386.8	120.575	4.237	147.3	726.05	1451.9	22.482	697.5	4900.0	3.2915	19.5	1522.0	102.64	2.839	2.8569	14655.0	14490.0	2.656
18	2013-05-28 00:00:00	95.01	666.5	1379.1	120.75	4.174	148.8	756.8	1460.6	22.18	693.75	4900.0	3.3115	19.5	1503.0	104.23	2.8528	2.9066	14645.0	14475.0	2.6627
19	2013-05-29 00:00:00	93.13	665.0	1391.3	121.375	4.148	153.6	747.75	1451.8	22.445	702.75	4900.0	3.291	19.5	1504.0	102.43	2.8031	2.8695	14675.0	14515.0	2.6702
20	2013-05-30 00:00:00	93.61	654.25	1411.5	120.35	4.023	153.75	758.0	1481.5	22.674	698.75	4900.0	3.3105	19.55	1500.0	102.19	2.8125	2.8431	14690.0	14585.0	2.672
21	2013-05-31 00:00:00	91.97	662.0	1392.6	121.3	3.984	151.35	751.05	1460.6	22.228	705.5	5200.0	3.289	19.38	1491.0	100.39	2.7792	2.7923	14780.0	14715.0	2.672
22	2013-06-03 00:00:00	93.45	655.75	1411.7	120.725	3.991	150.65	756.8	1496.2	22.715	708.75	5200.0	3.327	19.14	1507.0	102.06	2.7851	2.8334	14820.0	14770.0	2.6533
23	2013-06-04 00:00:00	93.31	660.5	1397.1	120.95	3.998	153.05	748.85	1489.9	22.4	709.0	5200.0	3.365	19.25	1528.0	103.24	2.8182	2.8649	14790.0	14780.0	2.6561
24	2013-06-05 00:00:00	93.74	660.75	1398.4	120.25	4.001	150.5	754.3	1509.4	22.465	701.5	5200.0	3.367	19.15	1552.0	103.04	2.823	2.8554	14865.0	14805.0	2.6443

1 - 23 von 2520 Springe zu: 1

Figure 5: SQLite database

After the analysis, we uploaded the results of the cointegration and causality tests into new tables – RESULTS_COINTEGRATION_1, RESULTS_COINTEGRATION_2 and RESULTS_CAUSALITY – in the same database (see appendix 9)

5 Analysis of Cointegration & Causality

5.1 Cointegration

The commodity futures at price level could be classified as nonstationary using the ADF test. To find out whether two commodity futures time series share a common long-run trend, have a long-run equilibrium and do not drift away from each other, they were tested for cointegration with a confidence interval of 95% and an alpha level of 5%:

H_0: No Cointegration

H_1: Cointegration

The test for cointegration was performed with one and two lags. The matrix with the calculated P-values as well as the visualizations can be found in appendix 7. The commodity future pairs with a P-value of less than 5% are highlighted in green. Using a lag of 1, 63 of the 380 null hypotheses could be rejected. Therefore, with an alpha level of 5%, 63 commodity future pairs can be assumed to be cointegrated. The test with a lag of 2 showed similar results and 62 commodity future pairs could be assumed to be cointegrated.

5.2 Causality

As already mentioned in chapter 5.1 Cointegration, the data are not stationary. For this reason, the time series must be differenced. Thereafter, we check again with the ADF test whether the data are stationary.

For the Granger Causality Test, we compare all variables with each other. For this we use a confidence interval of 95% and an alpha level of 5%. The hypothesis for the Granger Causality Test is as follows:

H_0: No Granger Causality

H_1: Granger Causality

The matrix with all the P-values can be seen in the appendix 8. Of all these, 104 cases with a P-value of less than 5% are marked in red in the table. This means, that the hypothesis for these cases can be rejected as there is a Granger Causality relation in place for them.

6 Conclusion

Like many financial time series, the twenty commodity futures analyzed follow stochastic trends, have cycles and are therefore non-stationary.

If non-stationary time series are used for the analysis of regression models, there is a risk of spurious regressions. With the first difference, the twenty time series analyzed became stationary and the risk of spurious regressions could be minimized. A disadvantage of the analysis of the first difference is that information about long-term dependencies gets lost.

The cointegration test was used to examine whether the individual pairs of the non-stationary commodity futures time series at the price level show a common long-term trend and do not move away from each other. Out of the 380 regressions analyzed with a lag of 1, 63 pairs were cointegrated. The result with a lag of 2 remained almost identical with 62 cointegrated pairs.

The Granger Causality Test indicated which variables can be used to predict future changes in other variables. Since the data for the Granger Causality Test should always be stationary, market prices must always be differentiated first. In the end, out of a total of 400 combinations, only 104 combinations showed a Granger Causality. Only the commodities PAc1 and PLc1 are not useful for predictions in any combination. All others can be used for at least one other commodity.

7 Bibliography

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Kirchgässner, G., Wolters, J., & Hassler, U. (2023). *Introduction to Modern Time Series Analysis* (Vol. 2). Berlin, Heidelberg: Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-33436-8.

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8 Appendix

8.1 Appendix 1

Comparison of data sets

Data retrieved by API

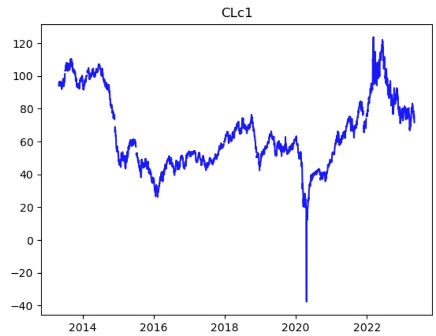
	CLc1	Cc1	GCc1	LCc1	NGc1	OJc1	PAc1	PLc1	SIc1	Wc1	SOYc1	HGc1	SFSc1	LCCc1	LCOc1	RBc1	HOc1	SAFc1	SZNc1	CUUc1
count	2265.0	2265	2265	2265	2265	2265	2265	2265	2265	2265	2265	2265	2265	2265	2265	2265	2265	2265	2265	2265
mean	65.100389	445,295585	1446,14618	127,332859	3,37443267	143,868698	1316,17115	1035,61545	18,9965898	577,67638	6327,80433	3,08119073	27,8230287	1830,38455	70,0082781	1,98785982	2,12431285	14940,9007	19784,5364	1,77611093
std	22.032751	124,732133	268,247042	18,38389	1,3945247	33,2521203	672,702892	197,417999	3,68956487	150,278615	1627,04713	0,67719696	4,7082728	235,359649	23,0644888	0,63982107	0,74395541	2755,21826	3970,54934	0,4900044
min	-37.63	301,5	1050,8	84,975	1,552	91,25	469,9	595,9	11,735	361	4145	1,9395	18,48	1326	19,33	0,4118	0,6308	9825	12275	0,805
25%	48.4	360,25	1241,2	113,35	2,59	120,95	757,5	903,2	16,216	476,25	4932	2,623	25,1	1657	51,66	1,5208	1,5744	13330	16100	1,415
50%	59.52	381,75	1317,1	123,35	2,928	138,85	990,6	974,4	17,773	526,25	5954	2,973	26,45	1787	65,25	1,8803	1,9525	14160	20265	1,55
75%	80.33	507	1735,8	139,55	3,834	157,3	1911,8	1116,2	21,678	658	7350	3,348	29,25	1993	84,71	2,4384	2,7144	15895	22935	2,1899
max	123,7	818,25	2051,5	176,475	9,68	286,3	2979,9	1540,7	29,398	1425,25	11113	4,929	43,5	2577	127,98	4,2762	5,1354	24330	28690	3,45

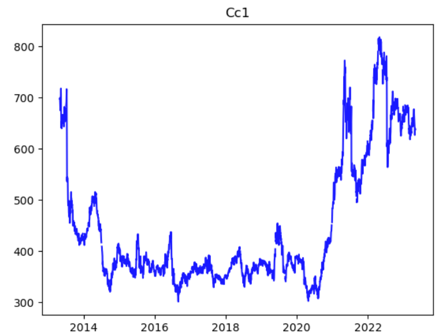
Data retrieved by Formula Builder

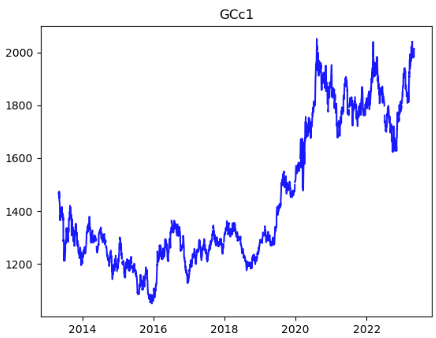
	CLc1	Cc1	GCc1	LCc1	NGc1	OJc1	PAc1	PLc1	SIc1	Wc1	SOYc1	HGc1	SFSc1	LCCc1	LCOc1	RBc1	HOc1	SAFc1	SZNc1	CUUc1
count	2265	2265	2265	2265	2265	2265	2265	2265	2265	2265	2265	2265	2265	2265	2265	2265	2265	2265	2265	2265
mean	65,1003885	445,295585	1446,14618	127,332859	3,37443267	143,868698	1316,17115	1035,61545	18,9965898	577,67638	6327,80433	3,08119073	27,8230287	1830,38455	70,0082781	1,98785982	2,12431285	14940,9007	19784,5364	1,77611093
std	22,0327512	124,732133	268,247042	18,38389	1,3945247	33,2521203	672,702892	197,417999	3,68956487	150,278615	1627,04713	0,67719696	4,7082728	235,359649	23,0644888	0,63982107	0,74395541	2755,21826	3970,54934	0,4900044
min	-37,63	301,5	1050,8	84,975	1,552	91,25	469,9	595,9	11,735	361	4145	1,9395	18,48	1326	19,33	0,4118	0,6308	9825	12275	0,805
25%	48,4	360,25	1241,2	113,35	2,59	120,95	757,5	903,2	16,216	476,25	4932	2,623	25,1	1657	51,66	1,5208	1,5744	13330	16100	1,415
50%	59,52	381,75	1317,1	123,35	2,928	138,85	990,6	974,4	17,773	526,25	5954	2,973	26,45	1787	65,25	1,8803	1,9525	14160	20265	1,55
75%	80,33	507	1735,8	139,55	3,834	157,3	1911,8	1116,2	21,678	658	7350	3,348	29,25	1993	84,71	2,4384	2,7144	15895	22935	2,1899
max	123,7	818,25	2051,5	176,475	9,68	286,3	2979,9	1540,7	29,398	1425,25	11113	4,929	43,5	2577	127,98	4,2762	5,1354	24330	28690	3,45

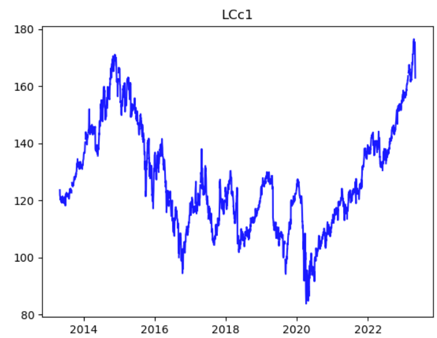
8.2 Appendix 2

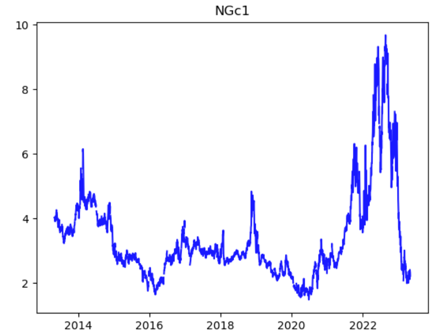
Plots original data

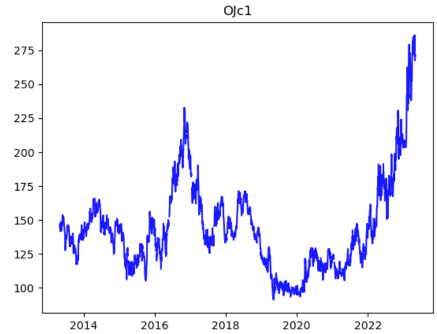


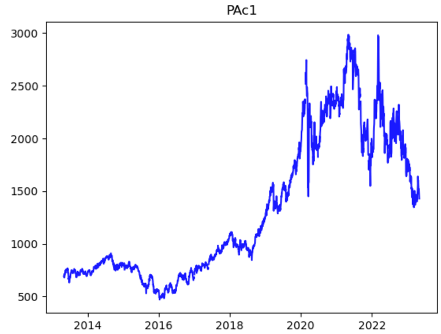


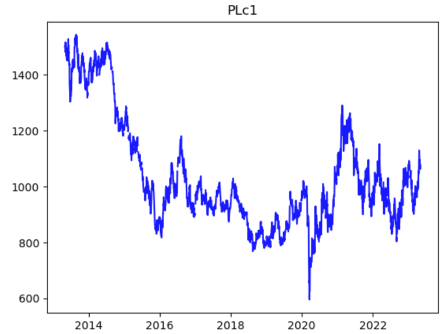


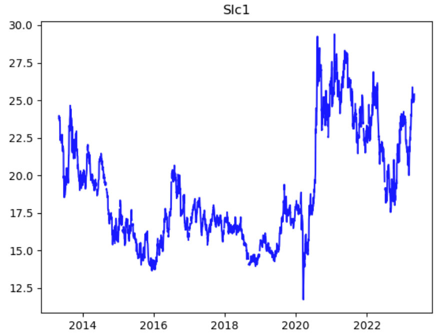


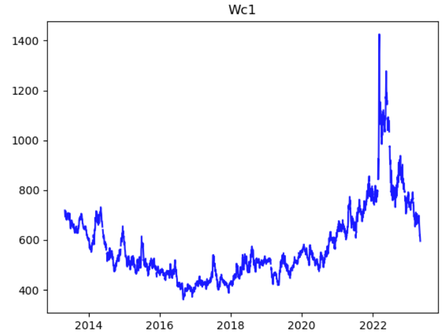

NGc1
10
8
6
4
2
2014
2016
2018
2020
2022

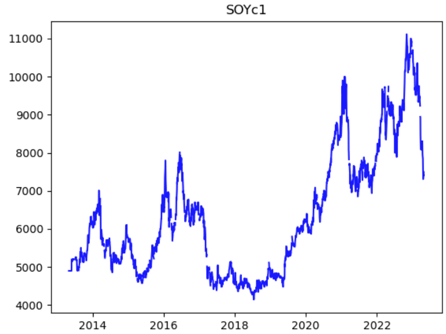

OJc1
275
250
225
200
175
150
125
100
2014
2016
2018
2020
2022

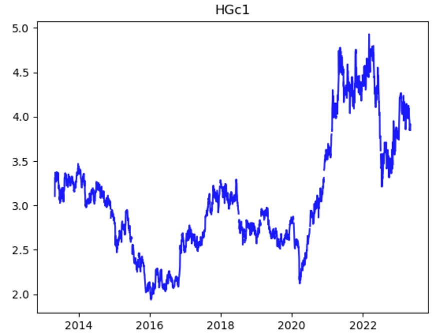

PAc1
3000
2500
2000
1500
1000
500
2014
2016
2018
2020
2022

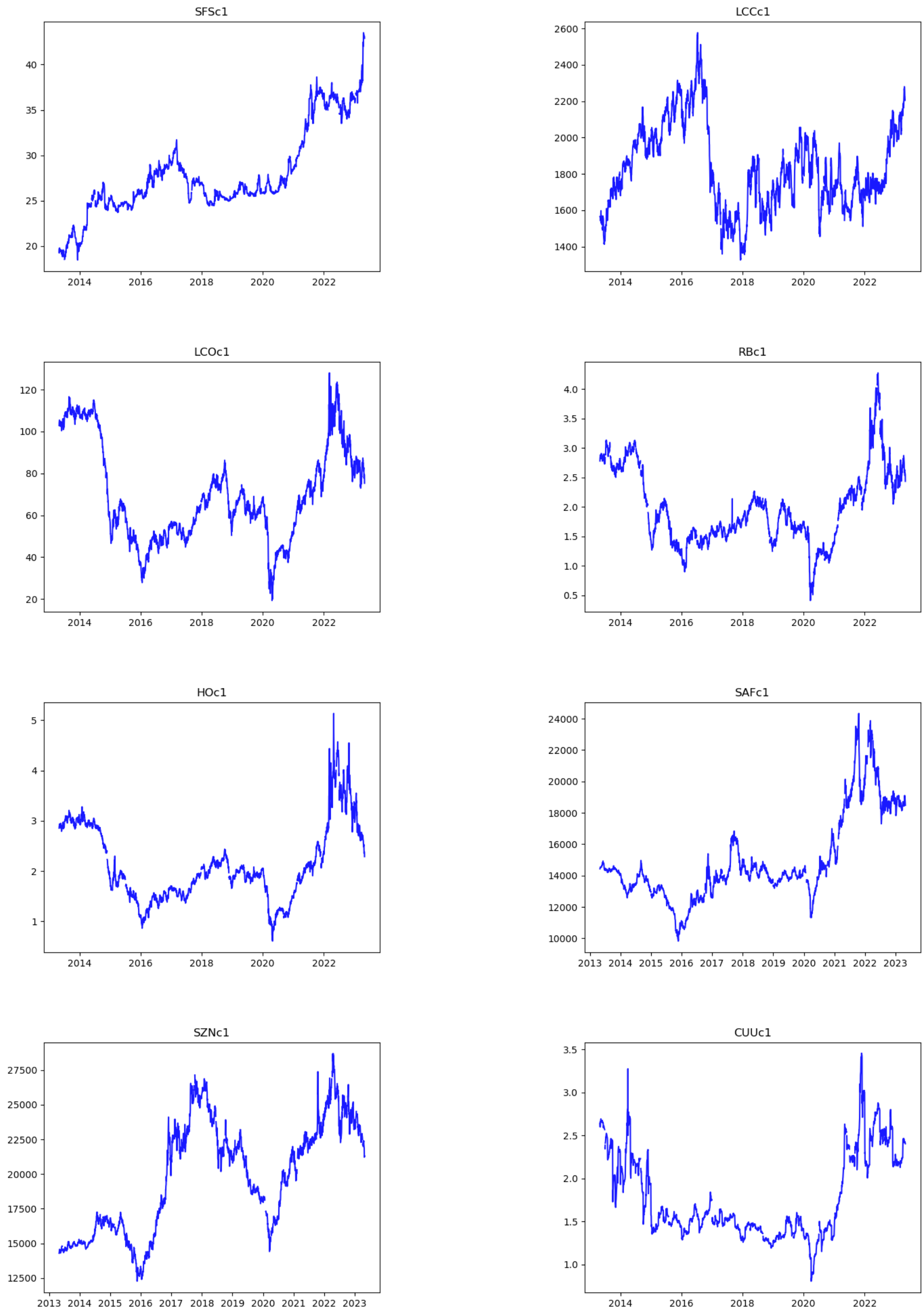

PLc1
1400
1200
1000
800
600
2014
2016
2018
2020
2022


SIc1
30.0
27.5
25.0
22.5
20.0
17.5
15.0
12.5
2014
2016
2018
2020
2022


Wc1
1400
1200
1000
800
600
400
2014
2016
2018
2020
2022

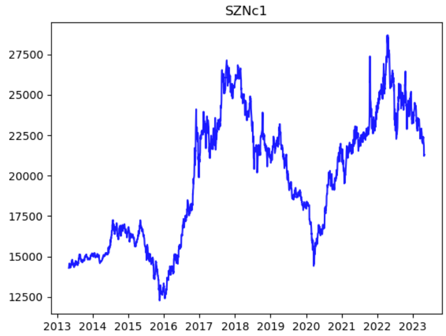

SOYc1
11000
10000
9000
8000
7000
6000
5000
4000
2014
2016
2018
2020
2022

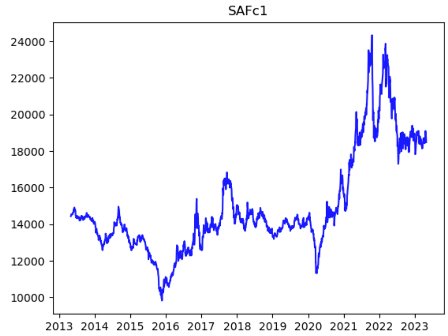

HGc1
5.0
4.5
4.0
3.5
3.0
2.5
2.0
2014
2016
2018
2020
2022

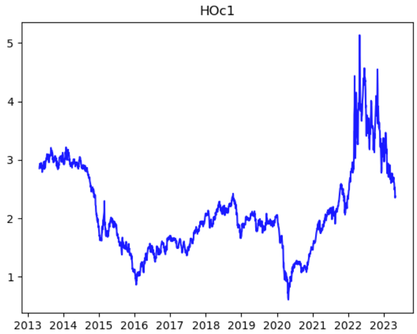

SFSc1
20 25 30 35 40
2014 2016 2018 2020 2022
LCCc1
1400 1600 1800 2000 2200 2400 2600
2014 2016 2018 2020 2022
LCOc1
20 40 60 80 100 120
2014 2016 2018 2020 2022
RBc1
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0
2014 2016 2018 2020 2022
HOc1
1 2 3 4 5
2014 2016 2018 2020 2022
SAFc1
10000 12000 14000 16000 18000 20000 22000 24000
2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023
SZNc1
12500 15000 17500 20000 22500 25000 27500
2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023
CUUc1
1.0 1.5 2.0 2.5 3.0 3.5
2014 2016 2018 2020 2022

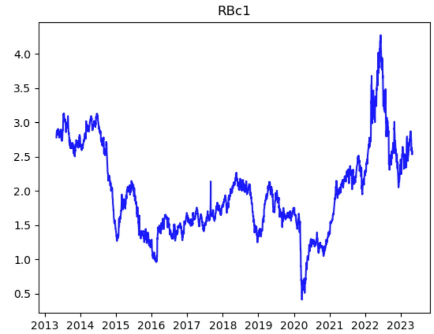
8.3 Appendix 3

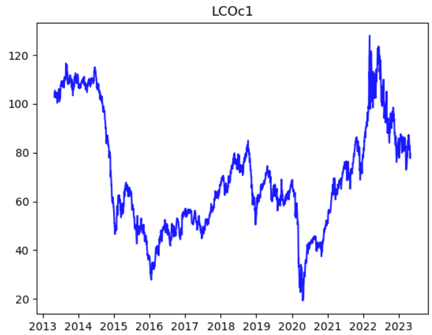
Plots clean data

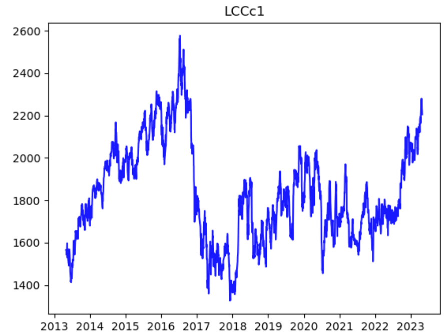


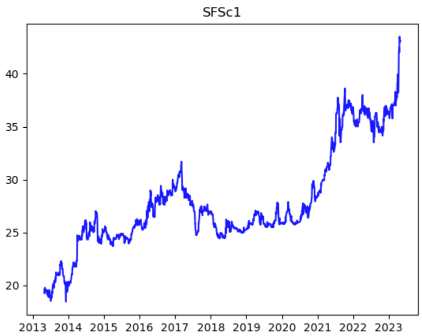


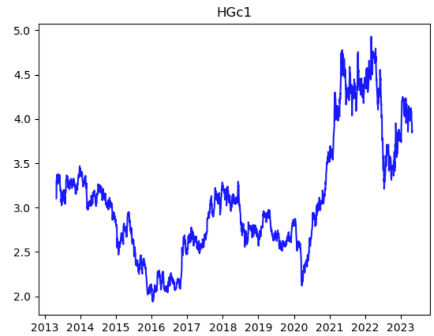


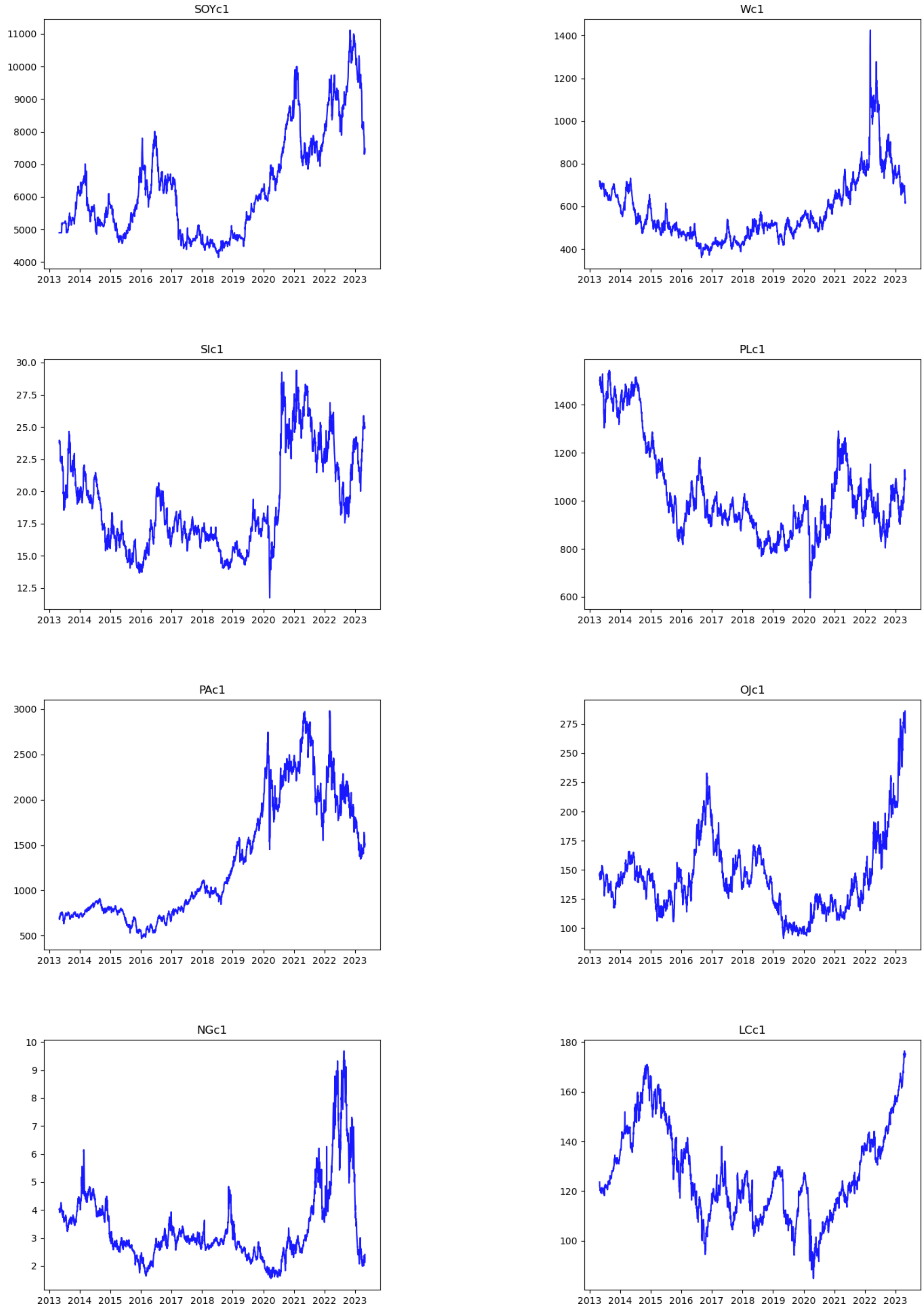


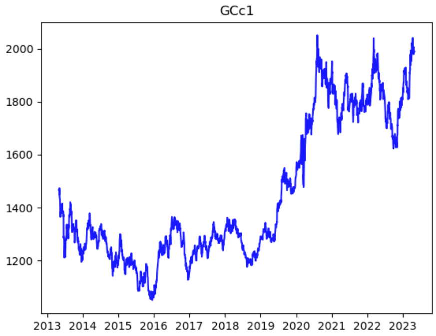


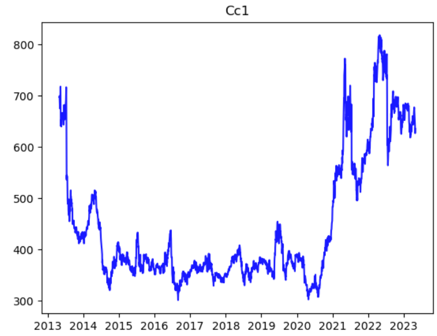


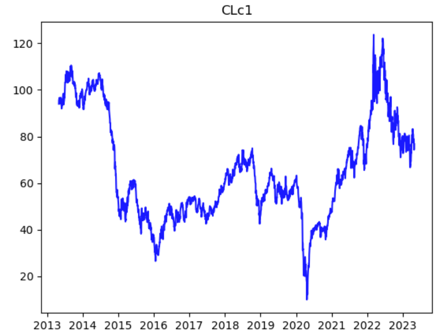


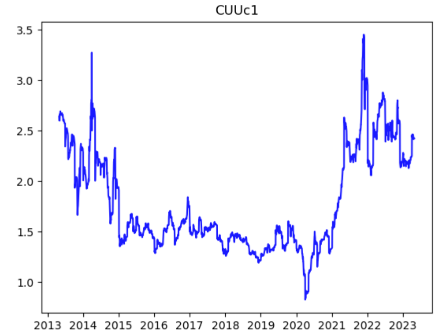



SOYc1
Wc1
SIc1
PLc1
PAc1
OJc1
NGc1
LCc1


GCc1
2000
1800
1600
1400
1200
2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023


Cc1
800
700
600
500
400
300
2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023


CLc1
120
100
80
60
40
20
2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023


CUUc1
3.5
3.0
2.5
2.0
1.5
1.0
2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023

8.4 Appendix 4

ADF-Test Prices (Level)

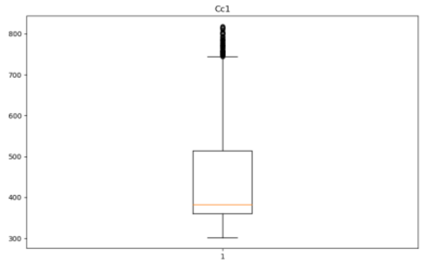
```
Number of lags used: 1
ADF P-Val for Prices (Level)
CLc1 : 0.34
Cc1 : 0.42
GCc1 : 0.86
LCc1 : 0.83
NGc1 : 0.21
OJc1 : 0.79
PAc1 : 0.52
PLc1 : 0.28
SIc1 : 0.55
Wc1 : 0.39
SOYc1 : 0.70
HGc1 : 0.67
SFSc1 : 0.99
LCCc1 : 0.71
LCOc1 : 0.32
RBc1 : 0.40
HOc1 : 0.33
SAFc1 : 0.73
SZNc1 : 0.73
CUUc1 : 0.38
____________________________________________

Number of lags used: 2
ADF P-Val for Prices (Level)
CLc1 : 0.34
Cc1 : 0.45
GCc1 : 0.86
LCc1 : 0.84
NGc1 : 0.23
OJc1 : 0.81
PAc1 : 0.53
PLc1 : 0.28
SIc1 : 0.55
Wc1 : 0.39
SOYc1 : 0.69
HGc1 : 0.67
SFSc1 : 0.99
LCCc1 : 0.71
LCOc1 : 0.31
RBc1 : 0.39
HOc1 : 0.33
SAFc1 : 0.75
SZNc1 : 0.75
CUUc1 : 0.40
____________________________________________
```

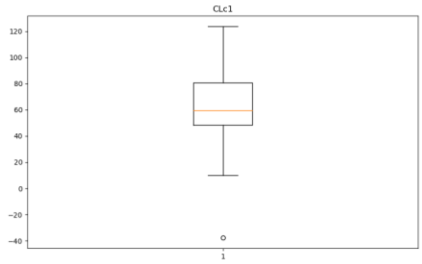
ADF-Test Absolute Returns

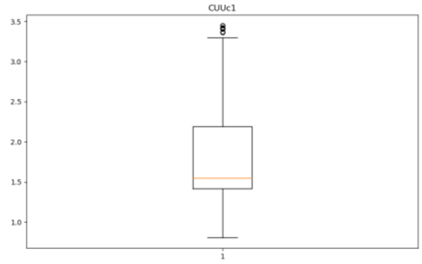
```
Number of lags used: 1
ADF P-Val for Absolute Returns (1st Difference)
CLc1 : 0.00
Cc1 : 0.00
GCc1 : 0.00
LCc1 : 0.00
NGc1 : 0.00
OJc1 : 0.00
PAc1 : 0.00
PLc1 : 0.00
SIc1 : 0.00
Wc1 : 0.00
SOYc1 : 0.00
HGc1 : 0.00
SFSc1 : 0.00
LCCc1 : 0.00
LCOc1 : 0.00
RBc1 : 0.00
HOc1 : 0.00
SAFc1 : 0.00
SZNc1 : 0.00
CUUc1 : 0.00
____________________________________________

Number of lags used: 2
ADF P-Val for Absolute Returns (1st Difference)
CLc1 : 0.00
Cc1 : 0.00
GCc1 : 0.00
LCc1 : 0.00
NGc1 : 0.00
OJc1 : 0.00
PAc1 : 0.00
PLc1 : 0.00
SIc1 : 0.00
Wc1 : 0.00
SOYc1 : 0.00
HGc1 : 0.00
SFSc1 : 0.00
LCCc1 : 0.00
LCOc1 : 0.00
RBc1 : 0.00
HOc1 : 0.00
SAFc1 : 0.00
SZNc1 : 0.00
CUUc1 : 0.00
____________________________________________
```

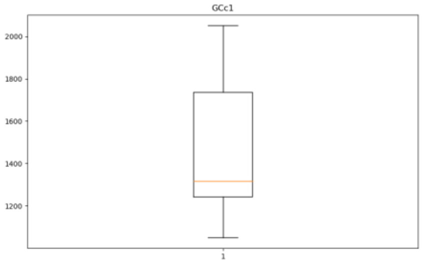
8.5 Appendix 5

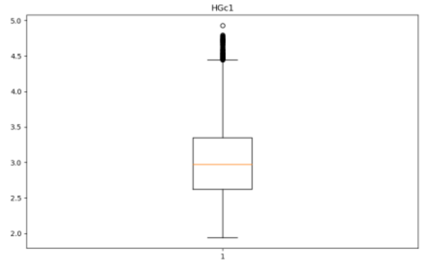
Box Plots

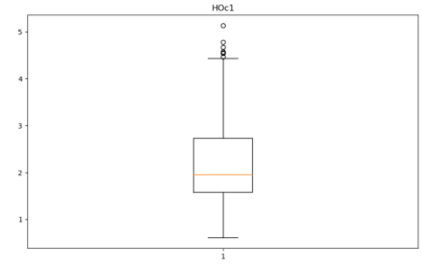


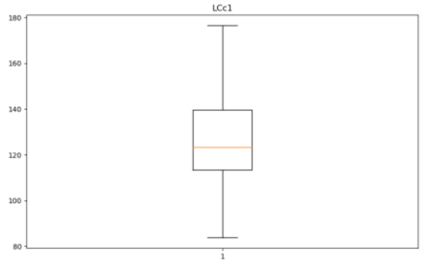


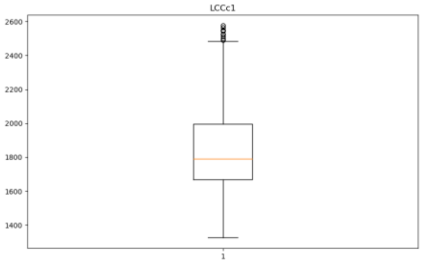


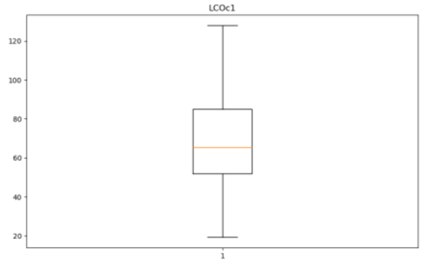


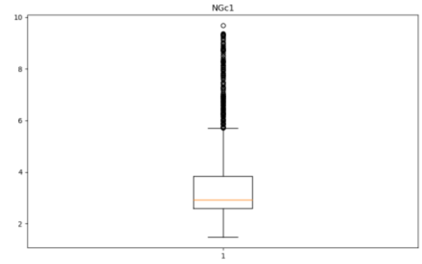


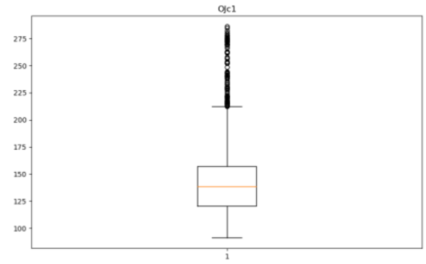


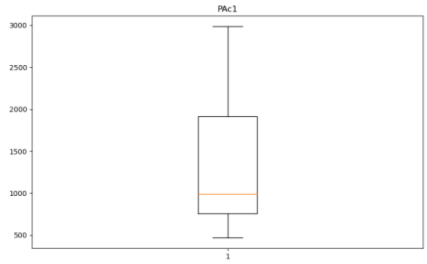


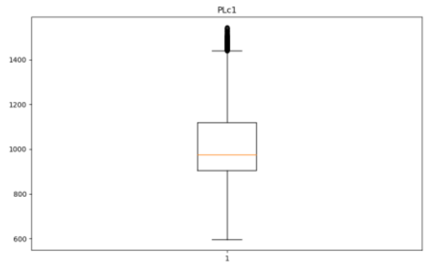


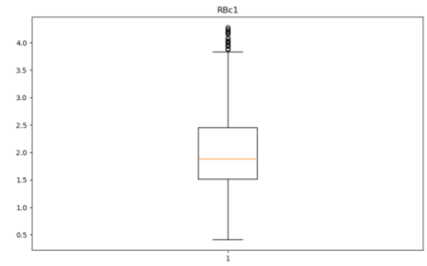


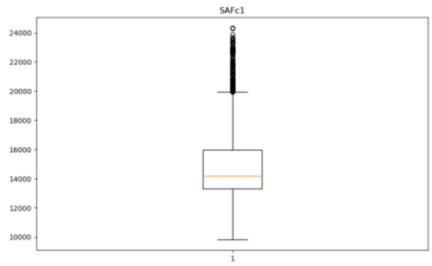


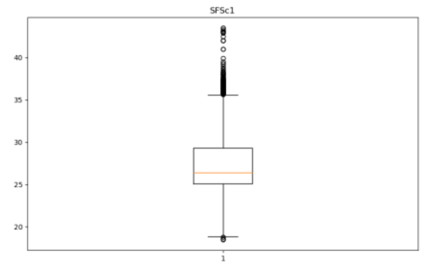

OJc1
275
250
225
200
175
150
125
100
1

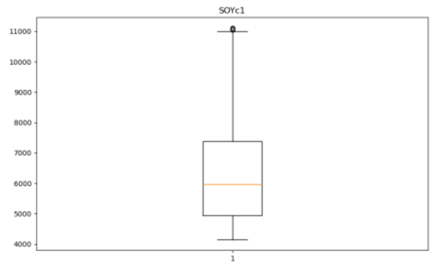

PAc1
3000
2500
2000
1500
1000
500
1

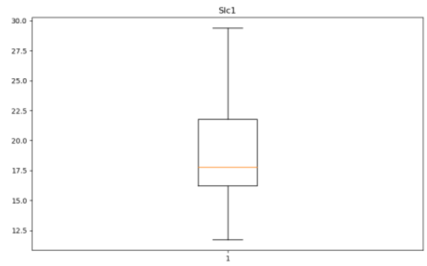

PLc1
1400
1200
1000
800
600
1

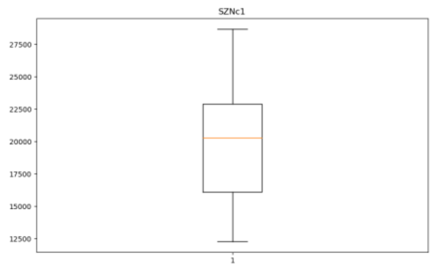

RBc1
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
1


SAFc1
24000
22000
20000
18000
16000
14000
12000
10000
1


SFSc1
40
35
30
25
20
1


SOYc1
11000
10000
9000
8000
7000
6000
5000
4000
1


SIc1
30.0
27.5
25.0
22.5
20.0
17.5
15.0
12.5
1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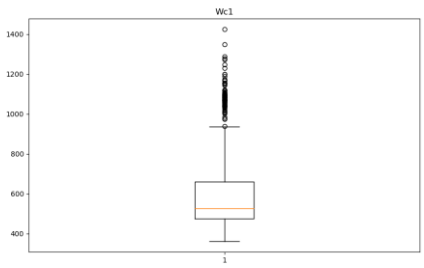
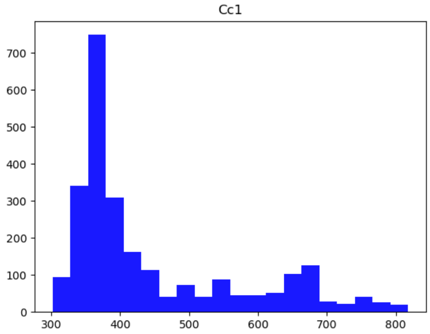
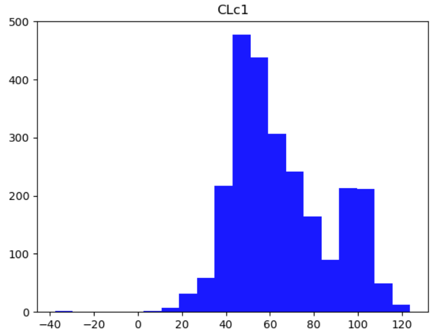
27500
25000
22500
20000
17500
15000
12500
1

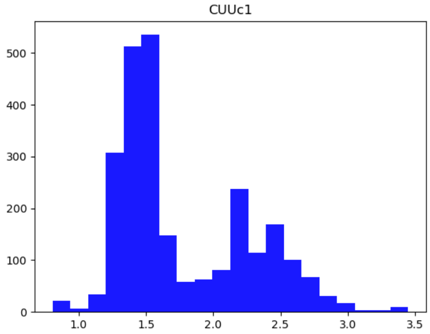

Wc1
1400
1200
1000
800
600
400
1

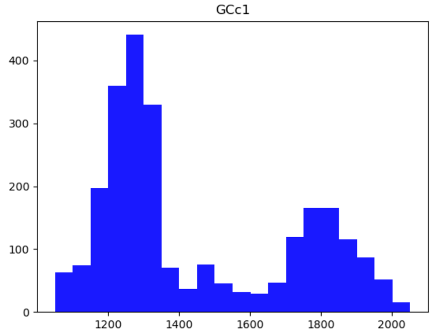
8.6 Appendix 6

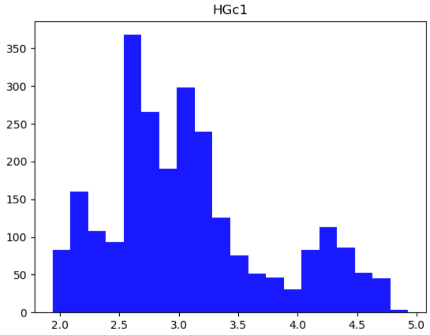
Histograms

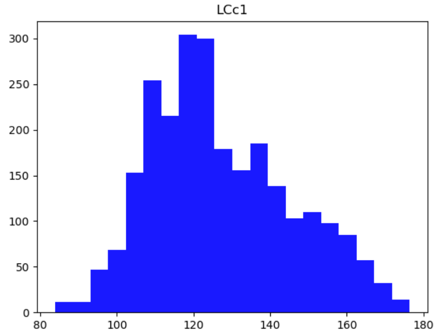


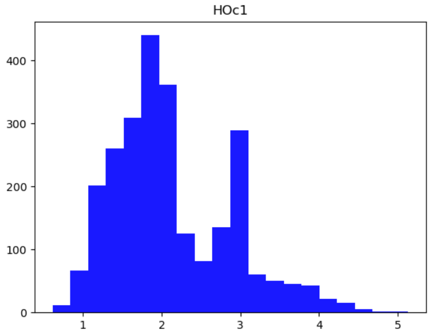


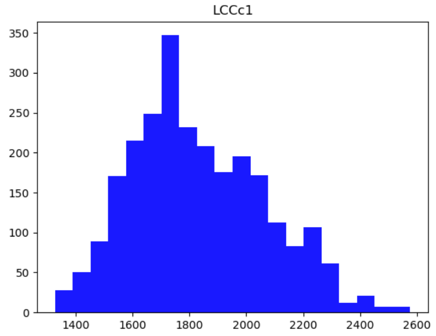












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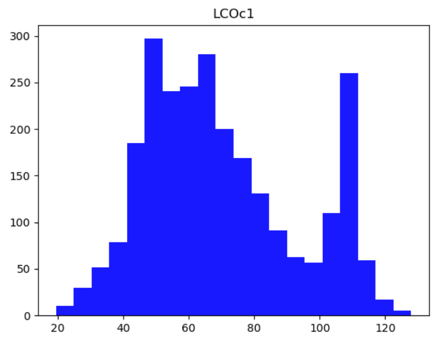
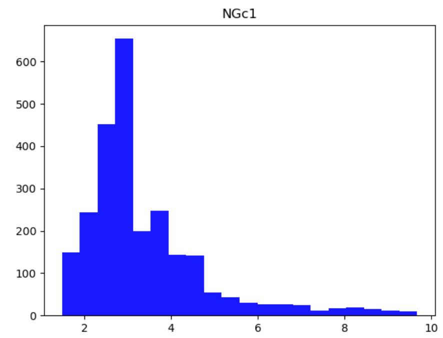
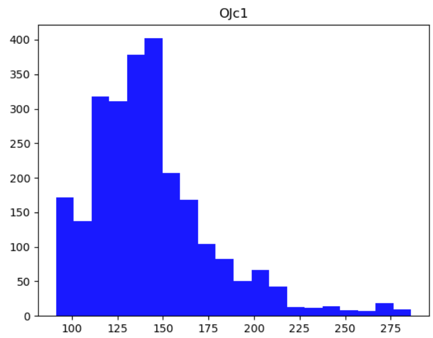
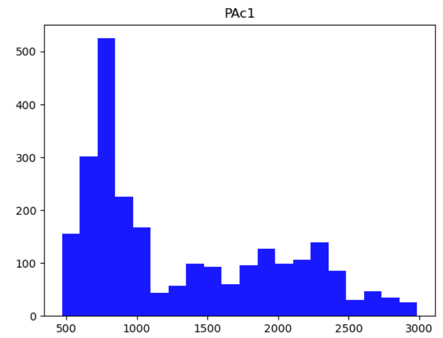
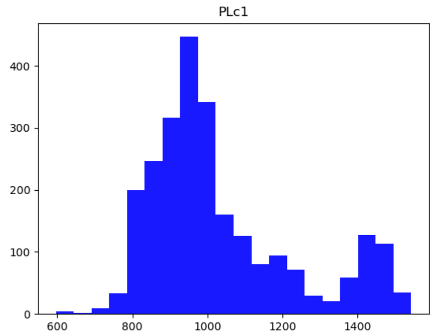
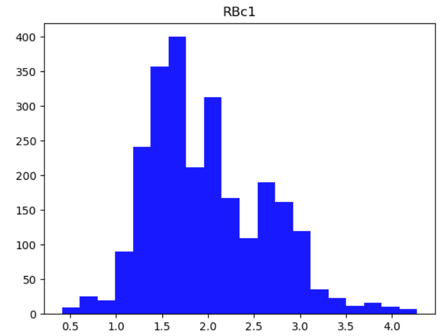

LCOc1
0
50
100
150
200
250
300
20
40
60
80
100
120

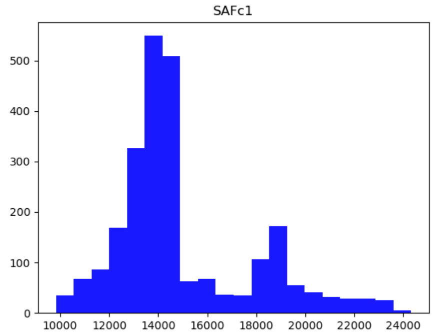

NGc1
0
100
200
300
400
500
600
2
4
6
8
10

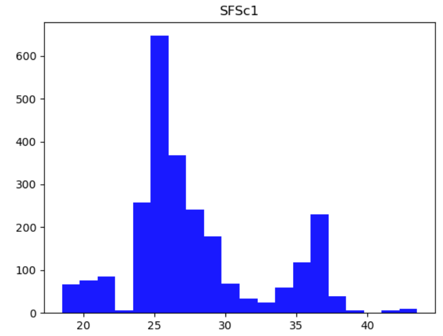

OJc1
0
50
100
150
200
250
300
350
400
100
125
150
175
200
225
250
275

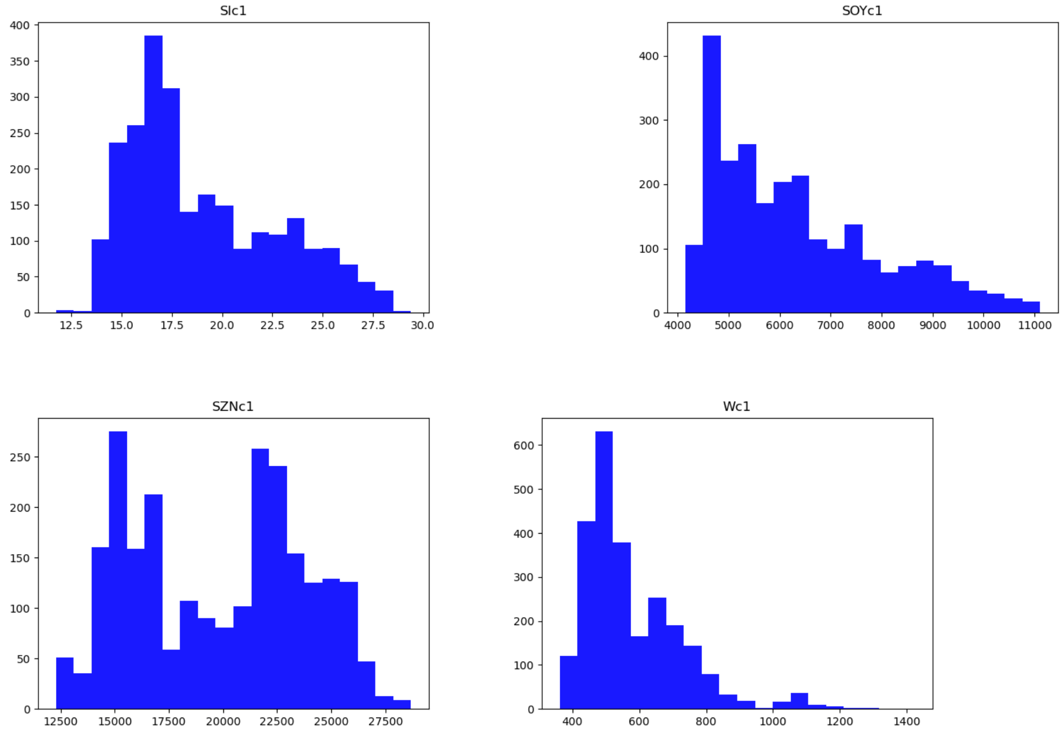

PAc1
0
100
200
300
400
500
500
1000
1500
2000
2500
3000


PLc1
0
100
200
300
400
600
800
1000
1200
1400


RBc1
0
50
100
150
200
250
300
350
400
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0


SAFc1
0
100
200
300
400
500
10000
12000
14000
16000
18000
20000
22000
24000

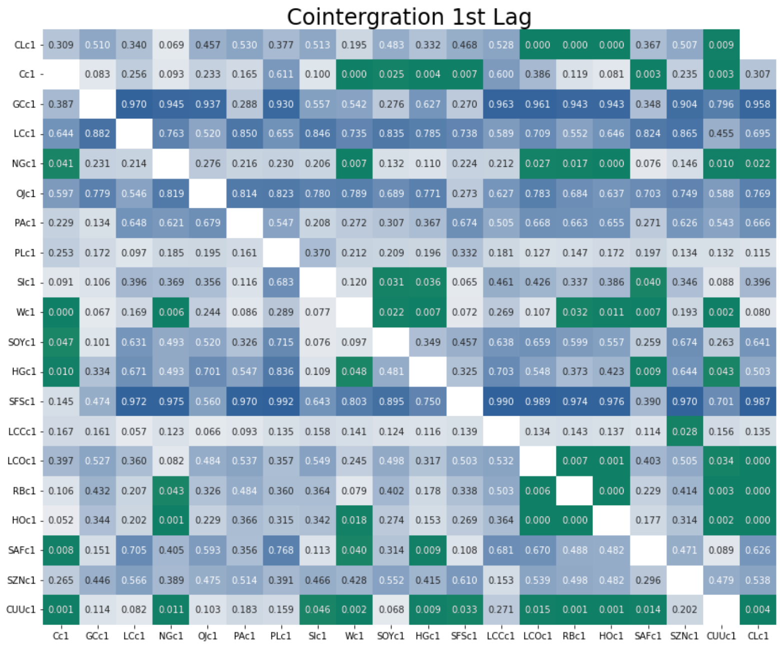

SFSc1
0
100
200
300
400
500
600
20
25
30
35
40

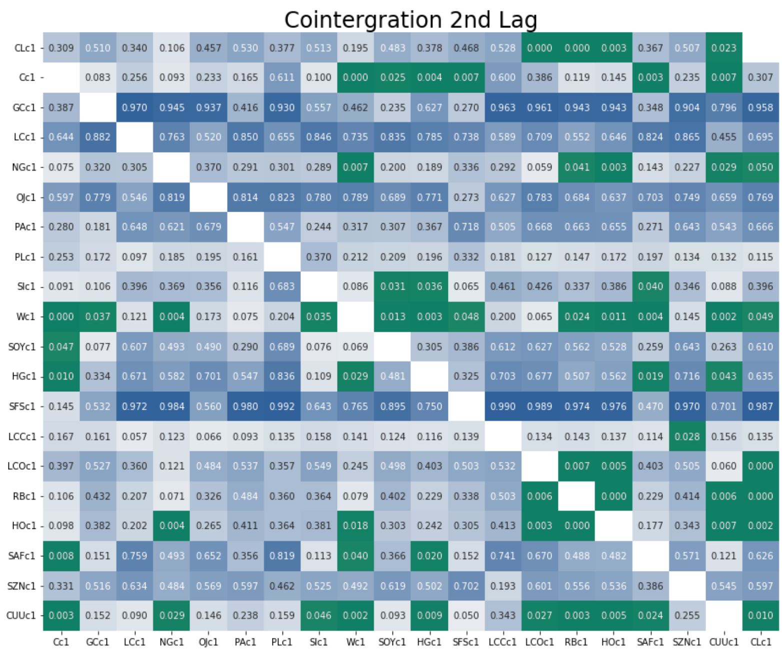

SIc1
400
350
300
250
200
150
100
50
0
12.5
15.0
17.5
20.0
22.5
25.0
27.5
30.0
SOYc1
400
300
200
100
0
4000
5000
6000
7000
8000
9000
10000
11000
SZNc1
250
200
150
100
50
0
12500
15000
17500
20000
22500
25000
27500
Wc1
600
500
400
300
200
100
0
400
600
800
1000
1200
1400

8.7 Appendix 7

Cointegration

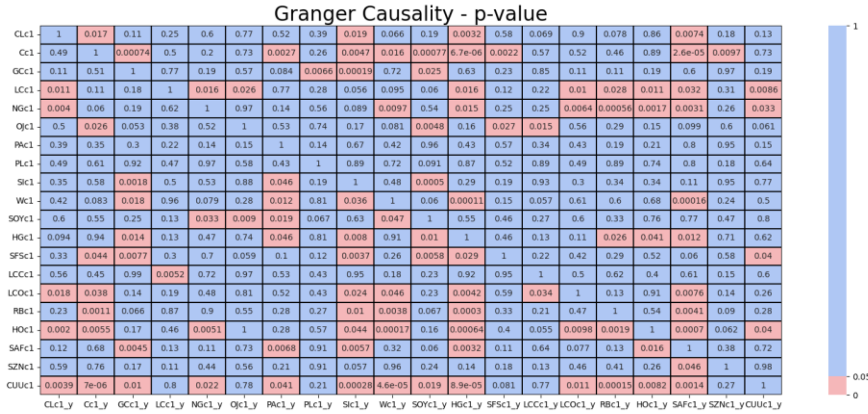
```
Number of identified cointegrations using the ECM Library by asset:
CLc1 : 8 out of total 38 ¦cointegration identified at ADF lags: [1, 1, 1, 1, 2, 2, 2, 2]
Cc1 : 12 out of total 38 ¦cointegration identified at ADF lags: [1, 1, 1, 1, 1, 1, 2, 2, 2, 2, 2, 2]
GCc1 : 0 out of total 38 ¦cointegration identified at ADF lags: []
LCc1 : 0 out of total 38 ¦cointegration identified at ADF lags: []
NGc1 : 12 out of total 38 ¦cointegration identified at ADF lags: [1, 1, 1, 1, 1, 1, 1, 2, 2, 2, 2, 2]
OJc1 : 0 out of total 38 ¦cointegration identified at ADF lags: []
PAc1 : 0 out of total 38 ¦cointegration identified at ADF lags: []
PLc1 : 0 out of total 38 ¦cointegration identified at ADF lags: []
SIc1 : 6 out of total 38 ¦cointegration identified at ADF lags: [1, 1, 1, 2, 2, 2]
Wc1 : 20 out of total 38 ¦cointegration identified at ADF lags: [1, 1, 1, 1, 1, 1, 1, 1, 2, 2, 2, 2, 2, 2, 2, 2, 2,
2, 2, 2]
SOYc1 : 2 out of total 38 ¦cointegration identified at ADF lags: [1, 2]
HGc1 : 8 out of total 38 ¦cointegration identified at ADF lags: [1, 1, 1, 1, 2, 2, 2, 2]
SFSc1 : 0 out of total 38 ¦cointegration identified at ADF lags: []
LCCc1 : 2 out of total 38 ¦cointegration identified at ADF lags: [1, 2]
LCOc1 : 7 out of total 38 ¦cointegration identified at ADF lags: [1, 1, 1, 1, 2, 2, 2]
RBc1 : 9 out of total 38 ¦cointegration identified at ADF lags: [1, 1, 1, 1, 1, 2, 2, 2, 2]
HOc1 : 12 out of total 38 ¦cointegration identified at ADF lags: [1, 1, 1, 1, 1, 1, 2, 2, 2, 2, 2, 2]
SAFc1 : 6 out of total 38 ¦cointegration identified at ADF lags: [1, 1, 1, 2, 2, 2]
SZNc1 : 0 out of total 38 ¦cointegration identified at ADF lags: []
CUUc1 : 21 out of total 38 ¦cointegration identified at ADF lags: [1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 2, 2, 2, 2, 2,
2, 2, 2, 2, 2]


total number of regressions conducted: 760
total number of identified cointegrations using only ECM Library: 125
```





8.8 Appendix 8

Granger Causality



	CLc1_y	Cc1_y	GCc1_y	LCc1_y	NGc1_y	OJc1_y	PAc1_y	PLc1_y	SIc1_y	Wc1_y	SOYc1_y	HGc1_y	SFSc1_y	LCCc1_y	LCOc1_y	RBc1_y	HOc1_y	SAFc1_y	SZNc1_y	CUUc1_y
CLc1	1	0.017	0.11	0.25	0.6	0.77	0.52	0.39	0.019	0.066	0.19	0.0032	0.58	0.069	0.9	0.078	0.86	0.0074	0.18	0.13
Cc1	0.49	1	0.00074	0.5	0.2	0.73	0.0027	0.26	0.0047	0.016	0.00077	6.7e-06	0.0022	0.57	0.52	0.46	0.89	2.6e-05	0.0097	0.73
GCc1	0.11	0.51	1	0.77	0.19	0.57	0.084	0.0066	0.00019	0.72	0.025	0.63	0.23	0.85	0.11	0.11	0.19	0.6	0.97	0.19
LCc1	0.011	0.11	0.18	1	0.016	0.026	0.77	0.28	0.056	0.095	0.06	0.016	0.12	0.22	0.01	0.028	0.011	0.032	0.31	0.0086
NGc1	0.004	0.06	0.19	0.62	1	0.97	0.14	0.56	0.089	0.0097	0.54	0.015	0.25	0.25	0.0064	0.00056	0.0017	0.0031	0.26	0.033
OJc1	0.5	0.026	0.053	0.38	0.52	1	0.53	0.74	0.17	0.081	0.0048	0.16	0.027	0.015	0.56	0.29	0.15	0.099	0.6	0.061
PAc1	0.39	0.35	0.3	0.22	0.14	0.15	1	0.14	0.67	0.42	0.96	0.43	0.57	0.34	0.43	0.19	0.21	0.8	0.95	0.15
PLc1	0.49	0.61	0.92	0.47	0.97	0.58	0.43	1	0.89	0.72	0.091	0.87	0.52	0.89	0.49	0.89	0.74	0.8	0.18	0.64
SIc1	0.35	0.58	0.0018	0.5	0.53	0.88	0.046	0.19	1	0.48	0.0005	0.29	0.19	0.93	0.3	0.34	0.34	0.11	0.95	0.77
Wc1	0.42	0.083	0.018	0.96	0.079	0.28	0.012	0.81	0.036	1	0.06	0.00011	0.15	0.057	0.61	0.6	0.68	0.00016	0.24	0.5
SOYc1	0.6	0.55	0.25	0.13	0.033	0.009	0.019	0.067	0.63	0.047	1	0.55	0.46	0.27	0.6	0.33	0.76	0.77	0.47	0.8
HGc1	0.094	0.94	0.014	0.13	0.47	0.74	0.046	0.81	0.008	0.91	0.01	1	0.46	0.13	0.11	0.026	0.041	0.012	0.71	0.62
SFSc1	0.33	0.044	0.0077	0.3	0.7	0.059	0.1	0.12	0.0037	0.26	0.0058	0.029	1	0.22	0.42	0.29	0.52	0.06	0.58	0.04
LCCc1	0.56	0.45	0.99	0.0052	0.72	0.97	0.53	0.43	0.95	0.18	0.23	0.92	0.95	1	0.5	0.62	0.4	0.61	0.15	0.6
LCOc1	0.018	0.038	0.14	0.19	0.48	0.81	0.52	0.43	0.024	0.046	0.23	0.0042	0.59	0.034	1	0.13	0.91	0.0076	0.14	0.26
RBc1	0.23	0.0011	0.066	0.87	0.9	0.55	0.28	0.27	0.01	0.0038	0.067	0.0003	0.33	0.21	0.47	1	0.54	0.0041	0.09	0.28
HOc1	0.002	0.0055	0.17	0.46	0.0051	1	0.28	0.57	0.044	0.00017	0.16	0.00064	0.4	0.055	0.0098	0.0019	1	0.0007	0.062	0.04
SAFc1	0.12	0.68	0.0045	0.13	0.11	0.73	0.0068	0.91	0.0057	0.32	0.06	0.0032	0.11	0.64	0.077	0.13	0.016	1	0.38	0.72
SZNc1	0.59	0.76	0.17	0.11	0.44	0.56	0.21	0.91	0.057	0.96	0.24	0.14	0.18	0.13	0.46	0.41	0.26	0.046	1	0.98
CUUc1	0.0039	7e-06	0.01	0.8	0.022	0.78	0.041	0.21	0.00028	4.6e-05	0.019	8.9e-05	0.081	0.77	0.011	0.00015	0.0082	0.0014	0.27	1

8.9 Appendix 9

Table RESULTS_COINTEGRATION_1

	index	Cc1	GCc1	LCc1	NGc1	OJc1	PAc1	PLc1	SIc1	Wc1	SOYc1	HGc1	SFSc1	LCCc1	LCOc1
	Filtern	Filtern	Filtern	Filtern	Filtern	Filtern	Filtern	Filtern	Filtern	Filtern	Filtern	Filtern	Filtern	Filtern	Filtern
1	CLc1	0.308870604820672	0.510148009750213	0.340182254131892	0.0689377196253997	0.457299641429664	0.530116541287247	0.377483687821476	0.51344972144458	0.194571034637454	0.48273675117218	0.331536330718235	0.468261374496838	0.528284552898907	2.06054282282
2	Cc1	NULL	0.0834088358518777	0.256269012786158	0.0933082282562718	0.232754989873682	0.16549337853322	0.611322683781423	0.100121765908183	0.000132403573871762	0.0245220430556864	0.00388414950635139	0.00673276732100909	0.599690500897261	0.38631550
3	GCc1	0.387154678202998	NULL	0.969916607209787	0.945225971990056	0.937118922996709	0.287925455178133	0.929769428095795	0.557425461945827	0.541892777638809	0.27617984869454	0.626702427262772	0.269695547425114	0.963055275892202	0.96118610
4	LCc1	0.64382949064354	0.882010481457697	NULL	0.763004987332645	0.519837584069867	0.849500395263054	0.655324232151914	0.846206734171184	0.734822282911261	0.834639263566315	0.784625267452525	0.73751520459593	0.588871665659922	0.7086870
5	NGc1	0.0412280821837884	0.231319084230141	0.213560147646118	NULL	0.276353304461389	0.215940102209078	0.229618462133562	0.206207137374152	0.00660348387393368	0.132316938769166	0.110378073651019	0.224302370098451	0.212252113216983	0.0270022
6	OJc1	0.596649945333633	0.778504844528005	0.546450500912975	0.819263580675647	NULL	0.813819330832567	0.823343269418489	0.779698247128398	0.788859221721242	0.689337443401847	0.770557567147867	0.272553588639909	0.62676394510128	0.7830264
7	PAc1	0.229163734234068	0.134000582934178	0.648309789787573	0.620961612283603	0.67923936933505	NULL	0.54665840194744	0.207691580967303	0.271685074514953	0.307160279909954	0.367179673993082	0.674167445139763	0.505345314628396	0.6684421
8	PLc1	0.253134336810777	0.171517030026094	0.0967522924345442	0.184680747338959	0.19462051775021	0.160936787156372	NULL	0.370470843639298	0.212353957191453	0.209009259271842	0.196373669842703	0.331793337216267	0.180985767787244	0.1269460
9	SIc1	0.090828196253682	0.105994474770968	0.396370611732013	0.368605817626813	0.356415058202037	0.115607821856327	0.683054734544425	NULL	0.11989517370359	0.0305878057370776	0.0357498086519553	0.0647690414183997	0.461030750063676	0.4258537
10	Wc1	4.88589339899314e-05	0.0667521023339689	0.169192186851653	0.00575019712218003	0.243879401194824	0.0856028513173297	0.289132386619402	0.0765287263771464	NULL	0.0215626205085013	0.00674080246978778	0.0722790563465828	0.26860417845403	0.1067042
11	SOYc1	0.0471642410582236	0.101031248777	0.631274131642452	0.492548706650165	0.519827081511695	0.325607395267028	0.715091596261004	0.0756680612950109	0.0973256877082485	NULL	0.348557726737372	0.456740806890538	0.638402770422742	0.6589844
12	HGc1	0.00985391703316851	0.33351085248027	0.67107877076532	0.493439191452194	0.70091335691193	0.547492112732794	0.835575828806848	0.108532785160159	0.0476055843921664	0.480642066326464	NULL	0.325029924460391	0.703306912933074	0.5478832
13	SFSc1	0.144885631505813	0.473861881981705	0.971636376239852	0.975075247720829	0.559888561431062	0.97024366147043	0.991926649627594	0.643052817878946	0.802915945747023	0.894818086707756	0.749587832942687	NULL	0.989965859171955	0.9891346
14	LCCc1	0.167051603821316	0.160848450512141	0.0569931825397124	0.12325953730663	0.0655745903479145	0.0927159077859873	0.134742247480393	0.15849057315578	0.141395186284484	0.124232211619281	0.116039266490041	0.138650425967049	NULL	0.1337608
15	LCOc1	0.397105867179142	0.527282601737486	0.360121162668356	0.0824379866230117	0.483783208899385	0.536722273358258	0.357382666834275	0.548802046541844	0.245009042238042	0.49774733384863	0.31737838076999	0.502910131346954	0.531662056151123	
16	RBc1	0.105892964245572	0.431812225798777	0.20654917628898	0.0434468304727686	0.326050472787988	0.484038634411792	0.360319352485784	0.36366740073681	0.0785402081471642	0.401800918071736	0.177531629746724	0.33820332625529	0.50306874767513	0.00621003653
17	HOc1	0.0523348806584325	0.344490733400439	0.20234700563848	0.000675857700525902	0.228797323178349	0.365790683008909	0.314741951557433	0.341553249047439	0.0176118636508978	0.274468468637259	0.152864561681882	0.269347174489761	0.364137751632603	0.00029540110
18	SAFc1	0.0080257192436359	0.151318558625738	0.704907588622403	0.405335653316196	0.592825109364963	0.356354560597497	0.76804739322473	0.113207826235823	0.0402868397379144	0.314050823421031	0.00947514114648372	0.107660366508254	0.680729220268149	0.66977598
19	SZNc1	0.265431950377762	0.445845373439558	0.565760302598641	0.388508898624954	0.475324258657486	0.514261180592461	0.391014829031261	0.466148603812485	0.427741379648093	0.551857512359535	0.41538820312723	0.610150571358324	0.153431085593818	0.5390137
20	CUUc1	0.00097561879087055	0.114017243183717	0.0823055647643916	0.0106742915322144	0.103196513127319	0.183345331621708	0.158549628359483	0.0459219443300452	0.00197688771117113	0.0676846309275991	0.00853565557687492	0.0328583701991476	0.27062963450208	0.0150435

Table RESULTS_COINTEGRATION_2

	index	Cc1	GCc1	LCc1	NGc1	OJc1	PAc1	PLc1	SIc1	Wc1	SOYc1	HGc1	SFSc1	LCCc1	LCOc1
	Filtern	Filtern	Filtern	Filtern	Filtern	Filtern	Filtern	Filtern	Filtern	Filtern	Filtern	Filtern	Filtern	Filtern	Filtern
1	CLc1	0.308870604820672	0.510148009750213	0.340182254131892	0.105925324934311	0.457299641429664	0.530116541287247	0.377483687821476	0.51344972144458	0.194571034637454	0.48273675117218	0.37808745936027	0.468261374496838	0.528284552898907	4.83415526958582
2	Cc1	NULL	0.0834088358518777	0.256269012786158	0.0933082282562718	0.232754989873682	0.16549337853322	0.611322683781423	0.100121765908183	7.97214225346199e-05	0.0245220430556864	0.00388414950635139	0.00673276732100909	0.599690500897261	0.38631550355
3	GCc1	0.387154678202998	NULL	0.969916607209787	0.945225971990056	0.937118922996709	0.416092887885789	0.929769428095795	0.557425461945827	0.461614457044222	0.234620065156387	0.626702427262772	0.269695547425114	0.963055275892202	0.96118610489
4	LCc1	0.64382949064354	0.882010481457697	NULL	0.763004987332645	0.519837584069867	0.849500395263054	0.655324232151914	0.846206734171184	0.734822282911261	0.834639263566315	0.784625267452525	0.73751520459593	0.588871665659922	0.70868702906
5	NGc1	0.0750074048305008	0.31964428724902	0.304940773504532	NULL	0.370102656788757	0.291449210454585	0.300988537951972	0.289026102591427	0.00660348387393368	0.199768389980198	0.189228294801018	0.335682409852866	0.292183997347208	0.058850134727
6	OJc1	0.596649945333633	0.778504844528005	0.546450500912975	0.819263580675647	NULL	0.813819330832567	0.823343269418489	0.779698247128398	0.788859221721242	0.689337443401847	0.770557567147867	0.272553588639909	0.62676394510128	0.7830264790
7	PAc1	0.280035957209081	0.180868087337535	0.648309789787573	0.620961612283603	0.67923936933505	NULL	0.54665840194744	0.243614037629253	0.317054396505546	0.307160279909954	0.367179673993082	0.718495928717934	0.505345314628396	0.66844211314
8	PLc1	0.253134336810777	0.171517030026094	0.0967522924345442	0.184680747338959	0.19462051775021	0.160936787156372	NULL	0.370470843639298	0.212353957191453	0.209009259271842	0.196373669842703	0.331793337216267	0.180985767787244	0.12694600236
9	SIc1	0.090828196253682	0.105994474770968	0.396370611732013	0.368605817626813	0.356415058202037	0.115607821856327	0.683054734544425	NULL	0.0864624746519684	0.0305878057370776	0.0357498086519553	0.0647690414183997	0.461030750063676	0.42585373397
10	Wc1	1.64413861264447e-05	0.0365291683408635	0.120883689862418	0.00405845770490566	0.17287124549143	0.0749523823661992	0.203886762591826	0.0354184758758788	NULL	0.0129243201048921	0.00321829723752567	0.0483669240376226	0.199800275907558	0.065060511906
11	SOYc1	0.0471642410582236	0.0766400641872633	0.606586669708586	0.492548706650165	0.490478556025956	0.289739832791158	0.68888110977997	0.0756680612950109	0.0690324199253813	NULL	0.304746639487297	0.385626983124414	0.612450324819226	0.62706057102
12	HGc1	0.00985391703316851	0.33351085248027	0.67107877076532	0.582180783852009	0.70091335691193	0.547492112732794	0.835575828806848	0.108532785160159	0.0294641598831519	0.480642066326464	NULL	0.325029924460391	0.703306912933074	0.67689483272
13	SFSc1	0.144885631505813	0.532241008244818	0.971636376239852	0.983503988024622	0.559888561431062	0.980044109153648	0.991926649627594	0.643052817878946	0.765456682345034	0.894818086707756	0.749587832942687	NULL	0.989965859171955	0.98913466669
14	LCCc1	0.167051603821316	0.160848450512141	0.0569931825397124	0.12325953730663	0.0655745903479145	0.0927159077859873	0.134742247480393	0.15849057315578	0.141395186284484	0.124232211619281	0.116039266490041	0.138650425967049	NULL	0.13376088763
15	LCOc1	0.397105867179142	0.527282601737486	0.360121162668356	0.120912678720264	0.483783208899385	0.536722273358258	0.357382666834275	0.548802046541844	0.245009042238042	0.49774733384863	0.403013079007926	0.502910131346954	0.531662056151123	
16	RBc1	0.105892964245572	0.431812225798777	0.20654917628898	0.0707615459711524	0.326050472787988	0.484038634411792	0.360319352485784	0.36366740073681	0.0785402081471642	0.401800918071736	0.229212921666927	0.33820332625529	0.50306874767513	0.0062100365733
17	HOc1	0.097683468428375	0.381764321533874	0.20234700563848	0.00425454968456005	0.26478331068248	0.411261822384372	0.364225972529471	0.380578896916274	0.0176118636508978	0.303488799724174	0.24197553495174	0.305478487112898	0.413242580033868	0.0031810758226
18	SAFc1	0.0080257192436359	0.151318558625738	0.759120072399009	0.493377776423718	0.651620637624975	0.356354560597497	0.818526863081603	0.113207826235823	0.0402868397379144	0.36612509705429	0.0197555695107308	0.152020946018615	0.740633178765994	0.66977598248
19	SZNc1	0.331412130762261	0.516409550778261	0.633942179907854	0.483613231597838	0.569096301979107	0.597172544885719	0.462029641992595	0.525494225863202	0.492450440904491	0.618614982142609	0.501878783650096	0.701650426203789	0.19258857221917	0.60070657669
20	CUUc1	0.00265355192626248	0.152298808094432	0.0896317914350359	0.0286491438066931	0.145574740327117	0.237748066323724	0.158549628359483	0.0459219443300452	0.00197688771117113	0.093300471432067	0.00853565557687492	0.0502439371762208	0.343366605476425	0.027232114975

Table RESULTS_CAUSALITY

	index	CLc1_y	Cc1_y	GCc1_y	LCc1_y	NGc1_y	OJc1_y	PAc1_y	PLc1_y	SIc1_y	Wc1_y	SOYc1_y	HGc1_y	SFSc1_y
	Filtern	Filtern	Filtern	Filtern	Filtern	Filtern	Filtern	Filtern	Filtern	Filtern	Filtern	Filtern	Filtern	Filtern
1	CLc1	0.99999952946927	0.0170788610923616	0.114206076638294	0.253424961001019	0.595217244975527	0.773506162263175	0.521014114719235	0.393238747977489	0.0188979807269152	0.0660378503186412	0.186074457933537	0.00322938321706373	0.583676526386578
2	Cc1	0.494942576776031	1.0	0.000740484013317615	0.500575162200672	0.196476329666296	0.726788059501207	0.00269721568763793	0.260297222056068	0.00465075404448212	0.0159826221521123	0.00077105367823878	6.6906277804945e-06	0.00224987944304491
3	GCc1	0.109499775888369	0.511641241323003	1.0	0.768949162393528	0.185526163740797	0.574488430183378	0.0842314972485904	0.00656953139203864	0.000188098124530159	0.719679906796554	0.0252342428840083	0.631289186149164	0.225406386947434
4	LCc1	0.0105279061218276	0.114986319450575	0.181737019883738	1.0	0.0163374447760976	0.025979481680967	0.768215415991404	0.276315693605091	0.0560764014697756	0.0951358790151816	0.0604642908755195	0.0161186789052025	0.117132525670251
5	NGc1	0.00397416428752276	0.0598656226578351	0.192484881513713	0.617006542196967	0.999999590986455	0.966067995874279	0.143035341157236	0.558156768459838	0.088746656386524	0.00973074410095047	0.535737348073671	0.0154094070690562	0.250967071857022
6	OJc1	0.500915410588445	0.0257691226716387	0.0534026775946067	0.379941007486727	0.520974499982476	0.999999330446354	0.529060001753072	0.735392153718212	0.171866483827203	0.0813814810730197	0.00483275929118412	0.160610550270874	0.0274882155874372
7	PAc1	0.391475540815944	0.354669904209028	0.29882128052372	0.216021407212237	0.136628891162284	0.145879725503056	1.0	0.136429820420006	0.666174900146376	0.420876944279338	0.960029716703219	0.431160481308176	0.572669645706377
8	PLc1	0.485572176858539	0.605580929587908	0.920786616451292	0.469531979130224	0.966130511471812	0.57559790397116	0.427423860272427	1.0	0.88858524131946	0.716641058294184	0.0910024733253829	0.865213646801237	0.517537198203524
9	SIc1	0.351293502152641	0.58301310190764	0.00175019375814896	0.499882990903422	0.527832687510094	0.879525474946181	0.0456983223242439	0.190528294482694	0.999999492107074	0.475364726878366	0.000497295961038175	0.287303915827831	0.19012798562306
10	Wc1	0.415639998247578	0.0832887114842166	0.0176686306745721	0.964548660303109	0.0794660328331964	0.279401906511641	0.0123170583081468	0.806063444367064	0.0359544437137894	1.0	0.0597632110957832	0.000114149766987039	0.145613700052772
11	SOYc1	0.604350462392677	0.549393190593908	0.245631475919777	0.13129159041776	0.033157107033311	0.00901979252006933	0.0191769135438416	0.0674297327337641	0.62539753769522	0.0465506912580734	1.0	0.545074580991447	0.459611099648672
12	HGc1	0.0936787957404371	0.940519725717669	0.0142583323287269	0.131651419813103	0.469422998519081	0.739874738764517	0.0461391876632019	0.811359674425155	0.00802687478621744	0.911666659473841	0.0100365837939668	0.999999476049053	0.464015186549639
13	SFSc1	0.328581364733086	0.0442534638108627	0.00770137447283657	0.302930027375889	0.699254915478234	0.0585393940125509	0.102232304425198	0.120418988699851	0.00371228015258701	0.26100574601067	0.0058122895899569	0.0289082612829728	0.999999246144165
14	LCCc1	0.561627352254722	0.446733852671845	0.991583479936736	0.00515965174088492	0.718375487237879	0.972736353775859	0.528887418079994	0.428794990809118	0.94615812456758	0.179023878445055	0.226336934840524	0.923035881786135	0.949684421749975
15	LCOc1	0.0178455884646836	0.0377182143969331	0.14075021281529	0.194517996932217	0.480304726538508	0.805540918616645	0.520186742377101	0.426845408026448	0.0243791995274713	0.0458969546011209	0.22720124970522	0.00415547217742786	0.594776306530418
16	RBc1	0.232760569062152	0.00113994020649264	0.0656473220565082	0.873903767275587	0.896307229616939	0.552430947686033	0.284038259725327	0.268103181257998	0.0100848918674216	0.0038220371170223	0.0672206772769273	0.000298758654974092	0.329511985120829
17	HOc1	0.00201279760895471	0.00549999569374099	0.168505418674485	0.460825417214497	0.00507791653699124	0.999685256900417	0.278303022109945	0.573046285855716	0.0436715048002924	0.000170833617134232	0.164617120766234	0.000636918487624912	0.404430351282071
18	SAFc1	0.116157675863213	0.676839434420804	0.00448960968200795	0.133363149996787	0.109734917156891	0.730619223039297	0.00679381523486081	0.905440724348851	0.00567274134127269	0.321810897738986	0.0602078899614186	0.00321322520933602	0.111946253336953
19	SZNc1	0.593270262150558	0.755093282386081	0.165014471086658	0.107146103626124	0.438657253601889	0.556177793266391	0.214147465716553	0.906107741261573	0.0573679841408979	0.956249905999289	0.244087564375319	0.136513054056591	0.181171210632466
20	CUUc1	0.0039093757296632	7.03144276603361e-06	0.0101305925712897	0.80493754404557	0.0216601631679486	0.775685815972296	0.0409677952753368	0.212312760197295	0.000277521639981166	4.55004333616394e-05	0.0191143132822333	8.90823926490904e-05	0.0814914393610946