Coca Cola Stock Analysis

Import Libraries

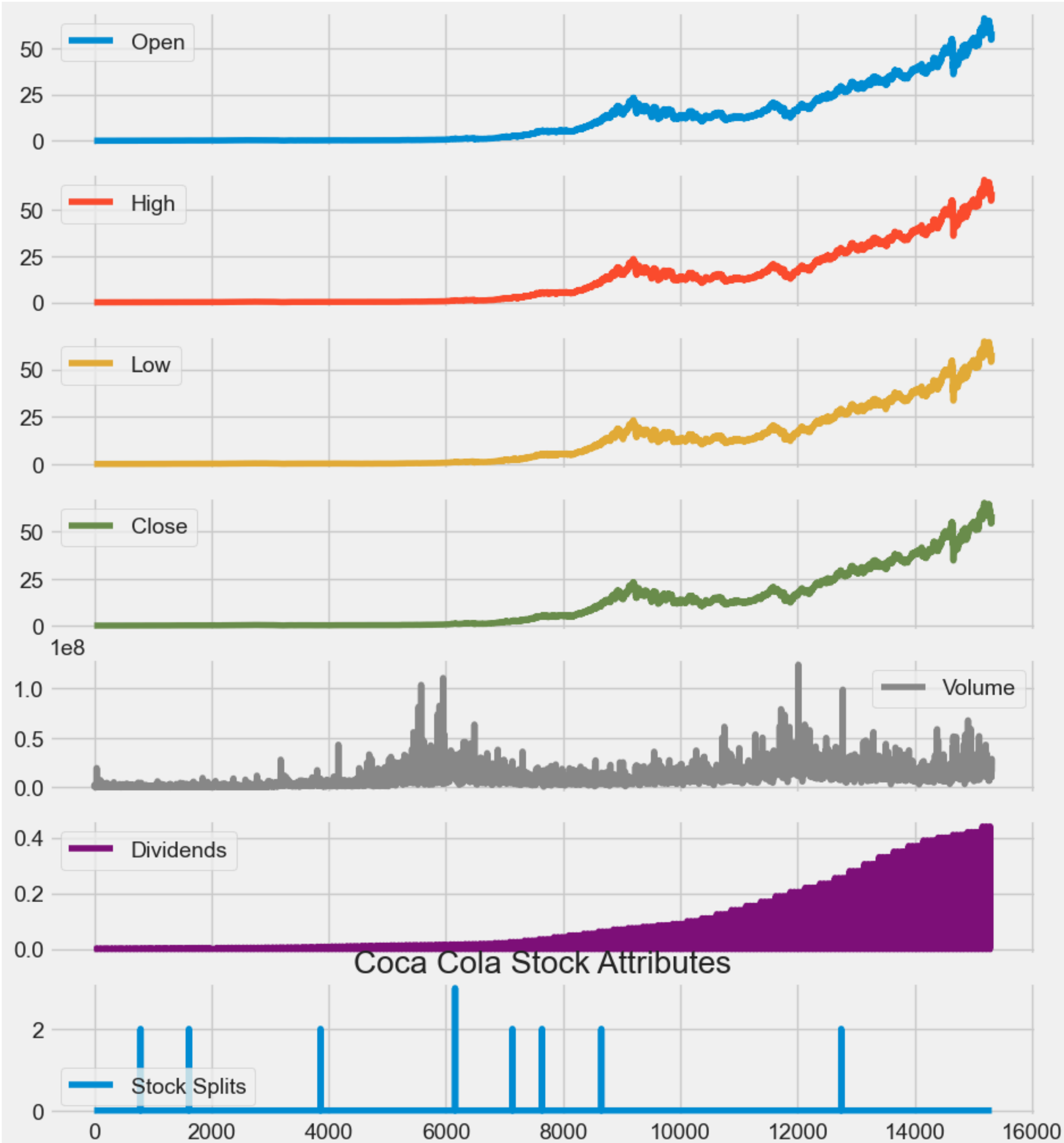
In [2]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
sns.set_style('whitegrid')
plt.style.use('fivethirtyeight')
%matplotlib inline

# For reading stock data from yahoo
from pandas_datareader.data import DataReader

# For time stamps
from datetime import datetime
from math import sqrt

from sklearn.metrics import mean_squared_error
from sklearn.preprocessing import MinMaxScaler

# Ignore the warnings
import warnings
warnings.filterwarnings('ignore')
```

Load Dataset

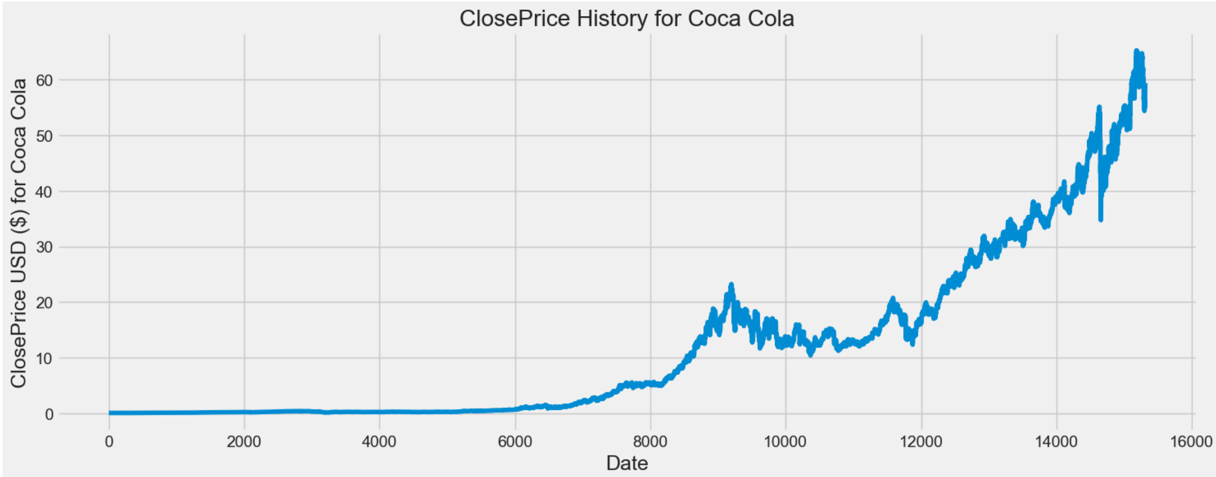
In [3]:
```
KO_Data=pd.read_csv('Coca-Cola_stock_history.csv')
```

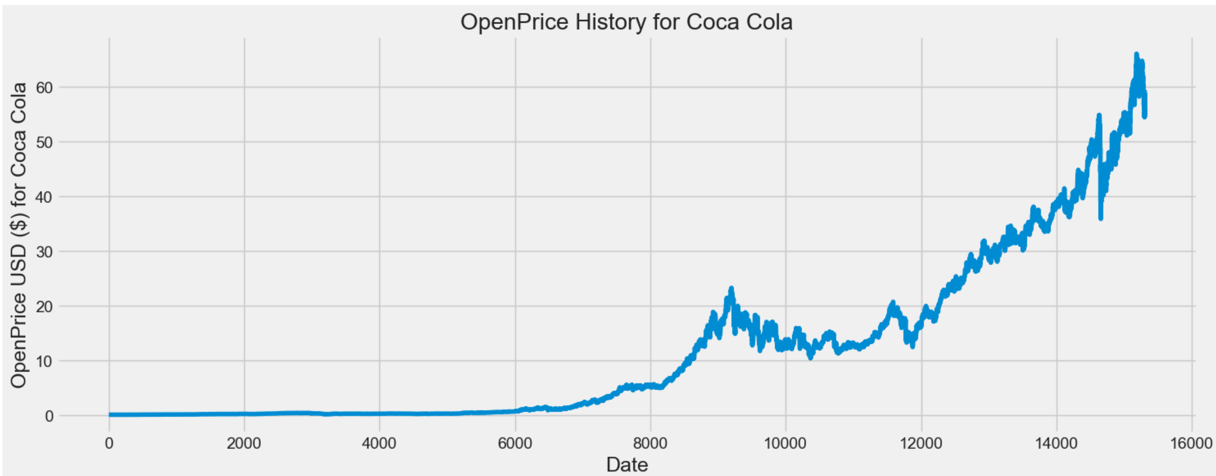
Basic EDA

In [4]:
```
KO_Data.plot(subplots=True,figsize=(10,12))
plt.title('Coca Cola Stock Attributes')
plt.show()
```



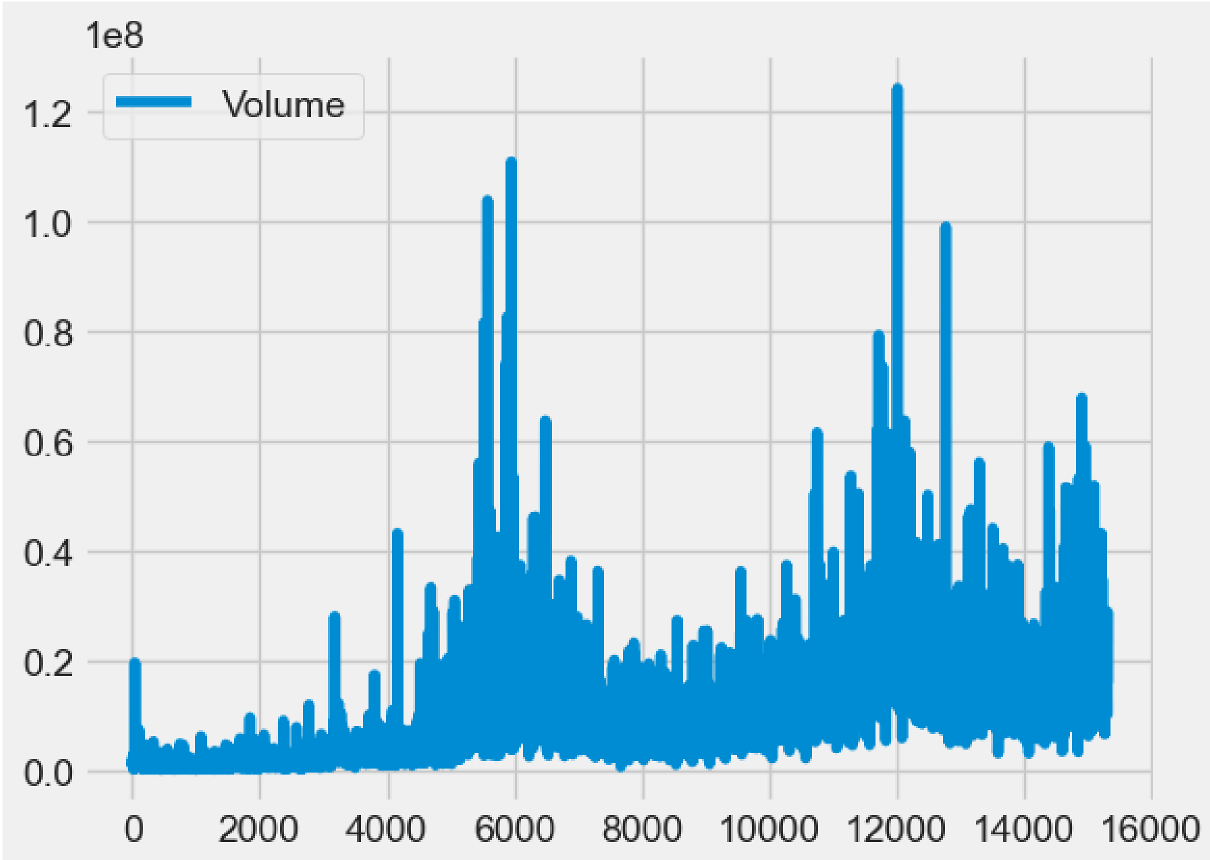
In [5]:
```
def plot_close_val(data_frame,column,stock):
    plt.figure(figsize=(16,6))
    plt.title(column+'Price History for ' +stock)
    plt.plot(data_frame[column])
    plt.xlabel('Date',fontsize=18)
    plt.ylabel(column+'Price USD ($) for ' +stock,fontsize=18)
    plt.show()

    # Test the function
plot_close_val(KO_Data,'Close','Coca Cola')
plot_close_val(KO_Data,'Open','Coca Cola')
```





In [6]:
```
KO_Data[['Volume']].plot()
```

Out[6]:
```
<Axes: >
```



Basic Company Info

In [7]:
```
ko_info=pd.read_csv('Coca-Cola_stock_info.csv',header=None,names=(['Description','I
ko_info.dropna()
ko_info.drop(ko_info.loc[ko_info['Information']=='nan'].index,inplace=True)
ko=ko_info.sort_values('Information').style
ko
```

Out[7]:

	Description	Information
49	gmtOffSetMilliseconds	-18000000
145	bid	0
138	ask	0
77	heldPercentInsiders	0.00636
68	sharesPercentSharesOut	0.0074
100	shortPercentOfFloat	0.0074
108	trailingAnnualDividendYield	0.027917083
147	dividendYield	0.028099999
29	returnOnAssets	0.07831
75	SandP52WeekChange	0.15025425
18	revenueGrowth	0.161
58	52WeekChange	0.21709049
15	profitMargins	0.23313999
19	operatingMargins	0.31123
14	ebitdaMargins	0.35199
33	returnOnEquity	0.39722002
74	lastDividendValue	0.42
93	earningsQuarterlyGrowth	0.423
27	earningsGrowth	0.425
16	grossMargins	0.60723996
71	heldPercentInstitutions	0.7005
84	beta	0.712113
109	payoutRatio	0.82269996
11	maxAge	1
41	quickRatio	1.173
28	currentRatio	1.516
81	shortRatio	1.6
116	trailingAnnualDividendRate	1.67
122	dividendRate	1.68
139	askSize	1000

	Description	Information
76	priceToBook	11.606621
17	operatingCashflow	12855000064
20	ebitda	13306000384
88	lastSplitDate	1344816000
35	totalCash	14871000064
70	lastFiscalYearEnd	1609372800
80	mostRecentQuarter	1633046400
91	lastDividendDate	1638230400
82	sharesShortPreviousMonthDate	1638230400
123	exDividendDate	1638230400
95	dateShortInterest	1640908800
78	nextFiscalYearEnd	1672444800
32	debtToEquity	172.826
136	averageVolume	17746368
140	volume	18219394
129	regularMarketVolume	18219394
23	grossProfits	19581000000
86	priceHint	2
73	trailingEps	2.031
42	recommendationMean	2.1
60	forwardEps	2.43
153	trailingPegRatio	2.6848
96	pegRatio	2.77
119	averageVolume10days	20867790
113	averageDailyVolume10Day	20867790
57	enterpriseToEbitda	21.583
98	forwardPE	24.526747
101	sharesShortPriorMonth	24026403
30	numberOfAnalystOpinions	25
133	marketCap	257437417472

	Description	Information
85	enterpriseValue	287178719232
128	trailingPE	29.34515
89	lastSplitFactor	2:1
143	fiveYearAvgDividendYield	3.21
38	totalCashPerShare	3.443
1	zip	30313
67	sharesShort	31874471
37	totalRevenue	37802000384
83	floatShares	3890760972
6	phone	404 676 2121
36	totalDebt	41707999232
102	impliedSharesOutstanding	4311130112
62	sharesOutstanding	4319419904
144	fiftyTwoWeekLow	48.11
66	bookValue	5.135
107	twoHundredDayAverage	55.77645
115	fiftyDayAverage	57.6512
21	targetLowPrice	58
137	dayLow	59.21
126	regularMarketDayLow	59.21
150	regularMarketPrice	59.6
26	currentPrice	59.6
117	open	59.79
106	regularMarketOpen	59.79
114	regularMarketPreviousClose	59.82
105	previousClose	59.82
94	priceToSalesTrailing12Months	6.8101535
149	dayHigh	60.345
111	regularMarketDayHigh	60.345
141	fiftyTwoWeekHigh	61.45

	Description	Information
31	targetMeanPrice	63.72
25	targetMedianPrice	64
55	enterpriseToRevenue	7.597
34	targetHighPrice	70
24	freeCashflow	7007374848
40	revenuePerShare	8.771
148	bidSize	800
3	fullTimeEmployees	80300
72	netIncomeToCommon	8812999680
46	exchangeTimezoneName	America/New_York
5	city	Atlanta
13	industry	Beverages—Non-Alcoholic
44	shortName	Coca-Cola Company (The)
2	sector	Consumer Defensive
50	quoteType	EQUITY
47	exchangeTimezoneShortName	EST
146	tradeable	False
48	isEsgPopulated	False
7	state	GA
51	symbol	KO
43	exchange	NYQ
12	address1	One Coca-Cola Plaza
45	longName	The Coca-Cola Company
4	longBusinessSummary	The Coca-Cola Company, a beverage company, manufactures, markets, and sells various nonalcoholic beverages worldwide. The company provides sparkling soft drinks; water, enhanced water, and sports drinks; juice, dairy, and plantÂ based beverages; tea and coffee; and energy drinks. It also offers beverage concentrates and syrups, as well as fountain syrups to fountain retailers, such as restaurants and convenience stores. The company sells its products under the Coca-Cola, Diet Coke/Coca-Cola Light, Coca-Cola Zero Sugar, Fanta, Fresca, Schweppes, Sprite, Thums Up, Aquarius, Ciel, Dasani, glacÃ©au smartwater, glacÃ©au vitaminwater, Ice Dew, I LOHAS, Powerade, Topo Chico, AdeS, Del Valle, fairlife,

	Description	Information
		innocent, Minute Maid, Minute Maid Pulpy, Simply, Ayataka, Costa, dogadan, FUZE TEA, Georgia, Gold Peak, HONEST TEA, and Kochakaden brands. It operates through a network of independent bottling partners, distributors, wholesalers, and retailers, as well as through bottling and distribution operators. The company was founded in 1886 and is headquartered in Atlanta, Georgia.
127	currency	USD
39	financialCurrency	USD
8	country	United States
0	Key	Value
9	companyOfficers	[]
22	recommendationKey	buy
52	messageBoardId	finmb_26642
152	logo_url	https://logo.clearbit.com/coca-colacompany.com
10	website	https://www.coca-colacompany.com
53	market	us_market
54	annualHoldingsTurnover	nan
56	beta3Year	nan
59	morningStarRiskRating	nan
61	revenueQuarterlyGrowth	nan
63	fundInceptionDate	nan
64	annualReportExpenseRatio	nan
65	totalAssets	nan
69	fundFamily	nan
79	yield	nan
87	threeYearAverageReturn	nan
90	legalType	nan
92	morningStarOverallRating	nan
97	ytdReturn	nan
99	lastCapGain	nan
103	category	nan
104	fiveYearAverageReturn	nan

	Description	Information
110	volume24Hr	nan
112	navPrice	nan
118	toCurrency	nan
120	expireDate	nan
121	algorithm	nan
124	circulatingSupply	nan
125	startDate	nan
130	lastMarket	nan
131	maxSupply	nan
132	openInterest	nan
134	volumeAllCurrencies	nan
135	strikePrice	nan
142	fromCurrency	nan
151	preMarketPrice	nan

Basic CAGR

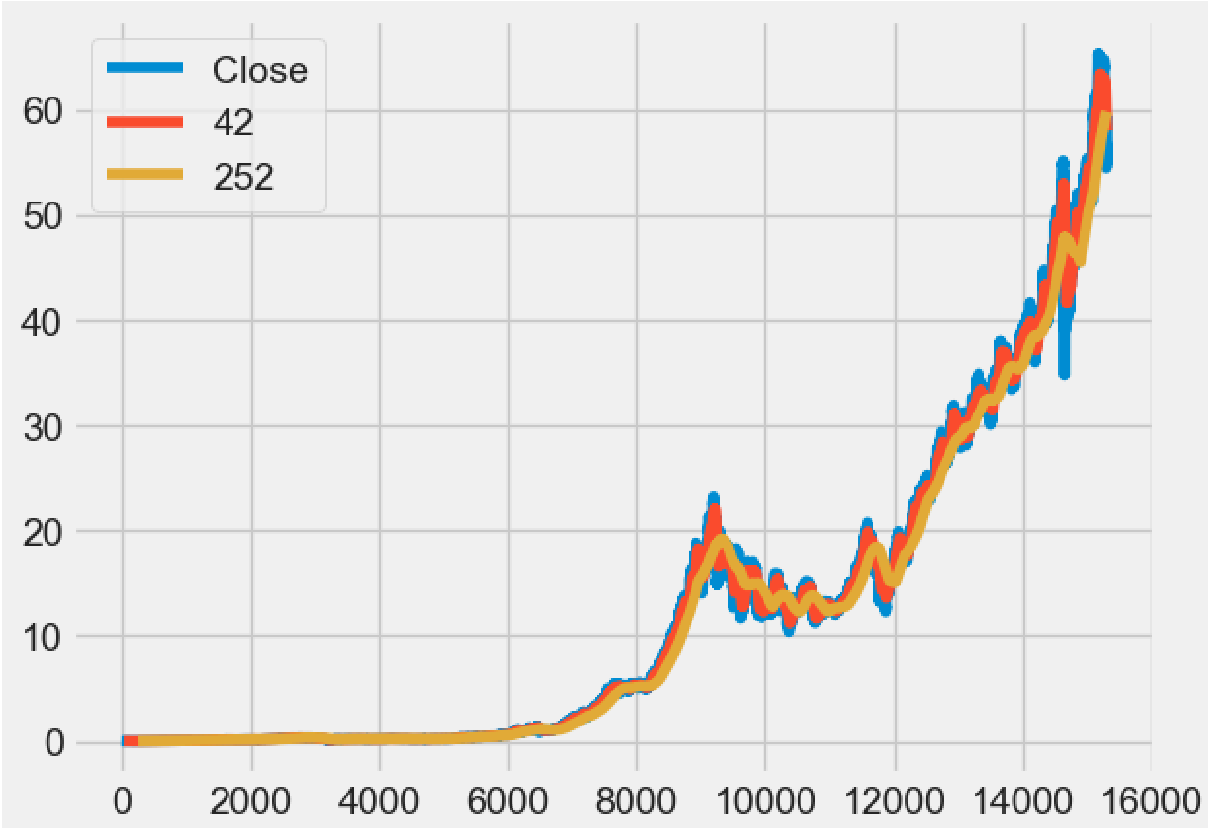
1. Basic Rolling Averages

In [8]:
```
# Isolate the adjusted closing prices
adj_close_px=KO_Data['Close']

#Calculate the moving average
moving_avg=adj_close_px.rolling(window=40).mean()

# Inspect the result
moving_avg[-10:]
```

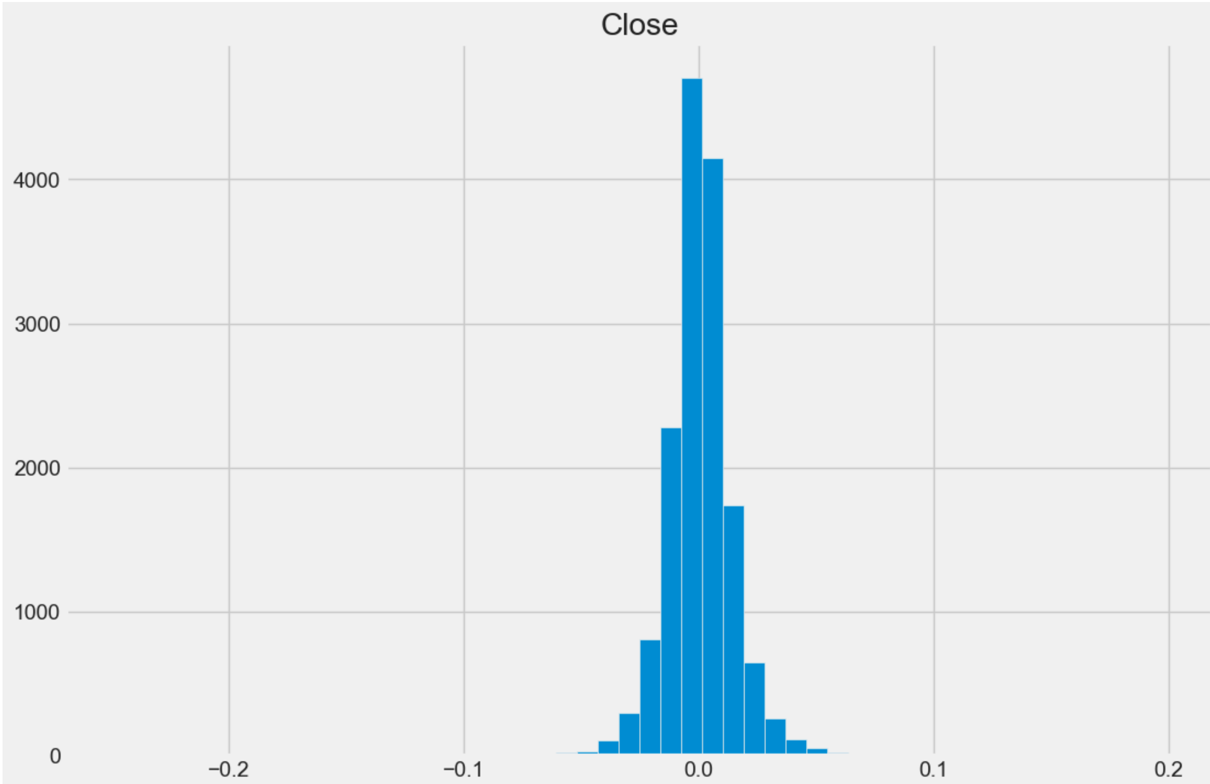
Out[8]:
```
15301    59.573229
15302    59.329031
15303    59.103823
15304    58.921440
15305    58.725320
15306    58.504966
15307    58.298918
15308    58.171838
15309    58.088689
15310    58.030935
Name: Close, dtype: float64
```

In [9]:
```
# Short moving window rolling mean
KO_Data['42']=adj_close_px.rolling(window=40).mean()
```

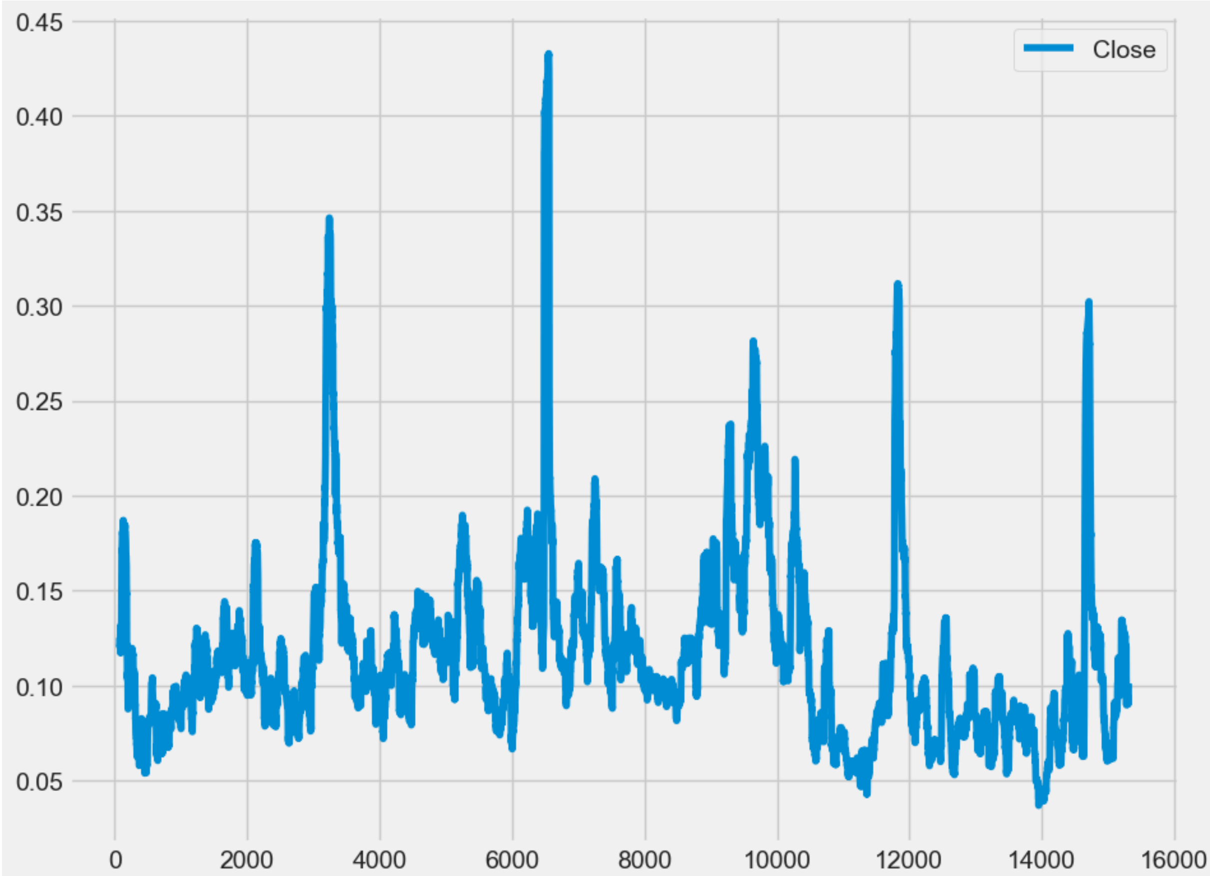
```
#long moving window rolling mean
KO_Data['252']=adj_close_px.rolling(window=252).mean()

# Plot the adjusted closing price,the short and long windows of rolling means
KO_Data[['Close','42','252']].plot()
plt.show()
```



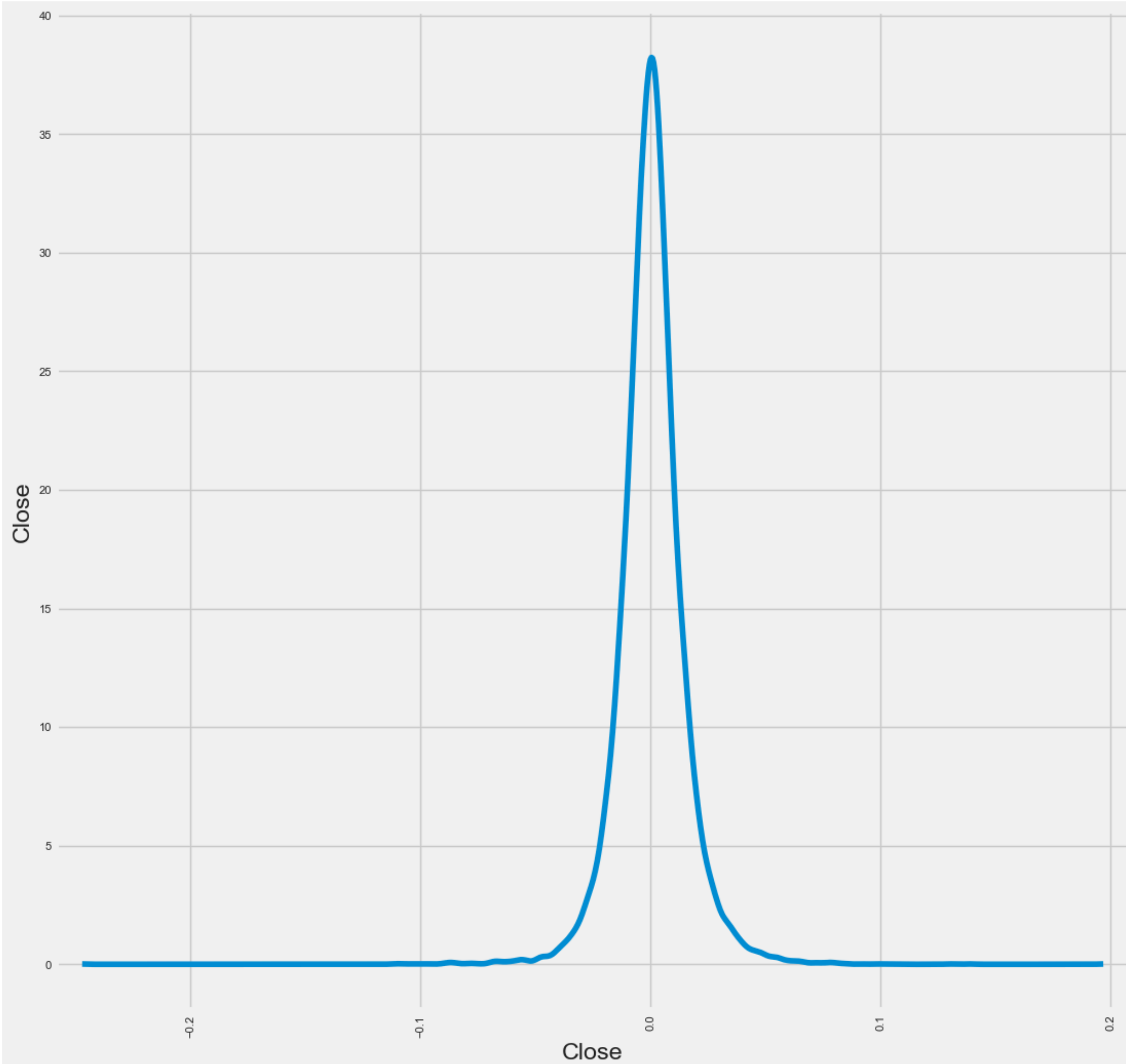
In [10]:
```
daily_close_px=KO_Data[['Close']]

# Calculate the daily percentage change for 'daily_close_px'
daily_pct_change=daily_close_px.pct_change()

# Plot the distributions
daily_pct_change.hist(bins=50,sharex=True,figsize=(12,8))

# Show the resulting plot
plt.show()
```



In [11]:
```
# Define the minimum of periods to consider
min_periods=75

# Calculate the volatility
np.sqrt(min_periods)

#Plot the volatility
vol=daily_pct_change.rolling(min_periods).std()*np.sqrt(min_periods)

# Plot the volatility
vol.plot(figsize=(10,8))

# Show the plot
plt.show()
```

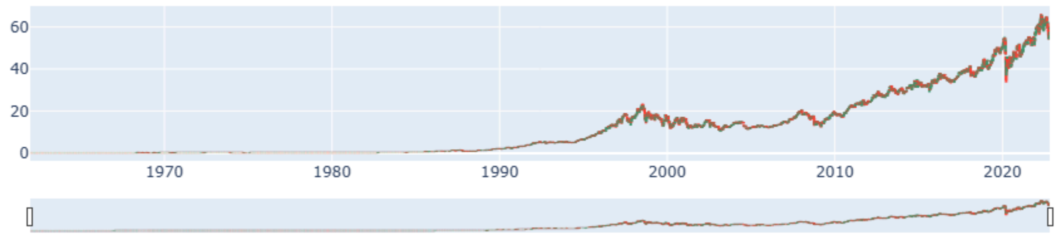


In [12]:
```
# Plot a scatter matrix with the 'daily_pct_change' data
pd.plotting.scatter_matrix(daily_pct_change,diagonal='kde',alpha=0.1,figsize=(12,12

# Show the plot
plt.show()
```



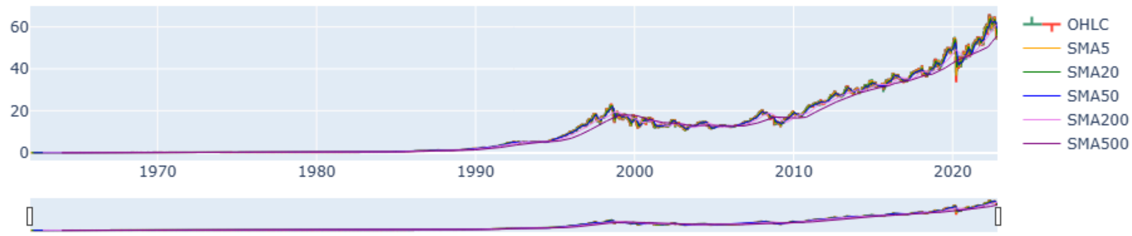
2. Basic MACD

In [13]:
```
import plotly.graph_objects as go

KO_Data=KO_Data.reset_index()

fig=go.Figure(data=go.Ohlc(x=KO_Data['Date'],
            open=KO_Data['Open'],
            high=KO_Data['High'],
            low=KO_Data['Low'],
            close=KO_Data['Close']))
fig.show()
```



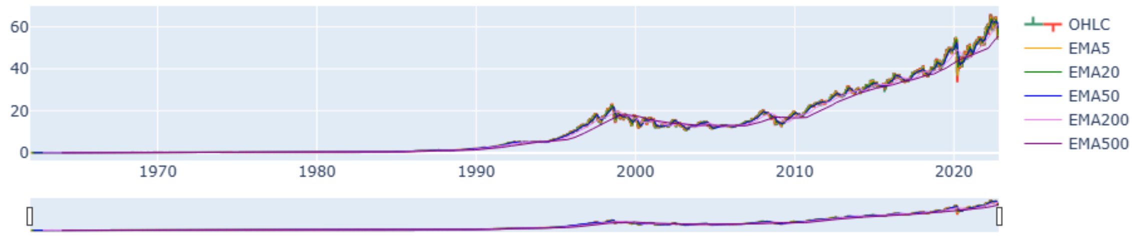
2.1 Basic SMA -Simple Moving Average

In [14]:
```
# KO_Data=KO_Data.reset_index()

KO_Data['SMA5']=KO_Data.Close.rolling(5).mean()
KO_Data['SMA20']=KO_Data.Close.rolling(20).mean()
KO_Data['SMA50']=KO_Data.Close.rolling(50).mean()
KO_Data['SMA200']=KO_Data.Close.rolling(200).mean()
KO_Data['SMA500']=KO_Data.Close.rolling(500).mean()

fig=go.Figure(data=[go.Ohlc(x=KO_Data['Date'],
            open=KO_Data['Open'],
            high=KO_Data['High'],
            low=KO_Data['Low'],
            close=KO_Data['Close'],
            name='OHLC'),
            go.Scatter(x=KO_Data.Date,y=KO_Data.SMA5,line=dict(color='orange',width
                       name='SMA5'),
            go.Scatter(x=KO_Data.Date,y=KO_Data.SMA20,line=dict(color='green',width
                       name='SMA20'),
            go.Scatter(x=KO_Data.Date,y=KO_Data.SMA50,line=dict(color='blue',width=
                       name='SMA50'),
            go.Scatter(x=KO_Data.Date,y=KO_Data.SMA200,line=dict(color='violet',wid
                       name='SMA200'),
            go.Scatter(x=KO_Data.Date,y=KO_Data.SMA500,line=dict(color='purple',wid
                       name='SMA500')])
fig.show()
```



2.2 Basic EMA -Exponential Moving Average

In [15]:
```
KO_Data['EMA5']=KO_Data.Close.ewm(span=5,adjust=False).mean()
KO_Data['EMA20']=KO_Data.Close.ewm(span=20,adjust=False).mean()
KO_Data['EMA50']=KO_Data.Close.ewm(span=50,adjust=False).mean()
KO_Data['EMA200']=KO_Data.Close.ewm(span=200,adjust=False).mean()
KO_Data['EMA500']=KO_Data.Close.ewm(span=500,adjust=False).mean()


fig = go.Figure(data=[go.Ohlc(x=KO_Data['Date'],
open=KO_Data['Open'],
high=KO_Data['High'],
low=KO_Data['Low'],
close=KO_Data['Close'], name =
"OHLC"),
   go.Scatter(x=KO_Data.Date,
y=KO_Data.SMA5, line=dict(color='orange', width=1),
name="EMA5"),
  go.Scatter(x=KO_Data.Date,
y=KO_Data.SMA20, line=dict(color='green', width=1),
name="EMA20"),
   go.Scatter(x=KO_Data.Date,
y=KO_Data.SMA50, line=dict(color='blue', width=1),
name="EMA50"),
   go.Scatter(x=KO_Data.Date,
y=KO_Data.SMA200, line=dict(color='violet', width=1),
name="EMA200"),
  go.Scatter(x=KO_Data.Date,
y=KO_Data.SMA500, line=dict(color='purple', width=1),
name="EMA500")])

fig.show()
```



In [16]:
```
KO_Data.head()
# KO_Data.fillna(0)
# KO_Data.set_index('Date')
```

Out[16]:

	index	Date	Open	High	Low	Close	Volume	Dividends	Stock Splits	42
0	0	1962-01-02	0.050016	0.051378	0.050016	0.050016	806400	0.0	0	NaN
1	1	1962-01-03	0.049273	0.049273	0.048159	0.048902	1574400	0.0	0	NaN
2	2	1962-01-04	0.049026	0.049645	0.049026	0.049273	844800	0.0	0	NaN
3	3	1962-01-05	0.049273	0.049892	0.048035	0.048159	1420800	0.0	0	NaN
4	4	1962-01-08	0.047787	0.047787	0.046735	0.047664	2035200	0.0	0	NaN

5 rows × 21 columns

FINTA Tech Analysis Ratios

Let us do a financial ratios calculation using FINTA library

In [17]:
```
from finta import TA
from backtesting import Backtest,Strategy
from backtesting.lib import crossover
```

In [18]:
```
fin_ma=pd.read_csv('Coca-Cola_stock_history.csv', parse_dates=True)
print(fin_ma.head())
ohlc=fin_ma
print(TA.SMA(ohlc,42))

# ohlc.index=ohlc[index].dt.date
```

```
         Date      Open      High       Low     Close   Volume  Dividends  \
0  1962-01-02  0.050016  0.051378  0.050016  0.050016   806400        0.0
1  1962-01-03  0.049273  0.049273  0.048159  0.048902  1574400        0.0
2  1962-01-04  0.049026  0.049645  0.049026  0.049273   844800        0.0
3  1962-01-05  0.049273  0.049892  0.048035  0.048159  1420800        0.0
4  1962-01-08  0.047787  0.047787  0.046735  0.047664  2035200        0.0

   Stock Splits
0             0
1             0
2             0
3             0
4             0
0              NaN
1              NaN
2              NaN
3              NaN
4              NaN
            ...
15306    58.759467
15307    58.572686
15308    58.422110
15309    58.297065
15310    58.219369
Name: 42 period SMA, Length: 15311, dtype: float64
```

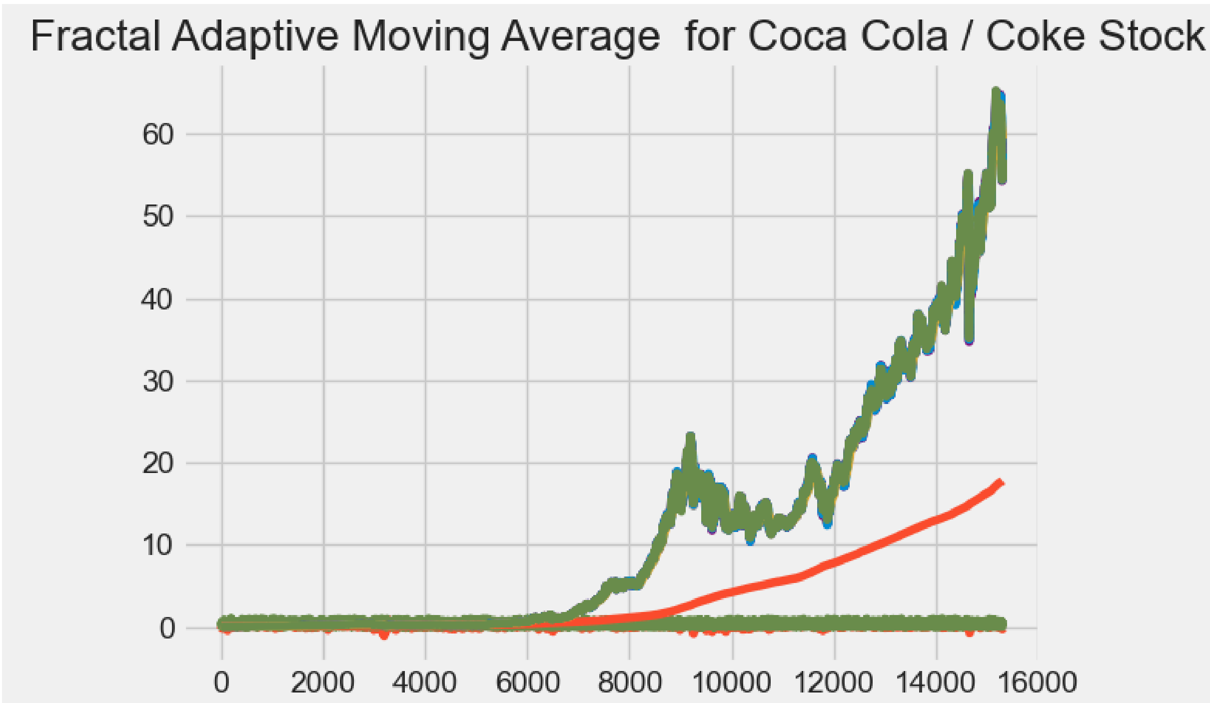
In [19]:

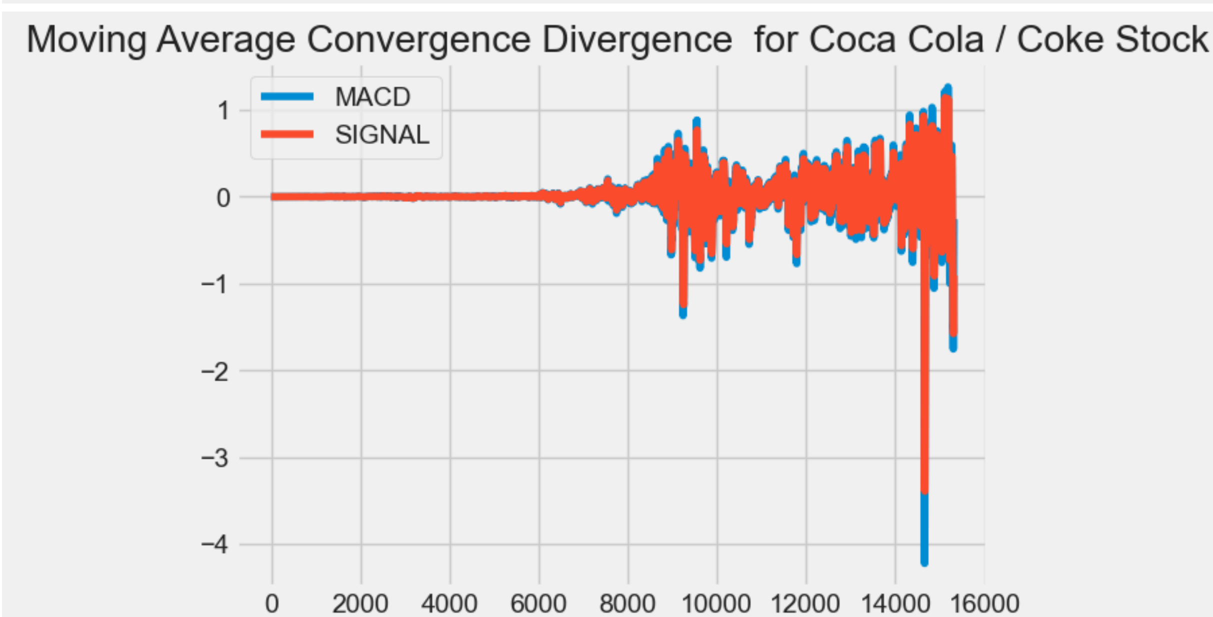
```python
function_dict = {' Simple Moving Average ' : 'SMA',
' Simple Moving Median ' : 'SMM',
' Smoothed Simple Moving Average ' : 'SSMA',
' Exponential Moving Average ' : 'EMA',
' Double Exponential Moving Average ' :
'DEMA',
' Triple Exponential Moving Average ' :
'TEMA',
' Triangular Moving Average ' : 'TRIMA',
' Triple Exponential Moving Average Oscillator' : 'TRIX',
' Volume Adjusted Moving Average ' : 'VAMA',
' Kaufman Efficiency Indicator ' : 'ER',
' Kaufmans Adaptive Moving Average ' : 'KAMA',
' Zero Lag Exponential Moving Average ' :
'ZLEMA',
' Weighted Moving Average ' : 'WMA',
' Hull Moving Average ' : 'HMA',
' Elastic Volume Moving Average ' : 'EVWMA',
' Volume Weighted Average Price ' : 'VWAP',
' Smoothed Moving Average ' : 'SMMA',
' Fractal Adaptive Moving Average ' : 'FRAMA',
' Moving Average Convergence Divergence ' :
'MACD',
' Percentage Price Oscillator ' : 'PPO',
' Volume-Weighted MACD ' : 'VW_MACD',
' Elastic-Volume weighted MACD ' : 'EV_MACD',
' Market Momentum ' : 'MOM',
' Rate-of-Change ' : 'ROC',
' Relative Strength Index ' : 'RSI',
' Inverse Fisher Transform RSI ' : 'IFT_RSI',
```

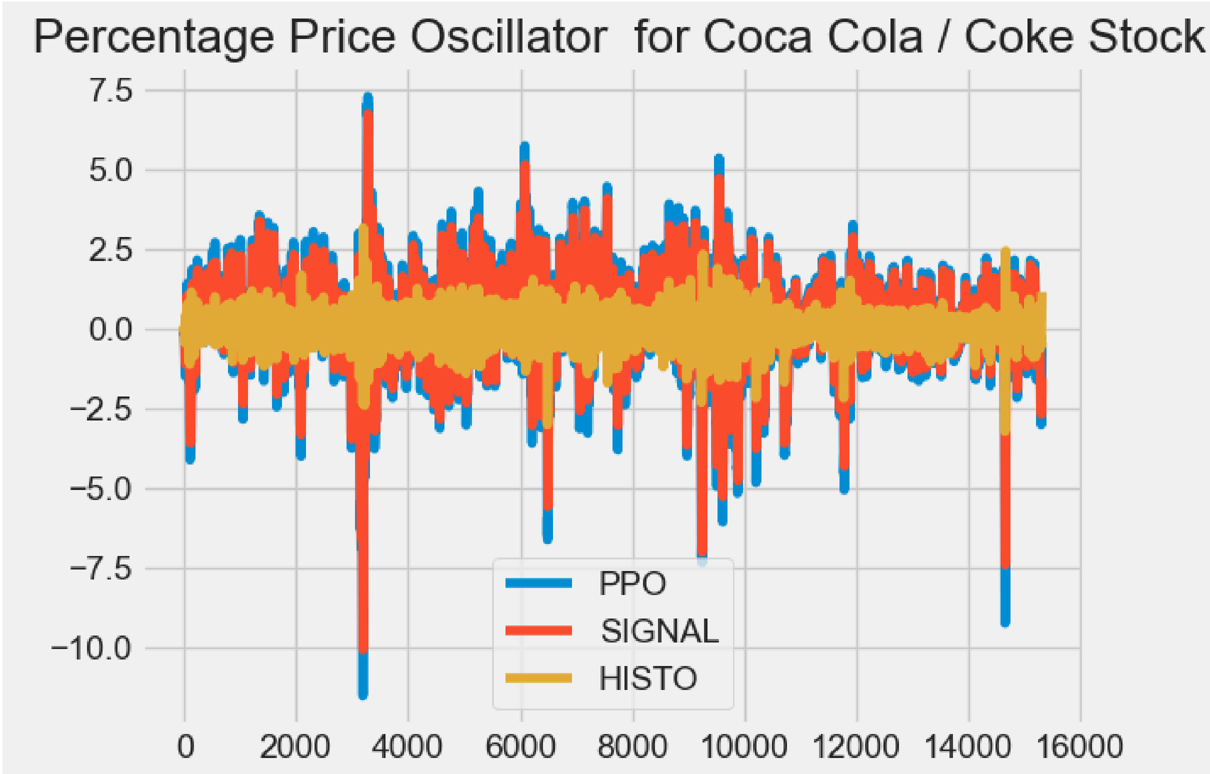
```
' True Range ' : 'TR',
' Average True Range ' : 'ATR',
' Stop-and-Reverse ' : 'SAR',
' Bollinger Bands ' : 'BBANDS',
' Bollinger Bands Width ' : 'BBWIDTH',
' Momentum Breakout Bands ' : 'MOBO',
' Percent B ' : 'PERCENT_B',
' Keltner Channels ' : 'KC',
' Donchian Channel ' : 'DO',
' Directional Movement Indicator ' : 'DMI',
' Average Directional Index ' : 'ADX',
' Pivot Points ' : 'PIVOT',
' Fibonacci Pivot Points ' : 'PIVOT_FIB',
' Stochastic Oscillator Percent K ' : 'STOCH',
' Stochastic oscillator Percent D ' :
'STOCHD',
' Stochastic RSI ' : 'STOCHRSI',
' Williams Percent R ' : 'WILLIAMS',
' Ultimate Oscillator ' : 'UO',
' Awesome Oscillator ' : 'AO',
' Mass Index ' : 'MI',
#' Vortex Indicator ' : 'VORTEX',
' Know Sure Thing ' : 'KST',
' True Strength Index ' : 'TSI',
' Typical Price ' : 'TP',
' Accumulation-Distribution Line ' : 'ADL',
' Chaikin Oscillator ' : 'CHAIKIN',
' Money Flow Index ' : 'MFI',
' On Balance Volume ' : 'OBV',
' Weighter OBV ' : 'WOBV',
' Volume Zone Oscillator ' : 'VZO',
' Price Zone Oscillator ' : 'PZO',
' Elders Force Index ' : 'EFI',
' Cummulative Force Index ' : 'CFI',
' Bull power and Bear Power ' : 'EBBP',
' Ease of Movement ' : 'EMV',
' Commodity Channel Index ' : 'CCI',
' Coppock Curve ' : 'COPP',
' Buy and Sell Pressure ' : 'BASP',
' Normalized BASP ' : 'BASPN',
' Chande Momentum Oscillator ' : 'CMO',
' Chandelier Exit ' : 'CHANDELIER',
' Qstick ' : 'QSTICK',
#' Twiggs Money Index ' : 'TMF',
' Wave Trend Oscillator ' : 'WTO',
' Fisher Transform ' : 'FISH',
' Ichimoku Cloud ' : 'ICHIMOKU',
' Adaptive Price Zone ' : 'APZ',
#' Squeeze Momentum Indicator ' : 'SQZMI',
' Volume Price Trend ' : 'VPT',
' Finite Volume Element ' : 'FVE',
' Volume Flow Indicator ' : 'VFI',
' Moving Standard deviation ' : 'MSD',
' Schaff Trend Cycle ' : 'STC'}

# Loop through each indicator
```

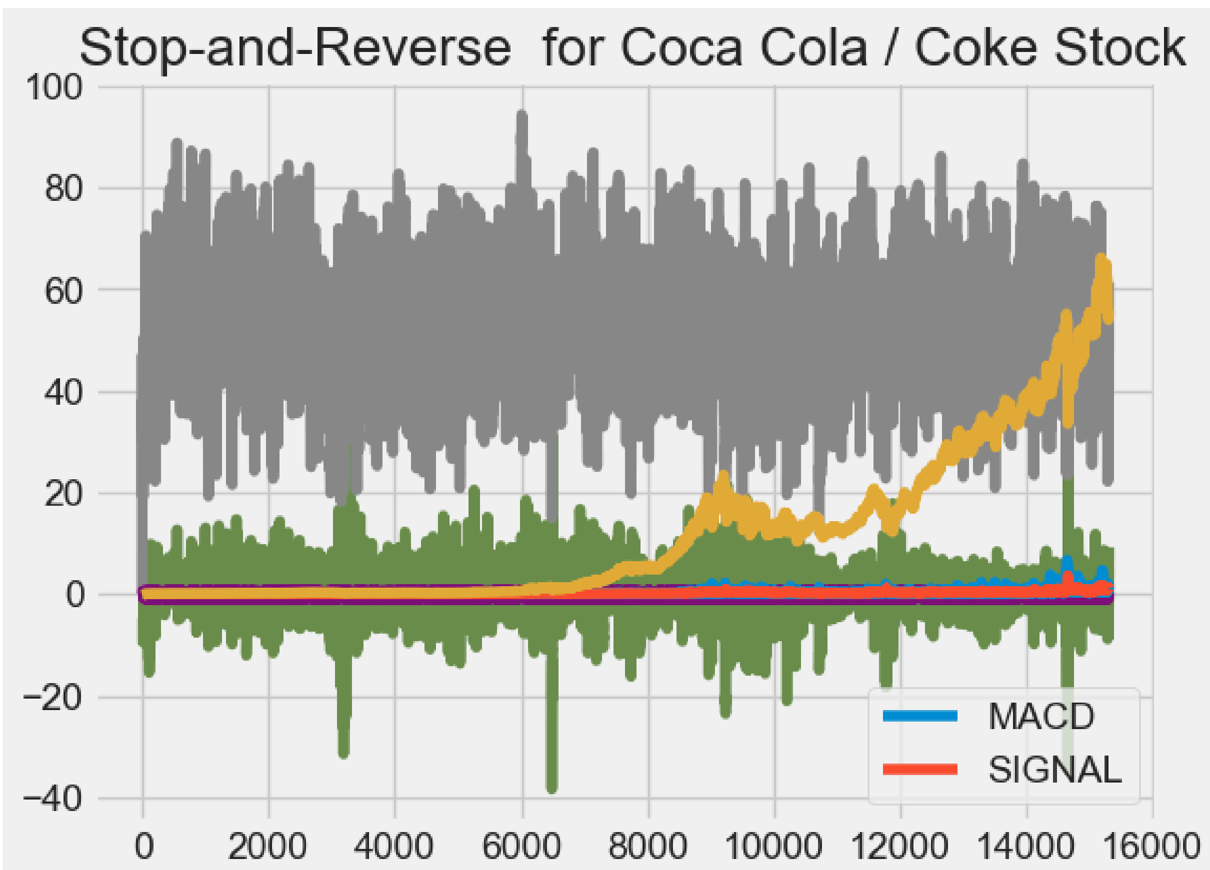
```
for key, value in function_dict.items():
    try:
        result = getattr(TA, value)(ohlc)
        result.plot(title=f"{key} for Coca Cola / Coke Stock")
    except Exception as e:
        print(f"Error in {key}: {e}")
```

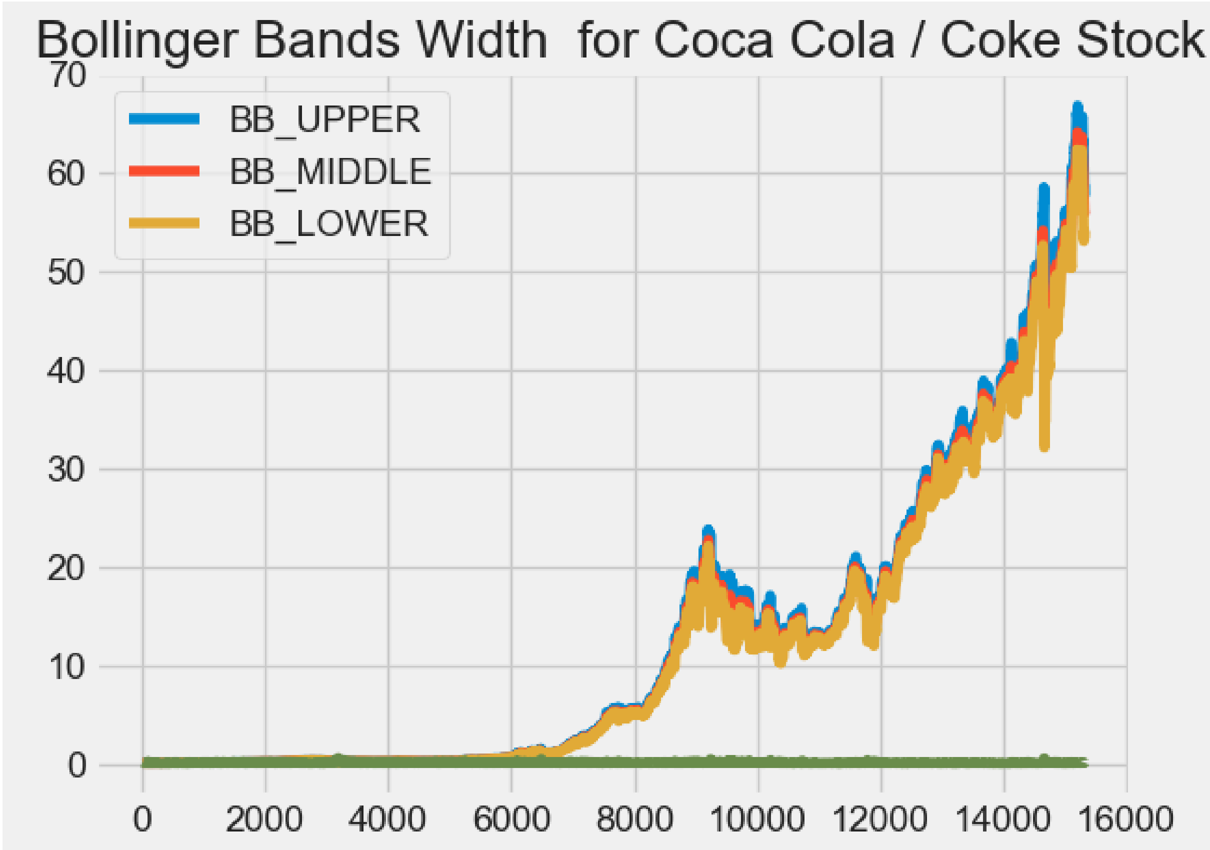
```
Error in  Kaufmans Adaptive Moving Average : 'Series' object has no attribute 'iteri
tems'
Error in  Elastic Volume Moving Average : 'Series' object has no attribute 'iteritem
s'
Error in  Elastic-Volume weighted MACD : 'Series' object has no attribute 'iteritem
s'
```

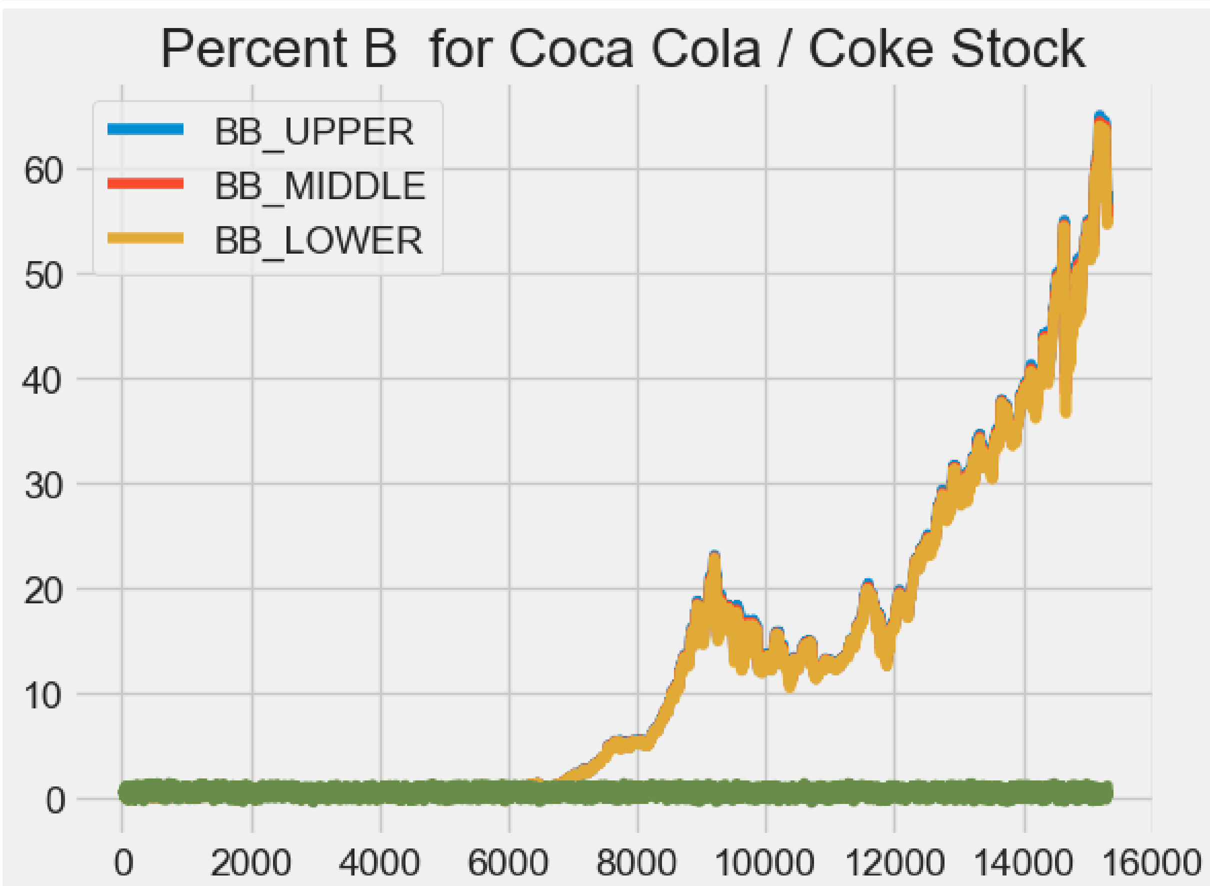


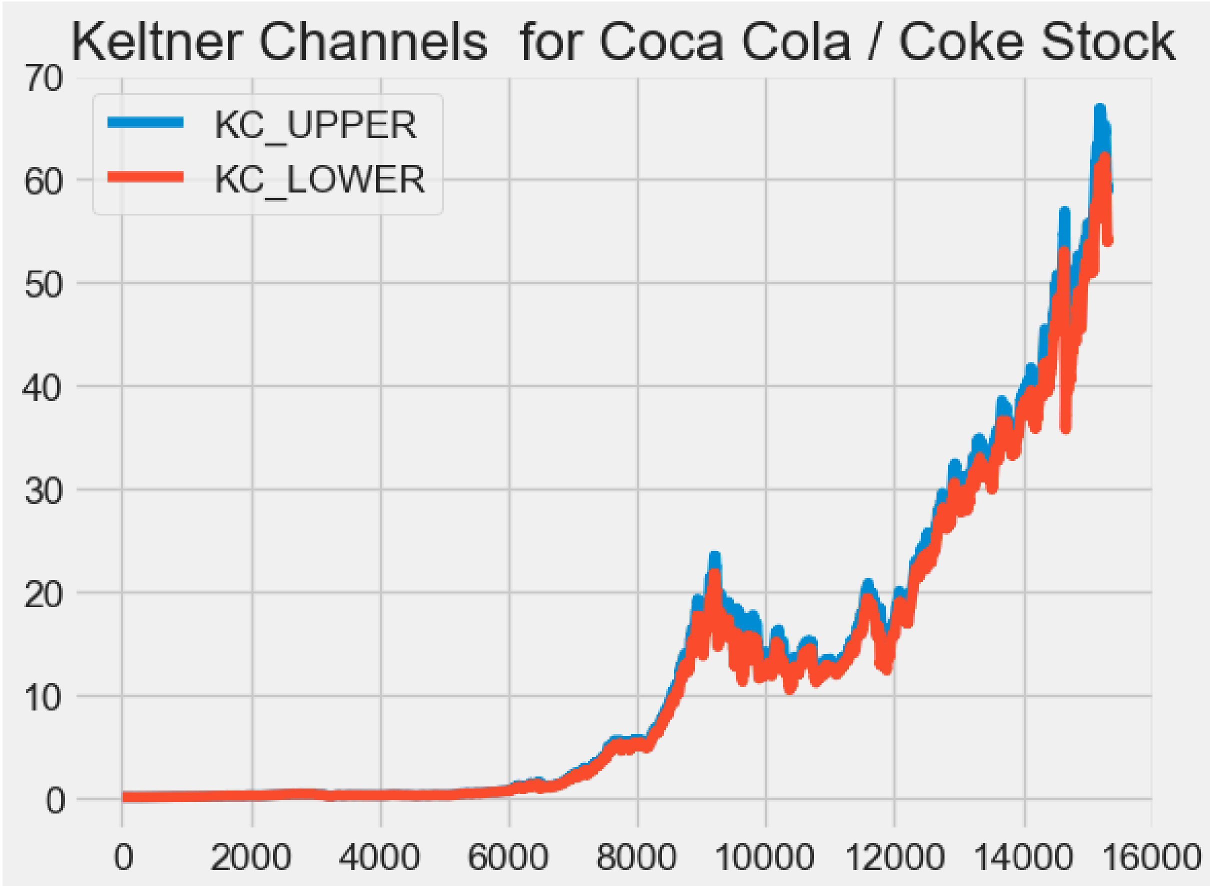


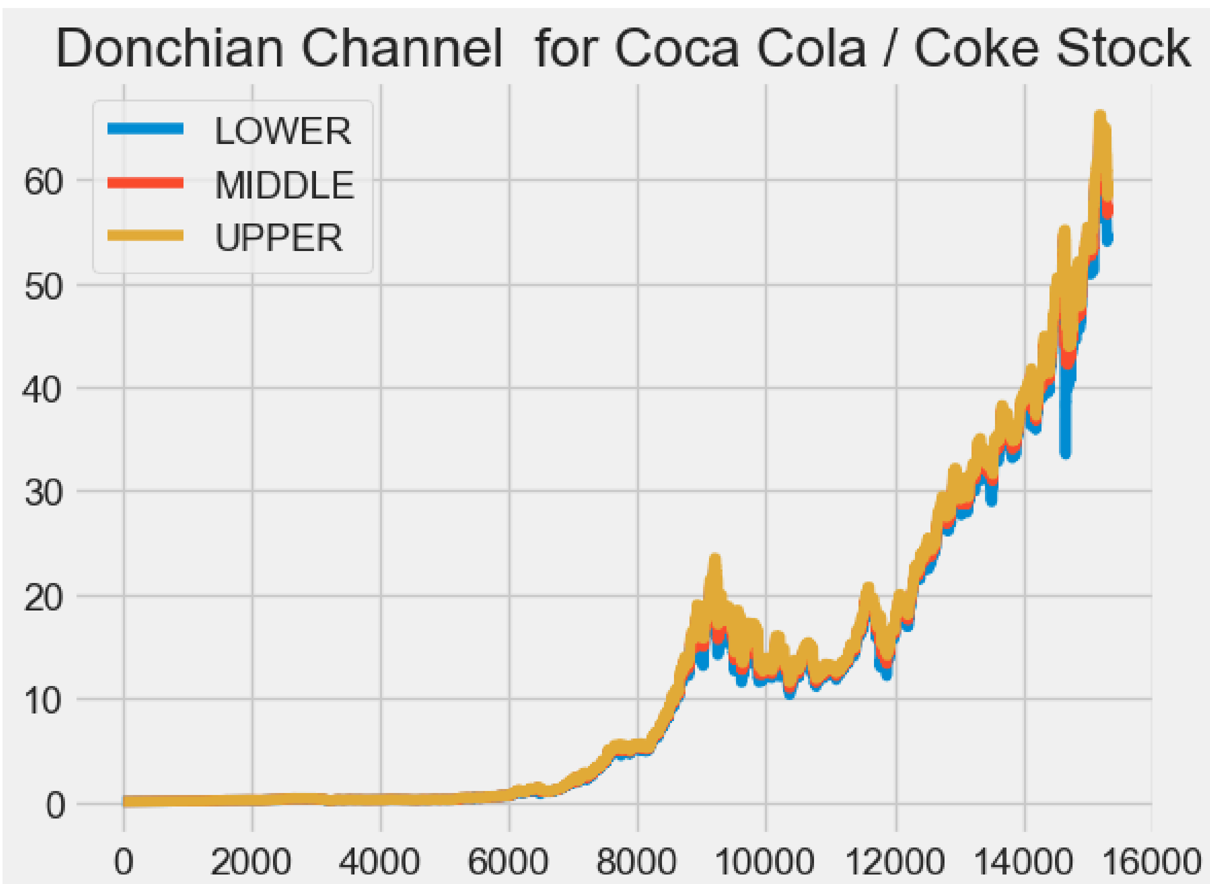

Percentage Price Oscillator for Coca Cola / Coke Stock
7.5
5.0
2.5
0.0
−2.5
−5.0
−7.5
−10.0
0
2000
4000
6000
8000
10000
12000
14000
16000
PPO
SIGNAL
HISTO

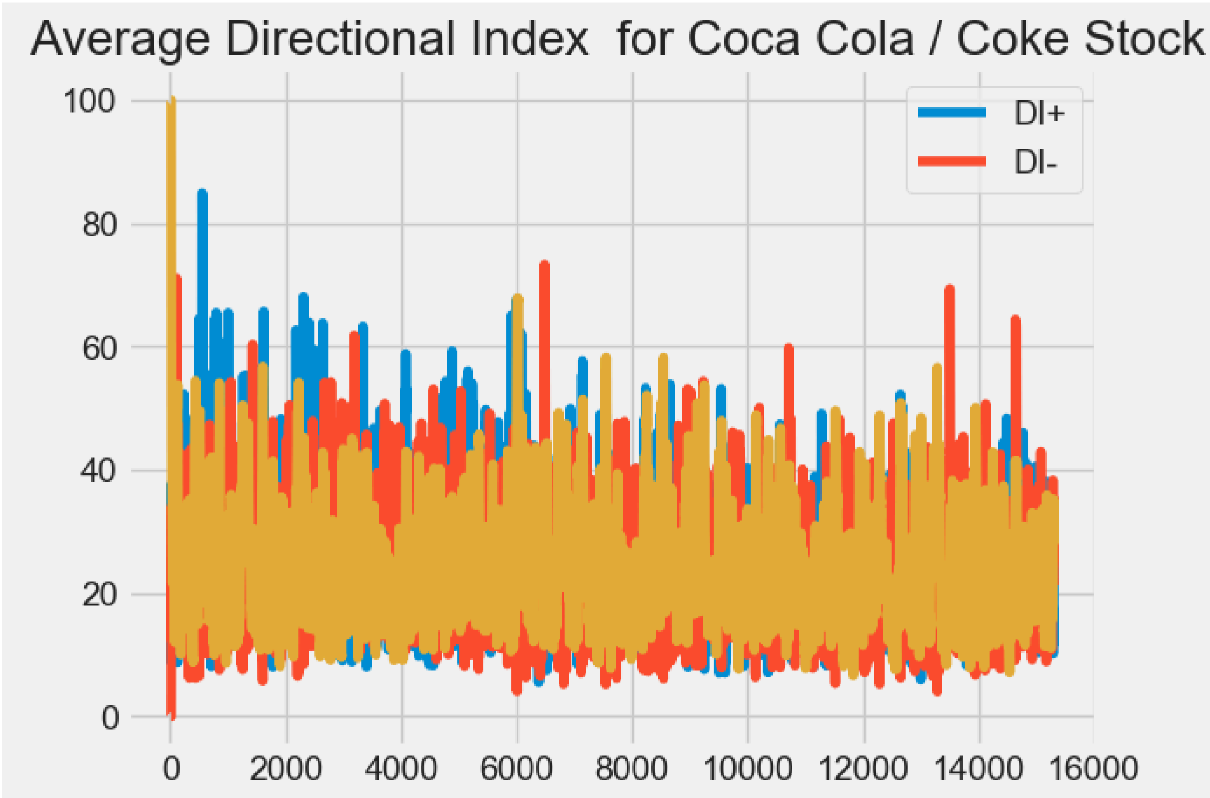

Stop-and-Reverse for Coca Cola / Coke Stock
100
80
60
40
20
0
−20
−40
0
2000
4000
6000
8000
10000
12000
14000
16000
MACD
SIGNAL

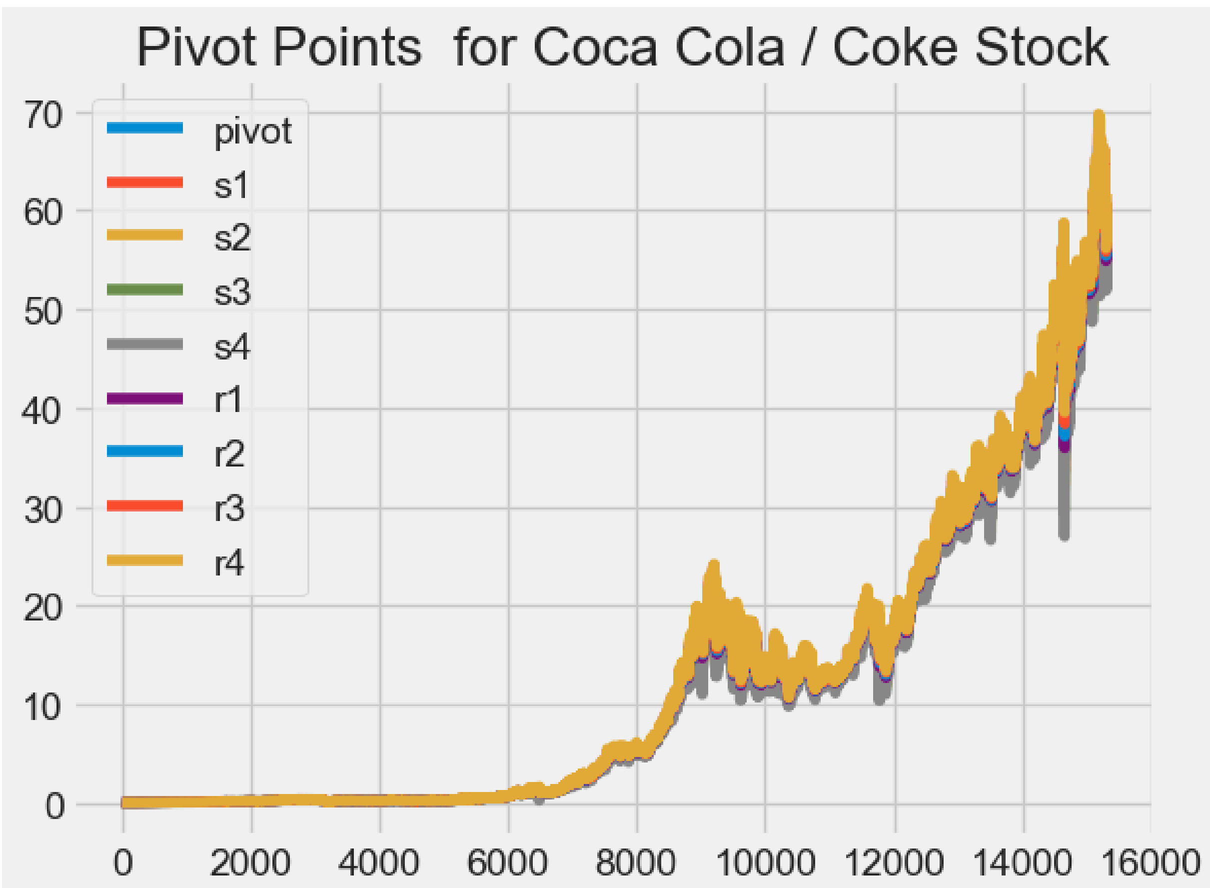

Bollinger Bands Width for Coca Cola / Coke Stock
BB_UPPER
BB_MIDDLE
BB_LOWER
70
60
50
40
30
20
10
0
0
2000
4000
6000
8000
10000
12000
14000
16000

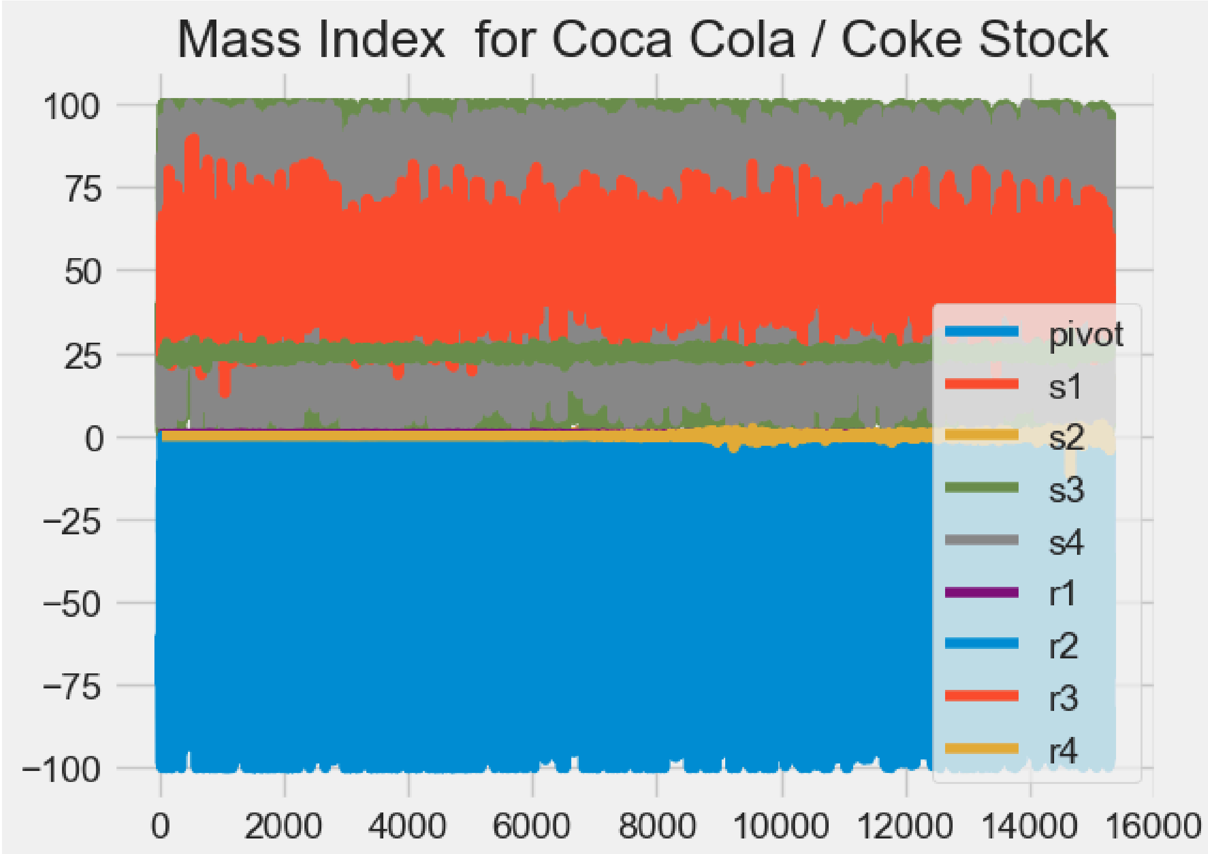

Percent B for Coca Cola / Coke Stock
BB_UPPER
BB_MIDDLE
BB_LOWER
60
50
40
30
20
10
0
0
2000
4000
6000
8000
10000
12000
14000
16000

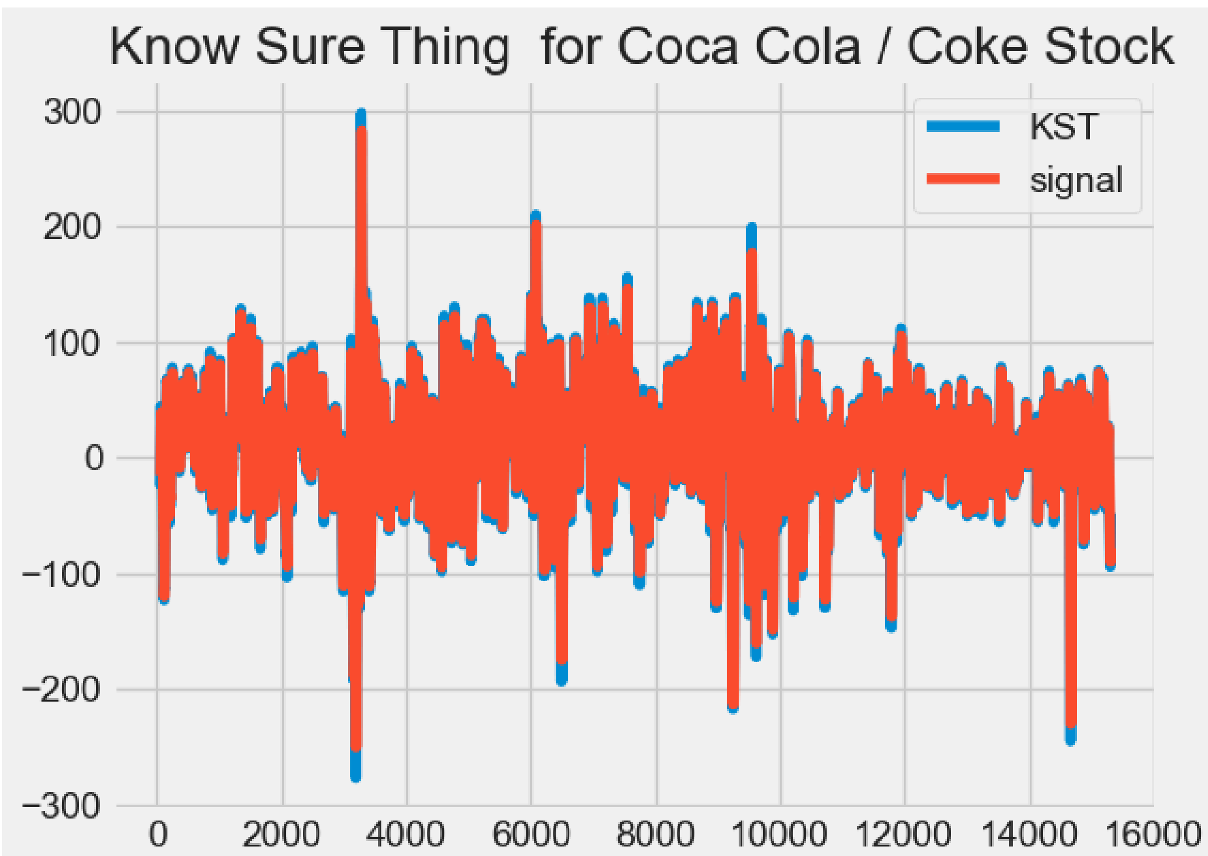

Keltner Channels for Coca Cola / Coke Stock
KC_UPPER
KC_LOWER
70
60
50
40
30
20
10
0
0
2000
4000
6000
8000
10000
12000
14000
16000

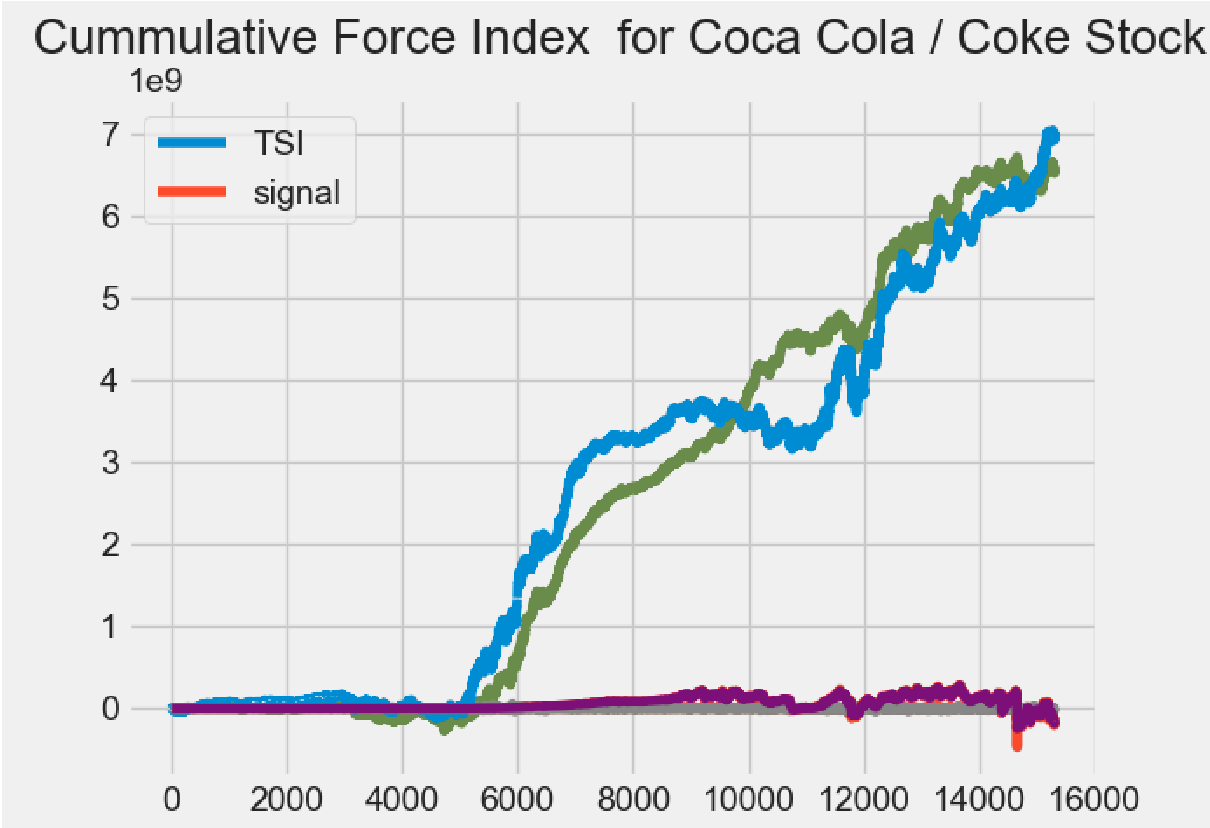

Donchian Channel for Coca Cola / Coke Stock
LOWER
MIDDLE
UPPER
60
50
40
30
20
10
0
0
2000
4000
6000
8000
10000
12000
14000
16000

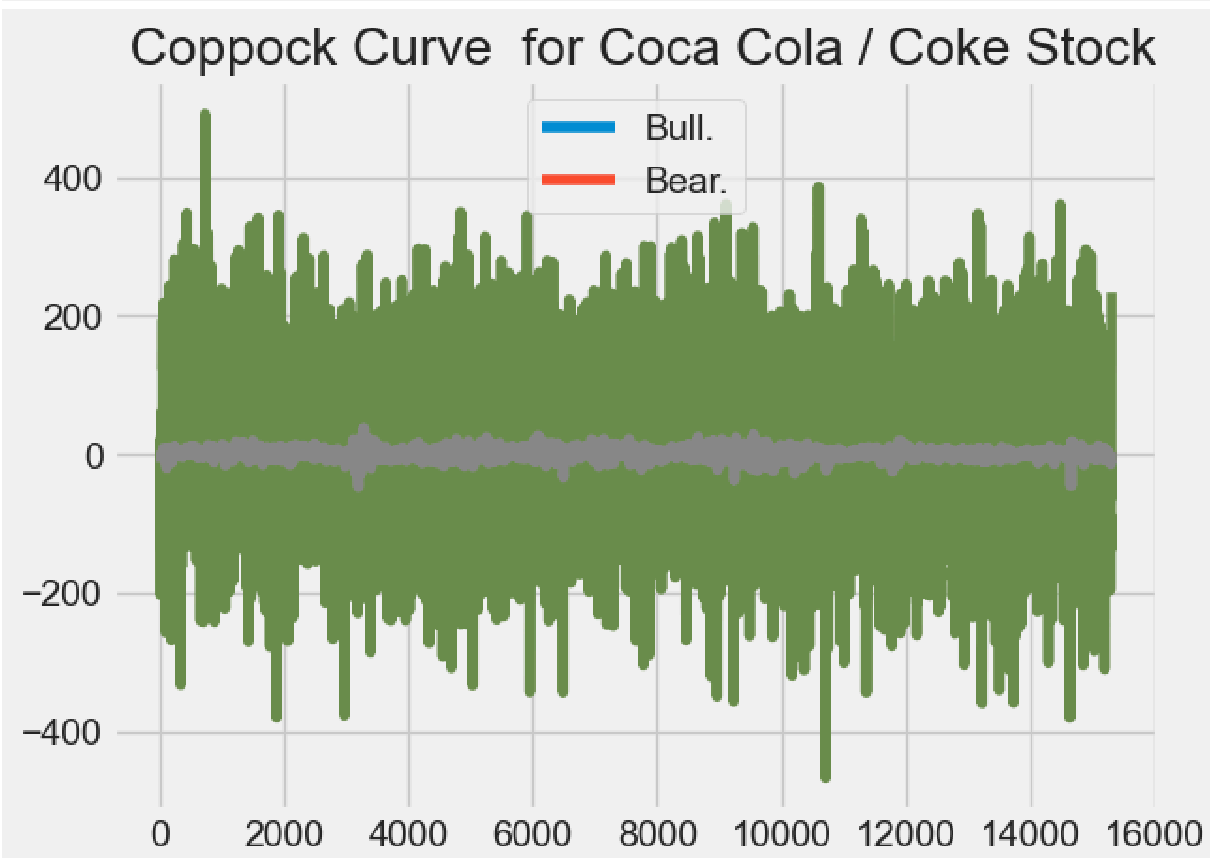

Average Directional Index for Coca Cola / Coke Stock
DI+
DI-
100
80
60
40
20
0
0
2000
4000
6000
8000
10000
12000
14000
16000

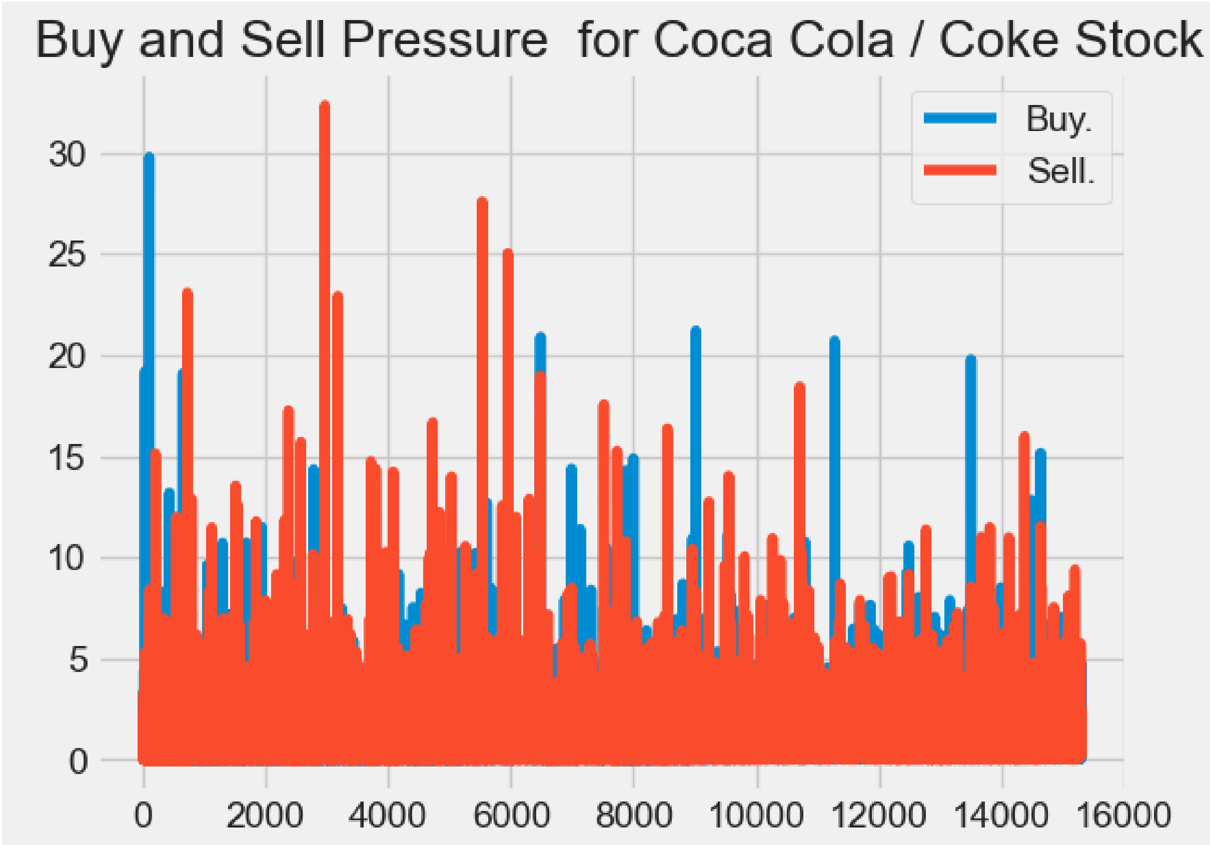

Pivot Points for Coca Cola / Coke Stock
pivot
s1
s2
s3
s4
r1
r2
r3
r4
70
60
50
40
30
20
10
0
0
2000
4000
6000
8000
10000
12000
14000
16000

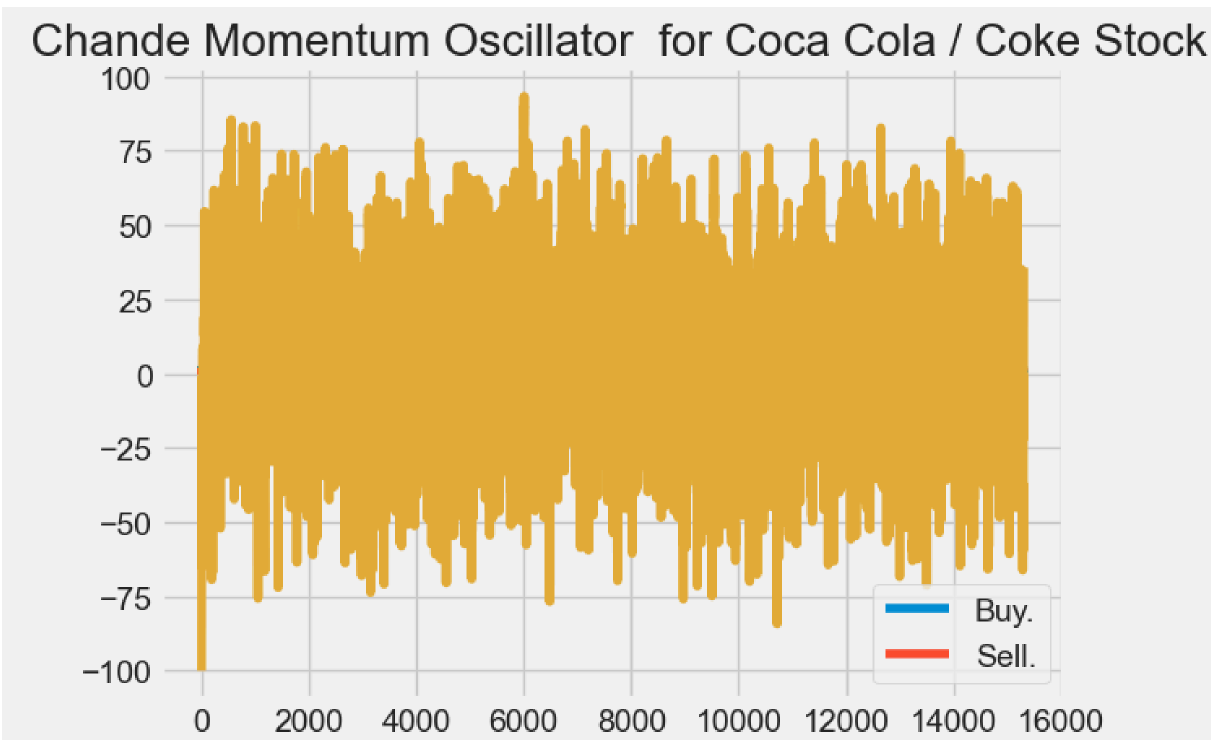

Mass Index for Coca Cola / Coke Stock
100
75
50
25
0
−25
−50
−75
−100
0
2000
4000
6000
8000
10000
12000
14000
16000
pivot
s1
s2
s3
s4
r1
r2
r3
r4

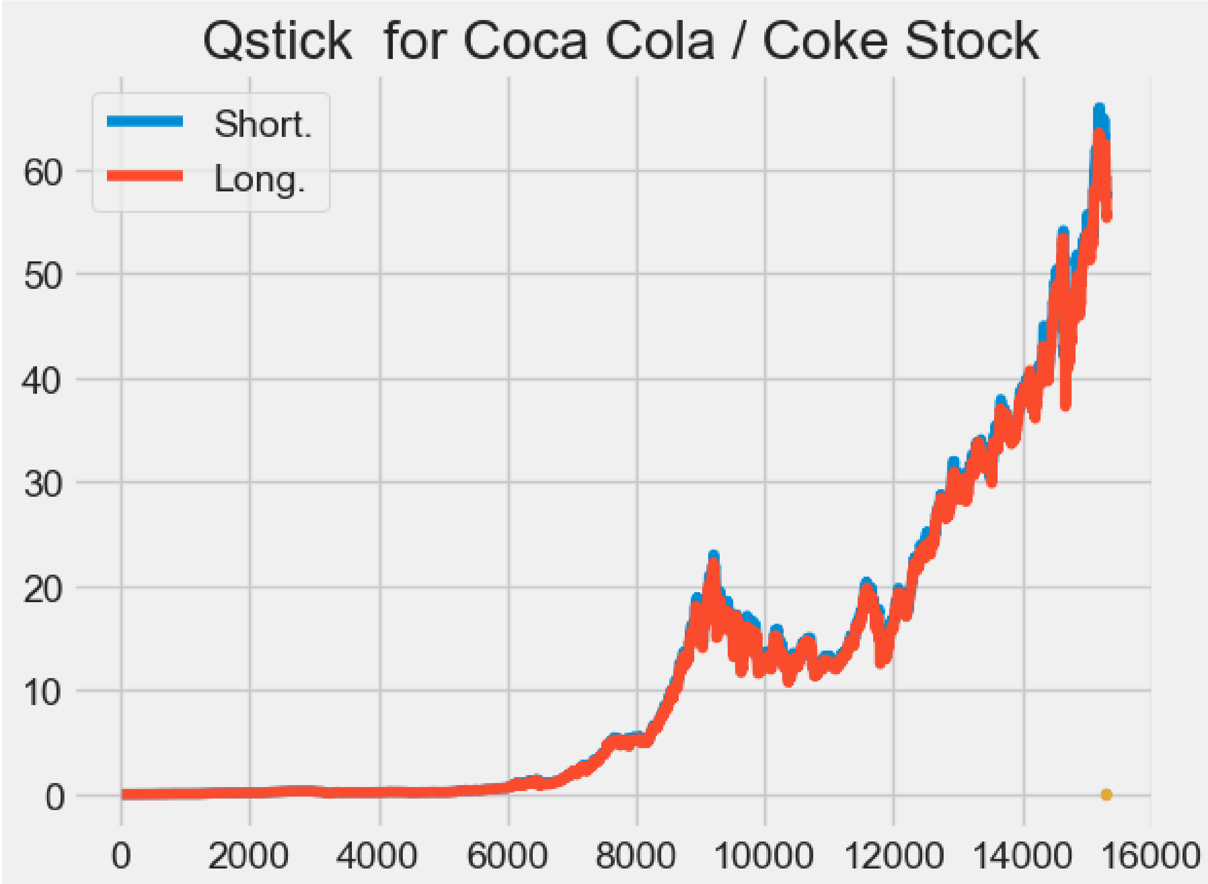

Know Sure Thing for Coca Cola / Coke Stock
300
200
100
0
−100
−200
−300
0
2000
4000
6000
8000
10000
12000
14000
16000
KST
signal

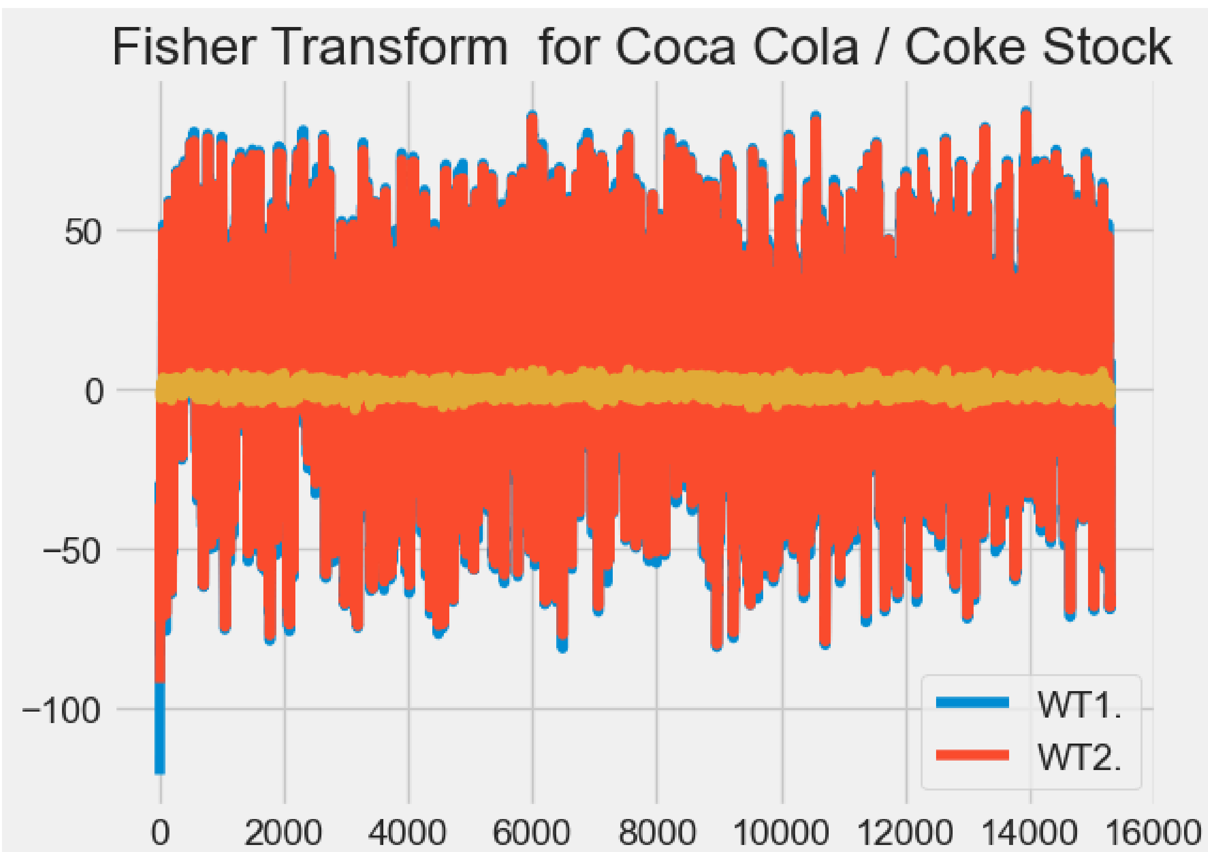

Cummulative Force Index for Coca Cola / Coke Stock
1e9
TSI
signal
7
6
5
4
3
2
1
0
0
2000
4000
6000
8000
10000
12000
14000
16000

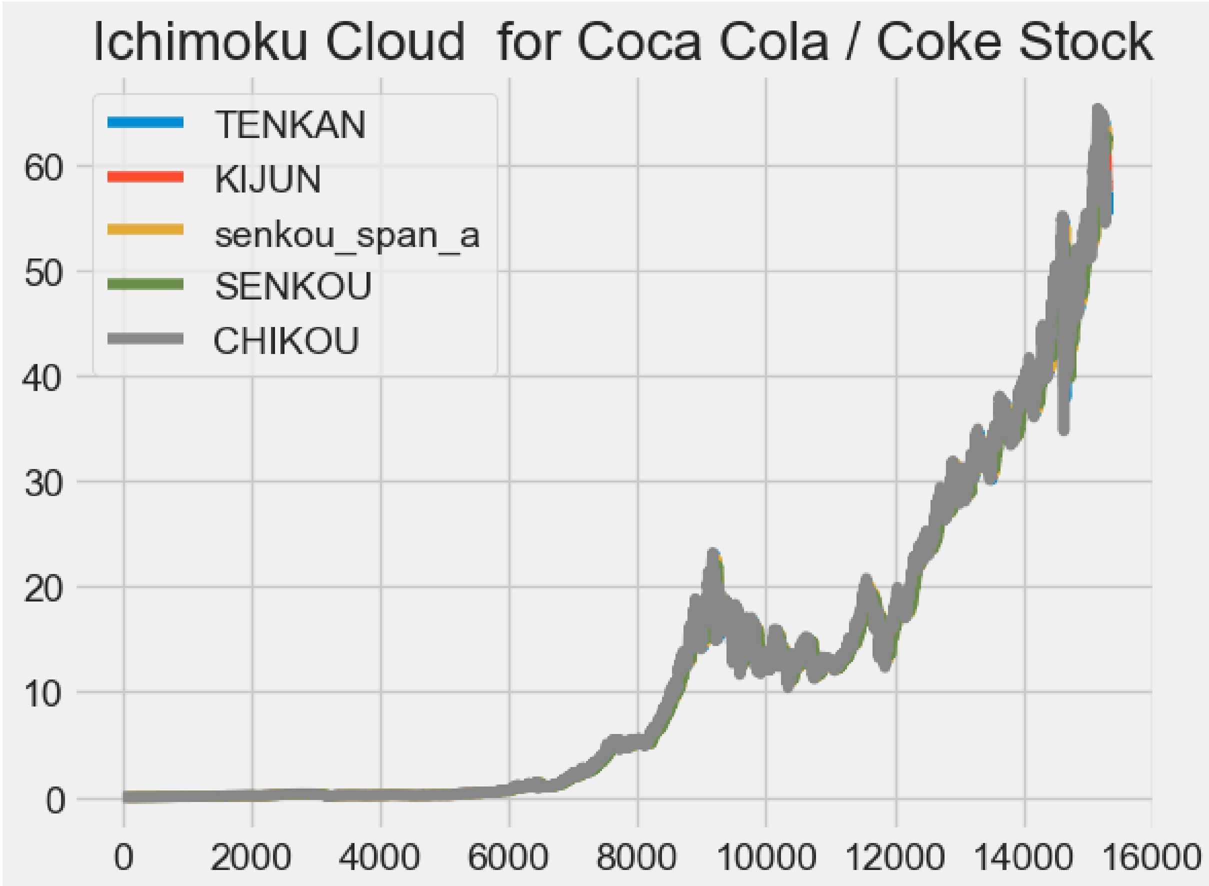

Coppock Curve for Coca Cola / Coke Stock
Bull.
Bear.
400
200
0
−200
−400
0
2000
4000
6000
8000
10000
12000
14000
16000

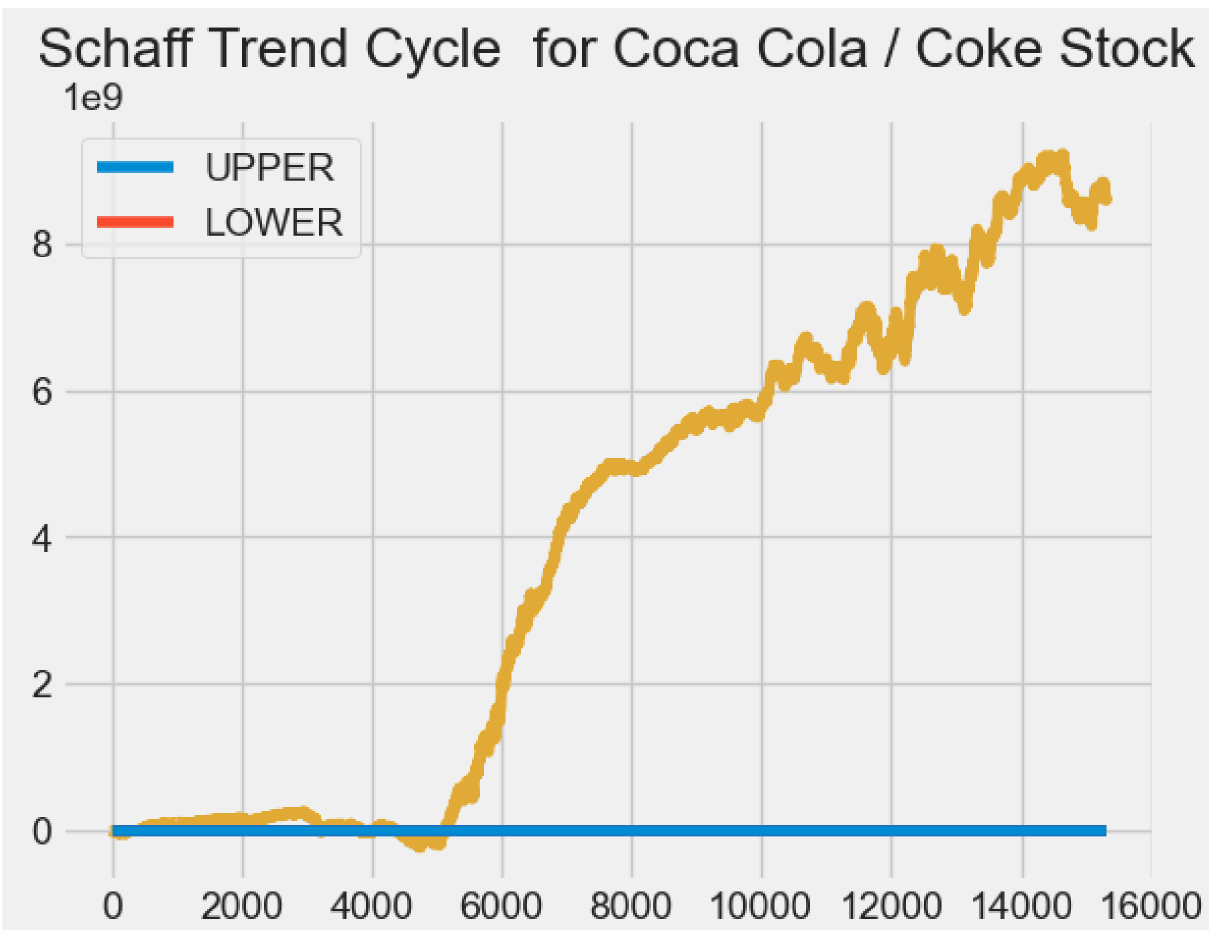

Buy and Sell Pressure for Coca Cola / Coke Stock
Buy.
Sell.
0
5
10
15
20
25
30
0
2000
4000
6000
8000
10000
12000
14000
16000


Chande Momentum Oscillator for Coca Cola / Coke Stock
100
75
50
25
0
−25
−50
−75
−100
0
2000
4000
6000
8000
10000
12000
14000
16000
Buy.
Sell.


Qstick for Coca Cola / Coke Stock
Short.
Long.
0
10
20
30
40
50
60
0
2000
4000
6000
8000
10000
12000
14000
16000


Fisher Transform for Coca Cola / Coke Stock
WT1.
WT2.
50
0
−50
−100
0
2000
4000
6000
8000
10000
12000
14000
16000


Ichimoku Cloud for Coca Cola / Coke Stock
TENKAN
KIJUN
senkou_span_a
SENKOU
CHIKOU
60
50
40
30
20
10
0
0
2000
4000
6000
8000
10000
12000
14000
16000


Schaff Trend Cycle for Coca Cola / Coke Stock
1e9
UPPER
LOWER
8
6
4
2
0
0
2000
4000
6000
8000
10000
12000
14000
16000

Back Testing Trading Strategy

In [20]:
```
# Defining DEMA cross strategy

class DemaCross(Strategy):

    def init(self):

        self.ma1=self.I(TA.DEMA,ohlc,10)
        self.ma2=self.I(TA.DEMA,ohlc,20)

    def next(self):
        if crossover(self.ma1,self.ma2):
            self.buy()
        elif crossover(self.ma2,self.ma1):
            self.sell()
```

Let us do a bit of backtesting with a value of $100000

In [21]:
```
ohlc.head()
print(ohlc.Date)
```

```
0                        1962-01-02
1                        1962-01-03
2                        1962-01-04
3                        1962-01-05
4                        1962-01-08
                       ...
15306    2022-10-20 00:00:00-04:00
15307    2022-10-21 00:00:00-04:00
15308    2022-10-24 00:00:00-04:00
15309    2022-10-25 00:00:00-04:00
15310    2022-10-26 00:00:00-04:00
Name: Date, Length: 15311, dtype: object
```

In [22]:
```
bt=Backtest(ohlc,DemaCross,
            cash=100000,commission=0.015,
            exclusive_orders=True)
```

Back Testing Summary

In [23]:
```
bt.run()
```

```
Backtest.run:   0%|          | 0/15310 [00:00<?, ?bar/s]
```

Out[23]:
```
Start                                      0.0
End                                    15310.0
Duration                               15310.0
Exposure Time [%]                     26.88263
Equity Final [$]                       0.19041
Equity Peak [$]                       100000.0
Commissions [$]                    77449.51548
Return [%]                           -99.99981
Buy & Hold Return [%]             118642.19364
Return (Ann.) [%]                          0.0
Volatility (Ann.) [%]                      NaN
Sharpe Ratio                               NaN
Sortino Ratio                              NaN
Calmar Ratio                               0.0
Alpha [%]                            -88.72432
Beta                                   -0.0001
Max. Drawdown [%]                    -99.99981
Avg. Drawdown [%]                    -99.99981
Max. Drawdown Duration                 15304.0
Avg. Drawdown Duration                 15304.0
# Trades                                 362.0
Win Rate [%]                          12.43094
Best Trade [%]                         45.6298
Worst Trade [%]                      -17.64692
Avg. Trade [%]                        -3.79272
Max. Trade Duration                       59.0
Avg. Trade Duration                   11.35635
Profit Factor                          0.15259
Expectancy [%]                        -3.68244
SQN                                    -5.3684
Kelly Criterion                       -1.02421
_strategy                            DemaCross
_equity_curve                           Equ...
_trades                            Size  En...
dtype: object
```

As you can see, if you had invested $100,000 in Coca Cola shares, you would have got by now a return of 118642%!

In [24]:
```
bt.plot()
```

Out[24]: **GridPlot**(id = 'p1325', ...)

In [25]:
```
data=ohlc
```

BackTesting Trading Strategy Heatmaps

In [26]:
```
from backtesting import Strategy
from backtesting.lib import crossover
from backtesting.test import SMA
```

In [27]:
```
def BBANDS(data,n_lookback,n_std):
    """Bollinger bands indicator"""
    hlc3=(data.High+data.Low+data.Close)/3
```

```
    mean=hlc3.rolling(n_lookback).mean()
    std=hlc3.rolling(n_lookback).std()

    upper=mean+n_std*std
    lower=mean-n_std*std
    return upper,lower

close=data.Close.values
sma10=SMA(data.Close,10)
sma20=SMA(data.Close,20)
sma50=SMA(data.Close,50)
sma100=SMA(data.Close,100)
upper,lower=BBANDS(data,20,2)

# Design matrix / independent features:

# Price-derived features
data['X_SMA10']=(close-sma10)/close
data['X_SMA20']=(close-sma20)/close
data['X_SMA50']=(close-sma50)/close
data['X_SMA100']=(close-sma100)/close

data['X_DELTA_SMA10']=(sma10-sma20)/close
data['X_DELTA_SMA20']=(sma20-sma50)/close
data['X_DELTA_SMA50']=(sma50-sma100)/close

# Indicator features
data['X_MOM']=data.Close.pct_change(periods=2)
data['X_BB_upper']=(upper-close)/close
data['X_BB_lower']=(lower-close)/close
data['X_BB_width']=(upper-lower)/close

#data['X_Sentiment'] =

# Step 1: Convert index to datetime (in case it's not already)
data.index = pd.to_datetime(data.index, errors='coerce')

# Step 2: Remove timezone if it exists
data.index = data.index.tz_localize(None)

# Step 3: Filter out the date range
data = data[~data.index.to_series().between('2017-09-27', '2017-12-14')]


# Some datetime features for good measure
#data['X_day'] = data.index.dayofweek
#data['X_hour'] = data.index.hour
#data = data.apply(pd.to_numeric)
#data = data.dropna().astype(np.float64)
#data.fillna(method="ffill")
#data =data[~data.isin([np.nan, np.inf, -np.inf]).any(1)]
#data.replace([np.inf, -np.inf], 0.0, inplace=True)
#data = data.fillna(data.mean(), inplace=True)
#data = data.dropna().astype(np.float64)
```

In [28]:
```
from backtesting import Strategy
from backtesting.lib import crossover
from finta import TA
import pandas as pd

# Define SMA function using Pandas for Backtesting.py
def SMA(series, period):
    return pd.Series(series).rolling(period).mean()

class Sma4Cross(Strategy):
    n1 = 50
    n2 = 100
    n_enter = 20
    n_exit = 10

    def init(self):
        self.sma1 = self.I(SMA, self.data.Close, self.n1)
        self.sma2 = self.I(SMA, self.data.Close, self.n2)
        self.sma_enter = self.I(SMA, self.data.Close, self.n_enter)
        self.sma_exit = self.I(SMA, self.data.Close, self.n_exit)

    def next(self):
        if not self.position:
            # Buy signal: upward trend and crossover
            if self.sma1[-1] > self.sma2[-1]:
                if crossover(self.data.Close, self.sma_enter):
                    self.buy()
            else:
                # Sell signal: downward trend and crossover
                if crossover(self.sma_enter, self.data.Close):
                    self.sell()
        else:
            # Exit condition
            if (
                (self.position.is_long and crossover(self.sma_exit, self.data.Close
                (self.position.is_short and crossover(self.data.Close, self.sma_exi
            ):
                self.position.close()
```

In [29]:
```
%%time

from backtesting import Backtest
from backtesting.test import GOOG
# Ensure index is datetime and sorted
ohlc.index = pd.to_datetime(ohlc.index)

# Remove duplicate index entries
ohlc = ohlc[~ohlc.index.duplicated(keep='first')]

# (Optional but safe) Sort the index just in case
ohlc = ohlc.sort_index()

backtest=Backtest(ohlc,Sma4Cross,commission=.002)

stats,heatmap=backtest.optimize(
```

```
    n1=range(10,110,10),
    n2=range(20,210,20),
    n_enter=range(15,35,5),
    n_exit=range(10,25,5),
    constraint=lambda p:p.n_exit<p.n_enter<p.n1<p.n2,
    maximize='Equity Final [$]',
    max_tries=200,
    random_state=0,
    return_heatmap=True)
```

```
Backtest.optimize:   0%|          | 0/177 [00:00<?, ?it/s]
Backtest.run:   0%|          | 0/15251 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15131 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15171 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15151 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15111 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15231 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15151 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15151 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15111 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15211 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15151 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15131 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15111 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15271 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15151 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15131 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15271 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15111 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15131 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15131 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15251 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15251 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15131 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15111 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15251 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15251 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15131 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15111 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15231 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15111 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15251 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15111 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15231 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15231 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15111 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15111 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15231 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15231 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15111 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15111 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15231 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15211 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15111 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15111 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15231 [00:00<?, ?bar/s]
```

```
Backtest.run:   0%|          | 0/15211 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15211 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15211 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15231 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15191 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15191 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15211 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15211 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15171 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15191 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15191 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15211 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15171 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15191 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15191 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15211 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15171 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15191 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15191 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15191 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15171 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15191 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15191 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15191 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15151 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15191 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15171 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15191 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15151 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15151 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15171 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15171 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15131 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15151 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15171 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15171 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15131 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15151 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15151 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15151 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15131 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15131 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15151 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15151 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15131 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15131 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15131 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15151 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15111 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15131 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15131 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15151 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15111 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15111 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15131 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15131 [00:00<?, ?bar/s]
```

```
Backtest.run:   0%|          | 0/15111 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15111 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15111 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15131 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15111 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15191 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15111 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15131 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15111 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15191 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15111 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15111 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15251 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15191 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15111 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15111 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15251 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15171 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15111 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15111 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15251 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15171 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15231 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15211 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15251 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15171 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15231 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15211 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15211 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15151 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15231 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15211 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15191 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15151 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15231 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15211 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15191 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15151 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15231 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15191 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15171 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15151 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15231 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15191 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15171 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15131 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15211 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15191 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15151 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15131 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15211 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15171 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15151 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15131 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15171 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15211 [00:00<?, ?bar/s]
```

```
Backtest.run:   0%|          | 0/15151 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15131 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15171 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15191 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15131 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15111 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15171 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15191 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15131 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15111 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15171 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15171 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15131 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15111 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15171 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15151 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15131 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15111 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15151 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15111 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15131 [00:00<?, ?bar/s]
CPU times: total: 1min 30s
Wall time: 1min 34s
```

In [30]:

```
heatmap
```

Out[30]:

```
n1   n2   n_enter  n_exit
20   60   15       10        1037.202781
     80   15       10        1732.296377
     100  15       10         515.576106
30   40   20       15        1507.154390
          25       15        1583.583763
                                 ...
100  200  15       10         615.769729
          20       10        1079.559655
                   15        2250.797500
          25       10         902.593707
          30       10        1349.497625
Name: Equity Final [$], Length: 177, dtype: float64
```

In [31]:

```
hm=heatmap.groupby(['n1','n2']).mean().unstack()
hm
```

Out[31]:

n2	40	60	80	100	120	140	
n1							
20	NaN	1037.202781	1732.296377	515.576106	NaN	NaN	
30	1545.369076	554.728136	669.472771	1058.163865	2030.296310	1436.389924	1022.78
40	NaN	794.121279	NaN	2239.206649	1474.256081	1656.168334	1018.69
50	NaN	1619.979124	1067.791968	1175.324642	1128.997495	903.669042	1417.74
60	NaN	NaN	1039.297363	638.441277	972.459041	787.947324	2210.72
70	NaN	NaN	1079.428319	946.038299	665.067509	702.192088	706.30
80	NaN	NaN	NaN	462.586626	634.978825	1176.042382	1050.81
90	NaN	NaN	NaN	1212.710682	808.598196	602.080384	1816.25
100	NaN	NaN	NaN	NaN	1155.639433	2300.093818	2019.25

In [32]:

```
from backtesting.lib import plot_heatmaps
plot_heatmaps(heatmap,agg='mean')
```

Out[32]: **GridPlot**(id = 'p1637', ...)

In [33]:

```
%%time

stats_sambo,heatmap,optimize_result=backtest.optimize(
    n1=[10,100],         # Note: For method="skopt", we
    n2=[20,200],         # only need interval end-points
    n_enter=[10,40],
    n_exit=[10,30],
    constraint=lambda p:p.n_exit<p.n_enter<p.n1<p.n2,
    maximize='Equity Final [$]',
    method='sambo',
    max_tries=200,
    random_state=0,
    return_heatmap=True,
    return_optimization=True)
```

```
Backtest.optimize:   0%|          | 0/200 [00:00<?, ?it/s]
Backtest.run:   0%|          | 0/15211 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15240 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15120 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15226 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15248 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15202 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15140 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15147 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15177 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15201 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15242 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15224 [00:00<?, ?bar/s]
```

```
Backtest.run:   0%|          | 0/15257 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15250 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15178 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15199 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15190 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15143 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15111 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15172 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15131 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15165 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15142 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15168 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15111 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15111 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15111 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15111 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15129 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15111 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15147 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15124 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15241 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15156 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15131 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15111 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15144 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15189 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15131 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15111 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15134 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15147 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15124 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15227 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15111 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15132 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15138 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15118 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15111 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15111 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15147 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15111 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15168 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15115 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15131 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15133 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15131 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15120 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15178 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15151 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15123 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15119 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15138 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15199 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15114 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15128 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15116 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15146 [00:00<?, ?bar/s]
```

```
Backtest.run:   0%|          | 0/15126 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15136 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15116 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15139 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15281 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15111 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15131 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15135 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15147 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15168 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15112 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15111 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15131 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15131 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15258 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15118 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15129 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15151 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15150 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15124 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15185 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15147 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15124 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15194 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15140 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15111 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15147 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15124 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15209 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15135 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15119 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15111 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15124 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15135 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15120 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15119 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15135 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15150 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15124 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15251 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15147 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15111 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15147 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15124 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15248 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15132 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15111 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15131 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15141 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15147 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15124 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15198 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15129 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15147 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15112 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15129 [00:00<?, ?bar/s]
```

```
Backtest.run:   0%|          | 0/15133 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15164 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15133 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15130 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15144 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15146 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15124 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15224 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15138 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15121 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15122 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15119 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15141 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15127 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15112 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15121 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15147 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15264 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15130 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15139 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15133 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15131 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15222 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15147 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15124 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15246 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15138 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15197 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15147 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15170 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15141 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15141 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15179 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15162 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15130 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15169 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15128 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15156 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15196 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15170 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15179 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15162 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15194 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15174 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15120 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15111 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15117 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15158 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15141 [00:00<?, ?bar/s]
Backtest.run:   0%|          | 0/15174 [00:00<?, ?bar/s]
CPU times: total: 1min 16s
Wall time: 1min 22s
```

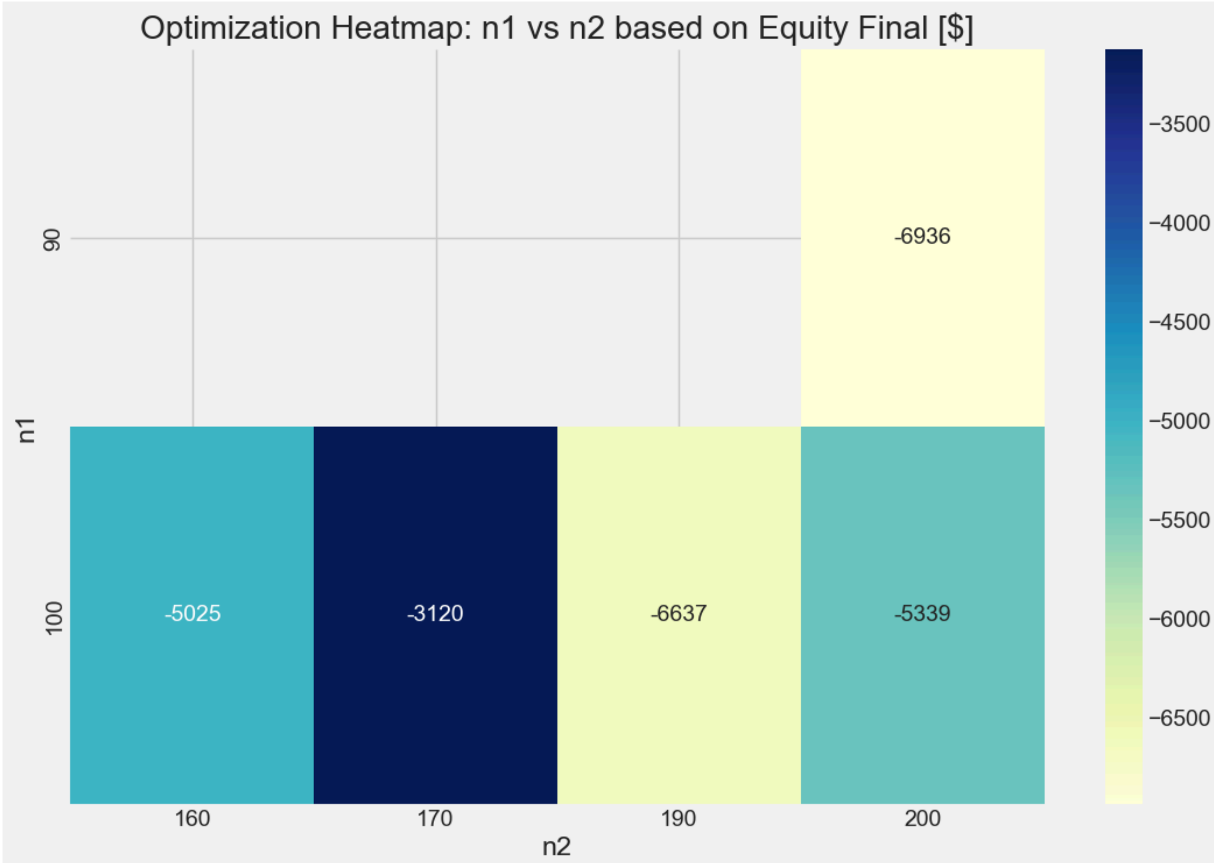
In [50]:
```python
print("Type:", type(optimize_result))

if isinstance(optimize_result, dict):
```

```
    print("Keys:", optimize_result.keys())
elif isinstance(optimize_result, list):
    print("First item type:", type(optimize_result[0]))
    print("First item:", optimize_result[0])
else:
    print("Object:", optimize_result)
```

```
Type: <class 'sambo._util.OptimizeResult'>
Keys: dict_keys(['x', 'fun', 'nit', 'nfev', 'xv', 'funv', 'success', 'message', 'spa
ce'])
```

In [52]:

```
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns

# Prepare data
x_values = optimize_result['xv']     # Parameter combinations
y_values = optimize_result['funv']   # Corresponding equity values

data = []
for x, y in zip(x_values, y_values):
    data.append({'n1': x[0], 'n2': x[1], 'Equity Final [$]': y})

results_df = pd.DataFrame(data)

# Optional filter for clean plot
filtered_df = results_df[(results_df['n1'] % 10 == 0) & (results_df['n2'] % 10 == 0

# ✅ Use pivot_table with aggregation (mean or max)
pivot_table = filtered_df.pivot_table(index='n1', columns='n2', values='Equity Fina

# Plot heatmap
plt.figure(figsize=(12, 8))
sns.heatmap(pivot_table, annot=True, fmt=".0f", cmap='YlGnBu')
plt.title('Optimization Heatmap: n1 vs n2 based on Equity Final [$]')
plt.xlabel("n2")
plt.ylabel("n1")
plt.show()
```


Optimization Heatmap: n1 vs n2 based on Equity Final [$]
n1
90
100
n2
160
170
190
200
-6936
-5025
-3120
-6637
-5339
−3500
−4000
−4500
−5000
−5500
−6000
−6500

In [ ]: