Strategies combination

August 1, 2022

1 Backtesting, Optimising and Implementing a Combination of strategies(SMA+Bollinger Band)

1.1 Getting and Preparing the Data

[1]:

```
import pandas as pd
import numpy as np
import fxcmpy
import matplotlib.pyplot as plt
plt.style.use("seaborn")
```

1.2 Getting data from FXCM(limit~10000 candles)

[2]:

```
api = fxcmpy.fxcmpy(config_file= "fxcm.cfg")
```

[5]:

```
data = api.get_candles('BTC/USD', start = "2022-03-01", end = "2022-08-01",
                period = "m15")
data
```

[5]:

```
                     bidopen  bidclose  bidhigh   bidlow  askopen  askclose  \
date
2022-03-01 00:00:00  43177.3   43375.0  43607.0  43169.0  43219.0   43420.0
2022-03-01 00:15:00  43375.0   43378.9  43402.5  43177.8  43418.0   43419.0
2022-03-01 00:30:00  43377.9   43527.9  43540.0  43309.4  43418.0   43567.9
2022-03-01 00:45:00  43527.4   43559.0  43716.0  43327.4  43567.4   43602.0
2022-03-01 01:00:00  43560.0   43273.0  43622.0  43255.5  43602.0   43316.0
…                      …        …       …        …        …        …
2022-07-31 23:00:00  23369.3   23297.7  23369.8  23282.8  23409.3   23337.7
2022-07-31 23:15:00  23297.7   23328.0  23352.0  23291.4  23337.7   23368.0
2022-07-31 23:30:00  23328.1   23389.1  23450.4  23313.5  23368.1   23429.1
2022-07-31 23:45:00  23388.1   23283.4  23395.1  23269.9  23428.1   23323.4
2022-08-01 00:00:00  23283.9   23271.1  23306.1  23250.3  23323.9   23311.1

                     askhigh   asklow  tickqty
date
2022-03-01 00:00:00  43654.3  43217.0     3132
2022-03-01 00:15:00  43442.5  43219.0     2919
```

```
2022-03-01 00:30:00  43581.0  43349.5     3090
2022-03-01 00:45:00  43759.0  43367.4     2681
2022-03-01 01:00:00  43665.0  43295.5     1932
…                          …        …      …
2022-07-31 23:00:00  23409.8  23322.8     5035
2022-07-31 23:15:00  23392.0  23331.4     4903
2022-07-31 23:30:00  23490.4  23353.5     4930
2022-07-31 23:45:00  23435.1  23309.9     4994
2022-08-01 00:00:00  23346.1  23290.3     5073

[10414 rows x 9 columns]
```

1.3 Converting to DF and saving in CSV file

[9]:

```python
df=pd.DataFrame(data)
df.to_csv('BTCUSD.csv')
```

[9]:

```
                     bidopen  bidclose  bidhigh   bidlow  askopen  askclose  \
date
2020-12-01 00:00:00  19694.0   19556.0  19712.0  19469.0  19733.2   19594.6
2020-12-01 01:00:00  19556.0   19572.0  19623.0  19431.0  19594.6   19612.0
2020-12-01 02:00:00  19572.0   19670.0  19695.0  19533.0  19612.0   19710.0
2020-12-01 03:00:00  19670.0   19418.0  19671.0  19335.0  19710.0   19457.0
2020-12-01 04:00:00  19418.0   19348.0  19517.0  19343.0  19457.0   19386.7
…                          …         …       …        …        …        …
2022-07-27 20:00:00  22746.1   22766.1  22893.0  22661.8  22786.1   22806.1
2022-07-27 21:00:00  22766.0   22657.0  22777.6  22568.0  22806.0   22697.0
2022-07-27 22:00:00  22657.0   22863.4  22937.5  22635.0  22697.0   22903.4
2022-07-27 23:00:00  22862.4   22942.6  22977.4  22798.0  22902.4   22982.6
2022-07-28 00:00:00  22942.6   22765.0  23048.6  22737.5  22982.6   22805.0

                     askhigh   asklow  tickqty
date
2020-12-01 00:00:00  19752.0  19508.0    29588
2020-12-01 01:00:00  19674.2  19459.0    27436
2020-12-01 02:00:00  19735.0  19573.0    21286
2020-12-01 03:00:00  19711.0  19374.0    18111
2020-12-01 04:00:00  19554.7  19380.0    23717
…                          …        …      …
2022-07-27 20:00:00  22933.0  22701.8    18236
2022-07-27 21:00:00  22817.6  22608.0    17854
2022-07-27 22:00:00  22977.5  22675.0    18404
2022-07-27 23:00:00  23017.4  22838.0    18007
2022-07-28 00:00:00  23088.6  22777.5    18202

[10311 rows x 9 columns]
```

```
[6]: data_csv = pd.read_csv('BTCUSD_m15.csv', parse_dates = ["date"], index_col =␣
      ↪"date")
     #data_csv.rename(columns = {'bidclose':'price'}, inplace = True)
     data_csv
```

```
[6]:                      bidopen  bidclose  bidhigh   bidlow  askopen  askclose  \
     date
     2022-03-01 00:00:00  43177.3   43375.0  43607.0  43169.0  43219.0   43420.0
     2022-03-01 00:15:00  43375.0   43378.9  43402.5  43177.8  43418.0   43419.0
     2022-03-01 00:30:00  43377.9   43527.9  43540.0  43309.4  43418.0   43567.9
     2022-03-01 00:45:00  43527.4   43559.0  43716.0  43327.4  43567.4   43602.0
     2022-03-01 01:00:00  43560.0   43273.0  43622.0  43255.5  43602.0   43316.0
     …                      …       …      …      …      …      …
     2022-07-31 23:00:00  23369.3   23297.7  23369.8  23282.8  23409.3   23337.7
     2022-07-31 23:15:00  23297.7   23328.0  23352.0  23291.4  23337.7   23368.0
     2022-07-31 23:30:00  23328.1   23389.1  23450.4  23313.5  23368.1   23429.1
     2022-07-31 23:45:00  23388.1   23283.4  23395.1  23269.9  23428.1   23323.4
     2022-08-01 00:00:00  23283.9   23271.1  23306.1  23250.3  23323.9   23311.1

                          askhigh   asklow  tickqty
     date
     2022-03-01 00:00:00  43654.3  43217.0     3132
     2022-03-01 00:15:00  43442.5  43219.0     2919
     2022-03-01 00:30:00  43581.0  43349.5     3090
     2022-03-01 00:45:00  43759.0  43367.4     2681
     2022-03-01 01:00:00  43665.0  43295.5     1932
     …                      …      …      …
     2022-07-31 23:00:00  23409.8  23322.8     5035
     2022-07-31 23:15:00  23392.0  23331.4     4903
     2022-07-31 23:30:00  23490.4  23353.5     4930
     2022-07-31 23:45:00  23435.1  23309.9     4994
     2022-08-01 00:00:00  23346.1  23290.3     5073

     [10414 rows x 9 columns]
```

1.4 Defining best time to trade

```
[7]: data_csv.info()
```

```
<class 'pandas.core.frame.DataFrame'>
DatetimeIndex: 10414 entries, 2022-03-01 00:00:00 to 2022-08-01 00:00:00
Data columns (total 9 columns):
 #   Column    Non-Null Count  Dtype
---  ------    --------------  -----
 0   bidopen   10414 non-null  float64
 1   bidclose  10414 non-null  float64
 2   bidhigh   10414 non-null  float64
 3   bidlow    10414 non-null  float64
 4   askopen   10414 non-null  float64
 5   askclose  10414 non-null  float64
 6   askhigh   10414 non-null  float64
 7   asklow    10414 non-null  float64
 8   tickqty   10414 non-null  int64
dtypes: float64(8), int64(1)
memory usage: 813.6 KB
```

[9]:

```
data_csv["INDTime"] = data_csv.index.tz_localize('UTC').tz_convert('Asia/
 ↪Calcutta') # converting timeframe from UTC to our Indian time
data_csv["hour"] = data_csv.INDTime.dt.hour                                   ␣
 ↪    # separating out hour from time
data_csv["mid"] = (data_csv["bidopen"]+data_csv["bidclose"])/2                ␣
 ↪    # getting the mid price
data_csv["price_change_abs"] = data_csv.mid.diff().abs()                      ␣
 ↪    # getting change between mids
data_csv["spread"] = abs((data_csv["askclose"]-data_csv["bidclose"]))         ␣
 ↪    # finding diff between ask and bid price
data_csv.dropna(inplace = True)                                               ␣
 ↪    # dropping null values
data_csv
```

[9]:

```
                     bidopen  bidclose  bidhigh   bidlow  askopen  askclose  \
date
2022-03-01 00:15:00  43375.0   43378.9  43402.5  43177.8  43418.0   43419.0
2022-03-01 00:30:00  43377.9   43527.9  43540.0  43309.4  43418.0   43567.9
2022-03-01 00:45:00  43527.4   43559.0  43716.0  43327.4  43567.4   43602.0
2022-03-01 01:00:00  43560.0   43273.0  43622.0  43255.5  43602.0   43316.0
2022-03-01 01:15:00  43273.0   43272.0  43372.9  43214.0  43314.0   43313.0
…                        …        …       …        …        …         …
2022-07-31 23:00:00  23369.3   23297.7  23369.8  23282.8  23409.3   23337.7
2022-07-31 23:15:00  23297.7   23328.0  23352.0  23291.4  23337.7   23368.0
2022-07-31 23:30:00  23328.1   23389.1  23450.4  23313.5  23368.1   23429.1
2022-07-31 23:45:00  23388.1   23283.4  23395.1  23269.9  23428.1   23323.4
2022-08-01 00:00:00  23283.9   23271.1  23306.1  23250.3  23323.9   23311.1

                     askhigh   asklow  tickqty                   INDTime  \
date
2022-03-01 00:15:00  43442.5  43219.0     2919 2022-03-01 05:45:00+05:30
2022-03-01 00:30:00  43581.0  43349.5     3090 2022-03-01 06:00:00+05:30
2022-03-01 00:45:00  43759.0  43367.4     2681 2022-03-01 06:15:00+05:30
2022-03-01 01:00:00  43665.0  43295.5     1932 2022-03-01 06:30:00+05:30
2022-03-01 01:15:00  43412.9  43254.0     1645 2022-03-01 06:45:00+05:30
…                        …        …       …                         …
2022-07-31 23:00:00  23409.8  23322.8     5035 2022-08-01 04:30:00+05:30
2022-07-31 23:15:00  23392.0  23331.4     4903 2022-08-01 04:45:00+05:30
2022-07-31 23:30:00  23490.4  23353.5     4930 2022-08-01 05:00:00+05:30
```

```
2022-07-31 23:45:00  23435.1  23309.9     4994 2022-08-01 05:15:00+05:30
2022-08-01 00:00:00  23346.1  23290.3     5073 2022-08-01 05:30:00+05:30

                     hour       mid  price_change_abs  spread
date
2022-03-01 00:15:00     5  43376.95            100.80    40.1
2022-03-01 00:30:00     6  43452.90             75.95    40.0
2022-03-01 00:45:00     6  43543.20             90.30    43.0
2022-03-01 01:00:00     6  43416.50            126.70    43.0
2022-03-01 01:15:00     6  43272.50            144.00    41.0
…                     …       …               …      …
2022-07-31 23:00:00     4  23333.50              5.20    40.0
2022-07-31 23:15:00     4  23312.85             20.65    40.0
2022-07-31 23:30:00     5  23358.60             45.75    40.0
2022-07-31 23:45:00     5  23335.75             22.85    40.0
2022-08-01 00:00:00     5  23277.50             58.25    40.0

[10413 rows x 14 columns]
```

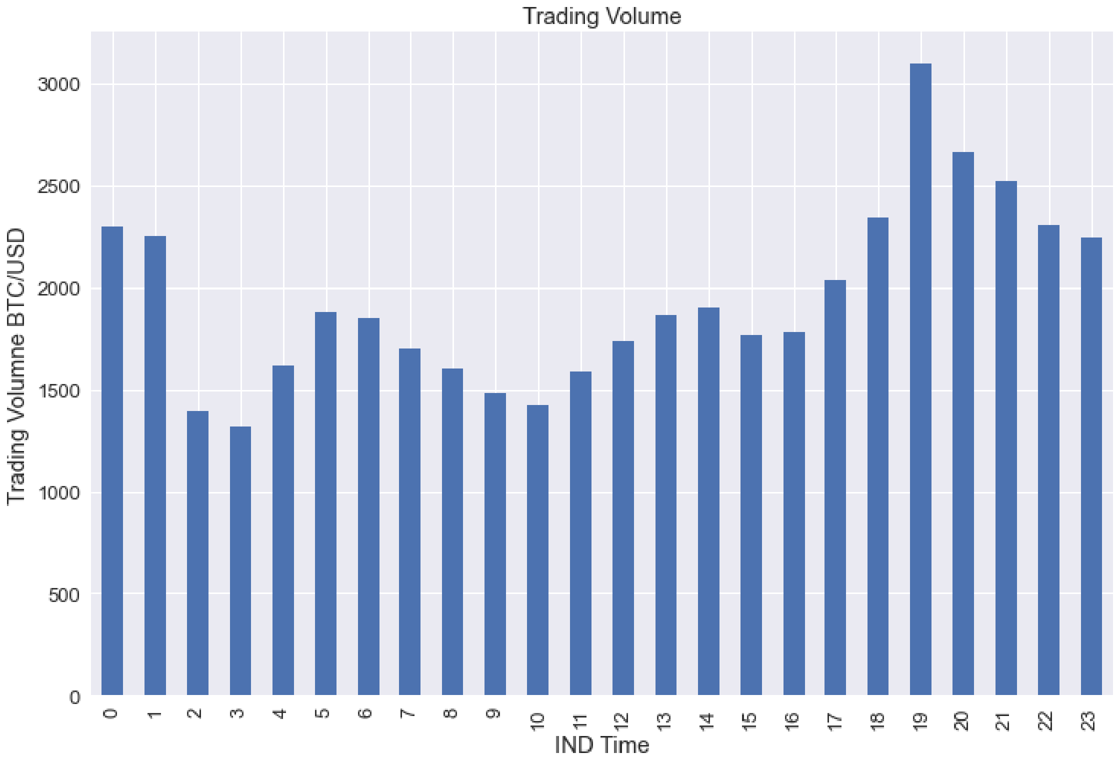
```
[10]: by_hour = data_csv.groupby("hour")[["tickqty", "spread", "price_change_abs"]].
       ↪mean() # grouping the mentioned cols in terms of hours and calculating their␣
       ↪mean
      by_hour
```

```
[10]:          tickqty     spread  price_change_abs
      hour
      0     2298.689573  40.312796         69.143246
      1     2254.435597  40.344028         69.037119
      2     1390.845455  40.276136         81.728523
      3     1316.598174  40.666667         57.117352
      4     1616.769053  40.313395         61.596189
      5     1876.993119  40.325000         58.510894
      6     1849.174312  40.324083         66.231881
      7     1701.692661  40.358257         65.139335
      8     1603.965596  40.291743         54.970298
      9     1484.332569  40.344954         53.038188
      10    1424.839450  40.443807         44.517775
      11    1588.260369  40.301382         47.430530
      12    1733.990783  40.418433         51.868779
      13    1860.598624  40.322018         52.316743
      14    1904.908257  40.446330         49.114679
      15    1767.733945  40.336697         42.321101
      16    1783.628440  40.415367         49.178211
      17    2036.495413  40.446560         50.811009
      18    2345.961009  40.419725         66.115596
      19    3096.974713  40.297701         87.863563
      20    2667.050459  40.270413         86.458486
```

```
21     2522.594037  40.256193         72.679817
22     2308.086247  40.221212         66.675524
23     2248.376499  40.380815         63.930576
```

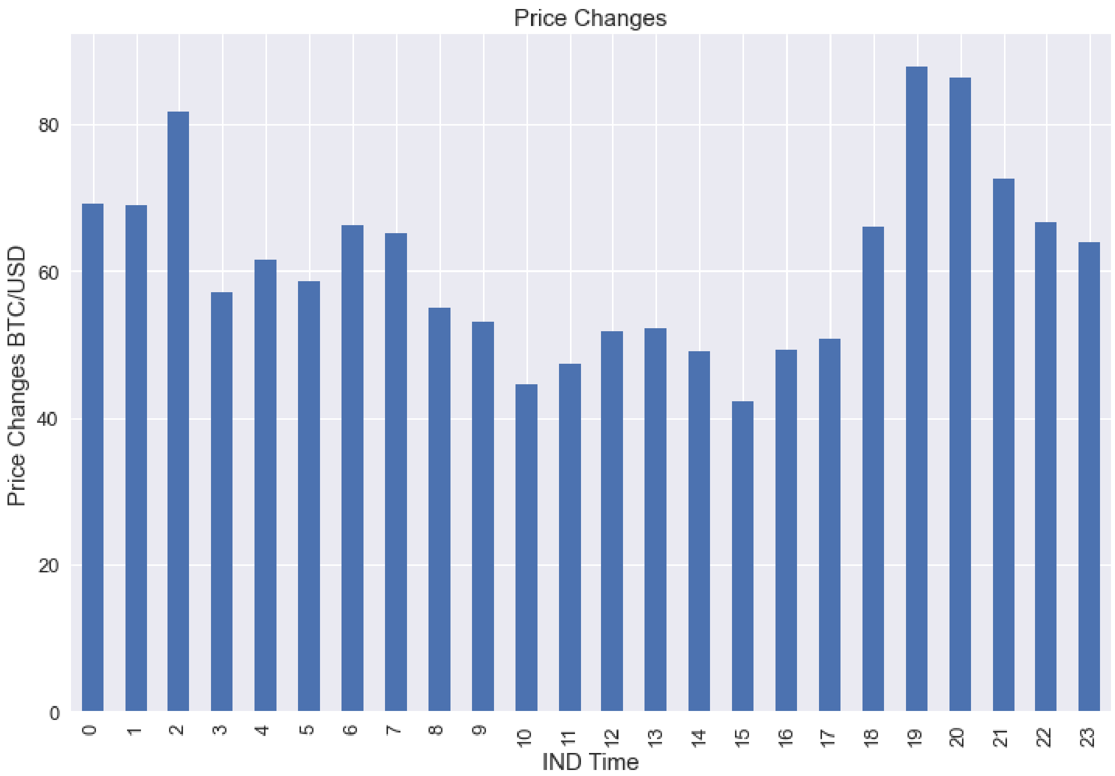
[11]:

```python
by_hour.tickqty.plot(kind = "bar", figsize = (12, 8), fontsize = 13)
plt.xlabel("IND Time", fontsize = 15)
plt.ylabel("Trading Volumne BTC/USD", fontsize = 15)
plt.title("Trading Volume", fontsize = 15)
plt.show()

# Combining the trading vol hour wise of the entire dataset
```



[12]:

```python
by_hour.price_change_abs.plot(kind = "bar", figsize = (12, 8), fontsize = 13)
plt.xlabel("IND Time", fontsize = 15)
plt.ylabel("Price Changes BTC/USD", fontsize = 15)
plt.title("Price Changes", fontsize = 15)
plt.show()

# finding the hour which sees the maximum price change
```



1.4.1 Hence from above two charts it is evident that the best Indian time to trade Bitcoin is between 6pm to 2am

1.5 Now before combining both strategies we will analyze each of them individually

1.5.1 Analyze SMA strategy

```
[13]: import SMA_Backtester as SMA
```

```
[14]: tester = SMA.SMABacktester("price", 50, 200, tc=0.00005) # starting with 50/200 SMA crossover strategy
```

```
[15]: tester.test_strategy() # our strategy: $1->$1.51 , buy and hold: $1->$0.98
```

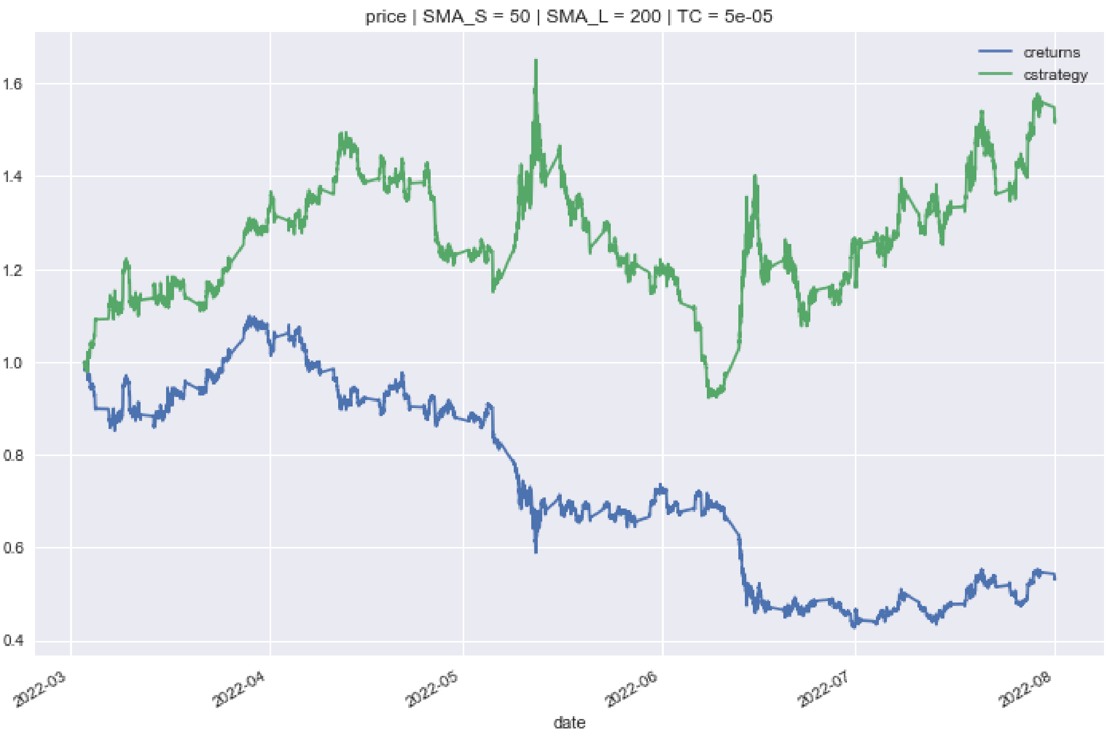
```
[15]: (1.515501, 0.984391)
```

```
[16]: tester.results          # getting parameters of our strategy as output
```

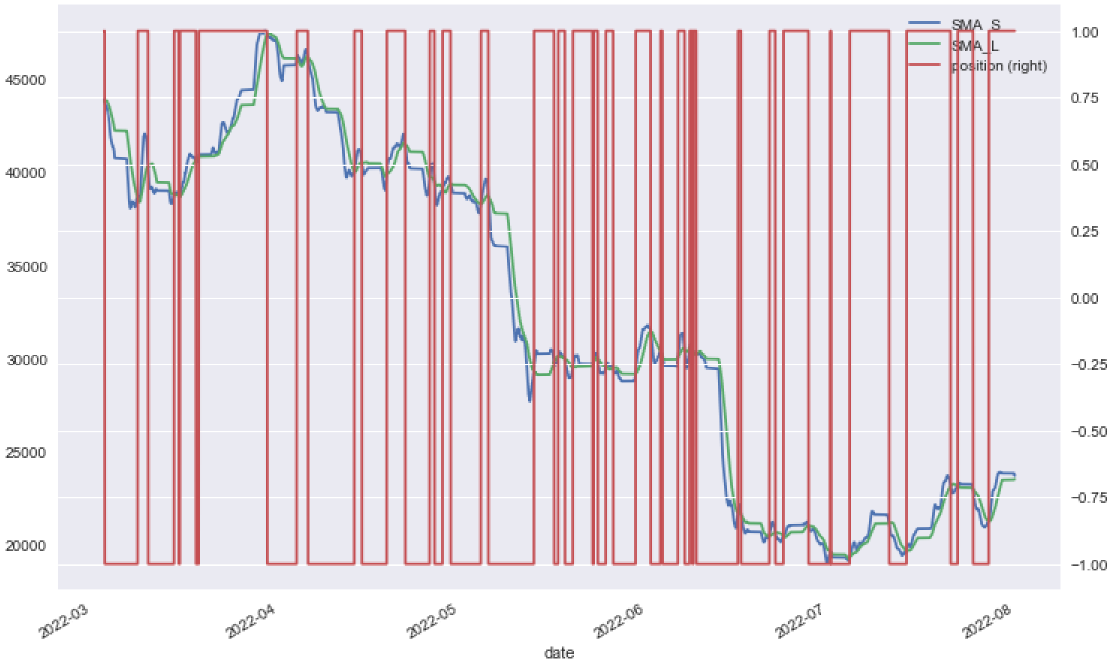
```
[16]:                          price    returns      SMA_S       SMA_L  position  \
      date
      2022-03-03 02:00:00  43727.0 -0.002033  43943.864  43840.2130         1
      2022-03-03 02:15:00  43752.0  0.000572  43948.484  43842.0785         1
```

```
2022-03-03 02:30:00  43779.0  0.000617  43950.722  43843.3340          1
2022-03-03 02:45:00  43792.5  0.000308  43951.698  43844.5015          1
2022-03-03 03:00:00  43718.0 -0.001703  43936.986  43846.7265          1
…                      …        …         …          …        …
2022-07-31 23:00:00  23297.7 -0.003069  23752.920  23514.7980          1
2022-07-31 23:15:00  23328.0  0.001300  23739.690  23518.0080          1
2022-07-31 23:30:00  23389.1  0.002616  23729.464  23521.5965          1
2022-07-31 23:45:00  23283.4 -0.004529  23719.224  23524.7285          1
2022-08-01 00:00:00  23271.1 -0.000528  23712.792  23527.2865          1

                     strategy  trades  creturns  cstrategy
date
2022-03-03 02:00:00 -0.002033     0.0  0.997969   0.997969
2022-03-03 02:15:00  0.000572     0.0  0.998539   0.998539
2022-03-03 02:30:00  0.000617     0.0  0.999156   0.999156
2022-03-03 02:45:00  0.000308     0.0  0.999464   0.999464
2022-03-03 03:00:00 -0.001703     0.0  0.997763   0.997763
…                         …     …        …         …
2022-07-31 23:00:00 -0.003069     0.0  0.531717   1.517233
2022-07-31 23:15:00  0.001300     0.0  0.532408   1.519206
2022-07-31 23:30:00  0.002616     0.0  0.533803   1.523185
2022-07-31 23:45:00 -0.004529     0.0  0.531390   1.516302
2022-08-01 00:00:00 -0.000528     0.0  0.531110   1.515501

[10214 rows x 9 columns]
```

[17]:
```
tester.plot_results()     # our strategy much better than buy and hold
```



[18]:
```
tester.results[["SMA_S", "SMA_L", "position"]].plot(secondary_y = "position",␣
 ↪figsize = (12, 8))
plt.show()

# red line signifies the no of trades and position duration in that period
```



```
[19]: tester.results.trades.value_counts() # no of trades takes = 56
```

```
[19]: 0.0    10158
      2.0       56
      Name: trades, dtype: int64
```

1.5.2 Analyze Mean Reversion Strategy(Bollinger Band)

```
[20]: import MeanRev_Backtester as MeanRev
```

```
[21]: tester2 = MeanRev.MeanRevBacktester(symbol = "price", SMA = 75, dev = 3, tc = 0.
       ↪00005)
```

```
[22]: tester2.test_strategy()
```

```
[22]: (0.572612, 0.041017)
```

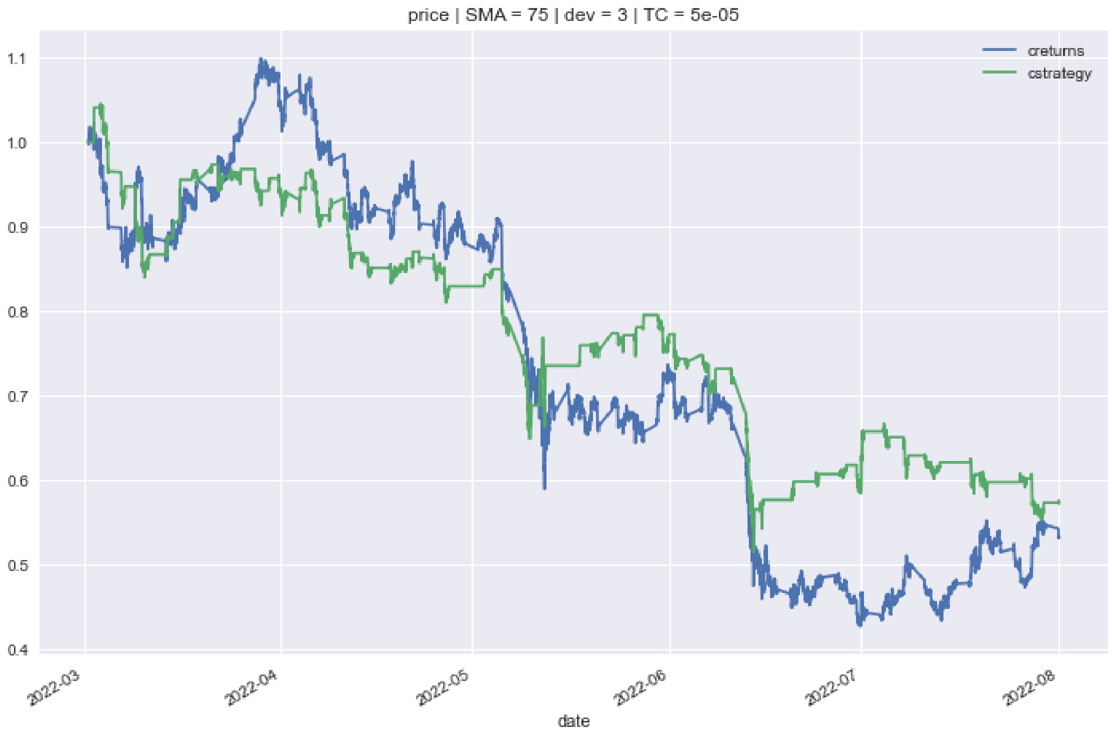
```
[23]: tester2.data
```

```
[23]:                          price   returns          SMA         Lower  \
      date
      2022-03-01 00:00:00  43375.0       NaN          NaN           NaN
      2022-03-01 00:15:00  43378.9  0.000090          NaN           NaN
      2022-03-01 00:30:00  43527.9  0.003429          NaN           NaN
      2022-03-01 00:45:00  43559.0  0.000714          NaN           NaN
```

```
2022-03-01 01:00:00  43273.0 -0.006587           NaN           NaN
…                        …         …          …           …
2022-07-31 23:00:00  23297.7 -0.003069  23822.761333  23210.837453
2022-07-31 23:15:00  23328.0  0.001300  23814.554667  23180.649998
2022-07-31 23:30:00  23389.1  0.002616  23806.456000  23158.979657
2022-07-31 23:45:00  23283.4 -0.004529  23798.308000  23126.778837
2022-08-01 00:00:00  23271.1 -0.000528  23789.793333  23095.109578

                            Upper
date
2022-03-01 00:00:00           NaN
2022-03-01 00:15:00           NaN
2022-03-01 00:30:00           NaN
2022-03-01 00:45:00           NaN
2022-03-01 01:00:00           NaN
…                            …
2022-07-31 23:00:00  24434.685214
2022-07-31 23:15:00  24448.459335
2022-07-31 23:30:00  24453.932343
2022-07-31 23:45:00  24469.837163
2022-08-01 00:00:00  24484.477089

[10414 rows x 5 columns]
```

[24]:

```
tester2.plot_results()
```

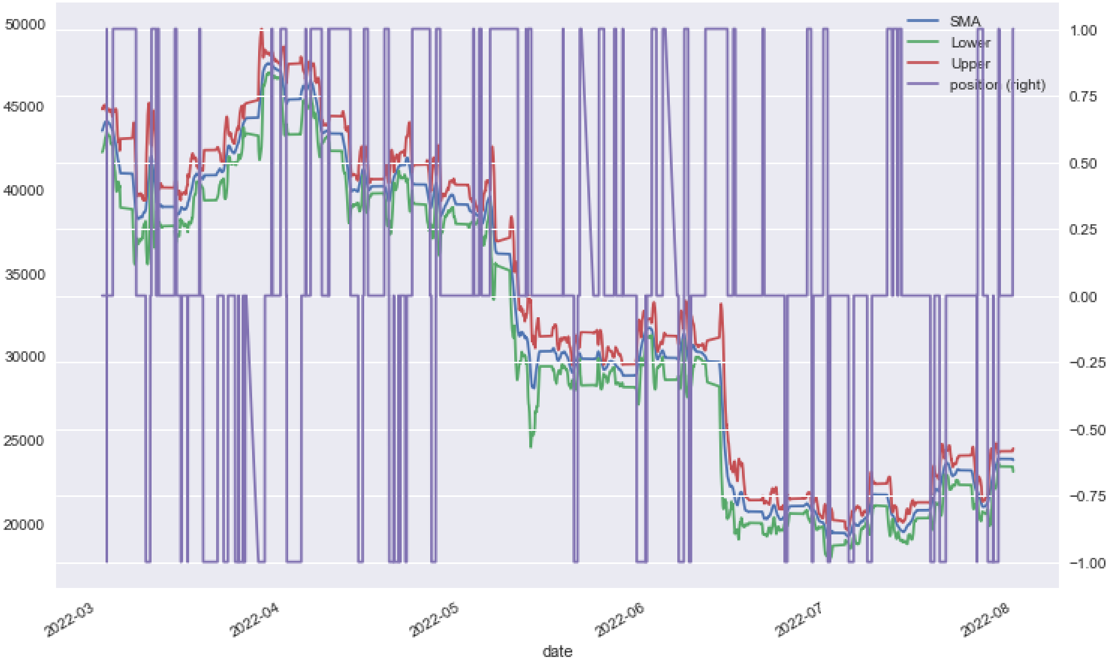


```
[25]: tester2.results
```

```
[25]:
                       price   returns           SMA         Lower  \
date
2022-03-01 18:45:00  43819.5  0.000993  43544.857333  42258.385299
2022-03-01 19:00:00  43723.9 -0.002184  43549.457333  42262.846928
2022-03-01 19:15:00  43984.0  0.005931  43555.538667  42260.186221
2022-03-01 19:30:00  43869.0 -0.002618  43559.672000  42259.775480
2022-03-01 19:45:00  43727.0 -0.003242  43565.725333  42268.494823
…                      …       …           …           …
2022-07-31 23:00:00  23297.7 -0.003069  23822.761333  23210.837453
2022-07-31 23:15:00  23328.0  0.001300  23814.554667  23180.649998
2022-07-31 23:30:00  23389.1  0.002616  23806.456000  23158.979657
2022-07-31 23:45:00  23283.4 -0.004529  23798.308000  23126.778837
2022-08-01 00:00:00  23271.1 -0.000528  23789.793333  23095.109578

                            Upper    distance  position  strategy  trades  \
date
2022-03-01 18:45:00  44831.329368  274.642667       0.0  0.000000     0.0
2022-03-01 19:00:00  44836.067739  174.442667       0.0 -0.000000     0.0
2022-03-01 19:15:00  44850.891113  428.461333       0.0  0.000000     0.0
2022-03-01 19:30:00  44859.568520  309.328000       0.0 -0.000000     0.0
2022-03-01 19:45:00  44862.955843  161.274667       0.0 -0.000000     0.0
…                           …         …       …       …     …
2022-07-31 23:00:00  24434.685214 -525.061333       1.0 -0.003069     0.0
2022-07-31 23:15:00  24448.459335 -486.554667       1.0  0.001300     0.0
2022-07-31 23:30:00  24453.932343 -417.356000       1.0  0.002616     0.0
2022-07-31 23:45:00  24469.837163 -514.908000       1.0 -0.004529     0.0
2022-08-01 00:00:00  24484.477089 -518.693333       1.0 -0.000528     0.0

                     creturns  cstrategy
date
2022-03-01 18:45:00  1.000994   1.000000
2022-03-01 19:00:00  0.998810   1.000000
2022-03-01 19:15:00  1.004751   1.000000
2022-03-01 19:30:00  1.002124   1.000000
2022-03-01 19:45:00  0.998881   1.000000
…                       …        …
2022-07-31 23:00:00  0.532203   0.573267
2022-07-31 23:15:00  0.532895   0.574012
2022-07-31 23:30:00  0.534290   0.575516
2022-07-31 23:45:00  0.531876   0.572915
2022-08-01 00:00:00  0.531595   0.572612
```

```
[10339 rows x 11 columns]
```

[26]:
```
tester2.results[["SMA","Lower","Upper","position"]].plot(secondary_y =␣
 ↪"position", figsize = (12, 8))
plt.show()
```



1.6 Combining both Strategies

Two different Methods:

Strategy 1 (pro: strong signals | con: restrictive / doesn´t work with too many Indicators) - Go Long if all Signals are long - Go Short if all Signals are short - Go Neutral if Signals are nonunanimous

Strategy 2 (pro: can be customized | con: more trades / weaker signals) - Go Long if sum of both the Signals > 0 (1+1 / 1+0/ 0+1) - Go Short if sum of both the Signals < 0 (-1-1 / -1+0/ 0-1) - Go Neutral if sum of both the Signals = 0

1.7 Strategy1

[30]:
```
import SMA_Backtester as SMA
import MeanRev_Backtester as MeanRev
```

[31]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
```

```
from scipy.optimize import brute
from scipy.optimize import minimize
plt.style.use("seaborn")
```

[32]:

```
def optimal_strategy(parameters):

    symbol = "price"
    tc = 0.00005

    # SMA
    tester1 = SMA.SMABacktester(symbol, int(parameters[0]), int(parameters[1]),␣
 ↪tc)
    tester1.test_strategy()

    # Bollinger
    tester2 = MeanRev.MeanRevBacktester(symbol,  int(parameters[2]), ␣
 ↪int(parameters[3]), tc)
    tester2.test_strategy()

    # Create comb
    comb = tester1.results.loc[:, ["returns", "position"]].copy()
    comb.rename(columns = {"position":"position_SMA"}, inplace = True)
    comb["position_MR"] = tester2.results.position

    # 2 Methods
    comb["position_comb"] = np.where(comb.position_MR == comb.position_SMA,␣
 ↪comb.position_MR, 0)
    #comb["position_comb"] = np.sign(comb.position_MR + comb.position_SMA)

    # Backtest
    comb["strategy"] = comb["position_comb"].shift(1) * comb["returns"]
    comb.dropna(inplace=True)
    comb["trades"] = comb.position_comb.diff().fillna(0).abs()
    comb.strategy = comb.strategy - comb.trades * tc
    comb["creturns"] = comb["returns"].cumsum().apply(np.exp)
    comb["cstrategy"] = comb["strategy"].cumsum().apply(np.exp)

    return -comb["cstrategy"].iloc[-1] # negative absolute performance to be␣
 ↪minimized

# this function optimises our strategy
```

[33]:

```
bnds =  ((5, 75), (20, 200), (10, 100), (1, 5))
start_par = (5, 20, 10, 1)
opts = minimize(optimal_strategy, start_par, method = "Powell" , bounds = bnds)
opts
```

```
# finding the best parameters for Strategy 1
```

[33]:

```
    direc: array([[1., 0., 0., 0.],
        [0., 1., 0., 0.],
        [0., 0., 1., 0.],
        [0., 0., 0., 1.]])
      fun: -1.0145117336128733
 message: 'Optimization terminated successfully.'
     nfev: 97
      nit: 1
   status: 0
  success: True
        x: array([ 5.53936656, 88.09209138, 43.64524116,  3.47219573])
```

[34]:

```
# class for backtesting strategy1

class CombStrategy():
    ''' Class for the vectorized backtesting of SMA-based trading strategies.
    '''

    def __init__(self, symbol, SMA_S, SMA_L, SMA, dev, tc):
        '''
        Parameters
        ----------
        symbol: str
            ticker symbol (instrument) to be backtested
        SMA_S: int
            moving window in bars (e.g. days) for shorter SMA
        SMA_L: int
            moving window in bars (e.g. days) for longer SMA
        '''
        self.symbol = symbol
        self.SMA_S = SMA_S
        self.SMA_L = SMA_L
        self.SMA = SMA
        self.dev = dev
        self.tc = tc
        self.results = None
        self.get_data()

    def __repr__(self):
        return "SMABacktester(symbol = {}, SMA_S = {}, SMA_L = {} )".
 ↪format(self.symbol, self.SMA_S, self.SMA_L)

    def get_data(self):
        ''' Imports the data from BTCUSD.csv (source can be changed).
        '''
        raw = pd.read_csv("BTCUSD_m15.csv", parse_dates = ["date"], index_col =␣
↪"date", usecols = ['date','bidclose'])
        raw.rename(columns = {'bidclose':'price'}, inplace = True)
        raw = raw[self.symbol].to_frame().dropna()
        raw.rename(columns={self.symbol: "price"}, inplace=True)
        raw["returns"] = np.log(raw / raw.shift(1))
        raw["SMA_S"] = raw["price"].rolling(self.SMA_S).mean()
        raw["SMA_L"] = raw["price"].rolling(self.SMA_L).mean()
        raw["SMA"] = raw["price"].rolling(self.SMA).mean()
        raw["Lower"] = raw["SMA"] - raw["price"].rolling(self.SMA).std() * self.
↪dev
        raw["Upper"] = raw["SMA"] + raw["price"].rolling(self.SMA).std() * self.
↪dev
        self.data = raw
        return raw

    def set_parameters(self, SMA_S = None, SMA_L = None, SMA = None, dev =␣
↪None):
        ''' Updates SMA parameters and the prepared dataset.
        '''
        if SMA_S is not None:
            self.SMA_S = SMA_S
            self.data["SMA_S"] = self.data["price"].rolling(self.SMA_S).mean()
        if SMA_L is not None:
            self.SMA_L = SMA_L
            self.data["SMA_L"] = self.data["price"].rolling(self.SMA_L).mean()
        if SMA is not None:
            self.SMA = SMA
            self.data["SMA"] = self.data["price"].rolling(self.SMA).mean()
            self.data["Lower"] = self.data["SMA"] - self.data["price"].
↪rolling(self.SMA).std() * self.dev
            self.data["Upper"] = self.data["SMA"] + self.data["price"].
↪rolling(self.SMA).std() * self.dev
        if dev is not None:
            self.dev = dev
            self.data["Lower"] = self.data["SMA"] - self.data["price"].
↪rolling(self.SMA).std() * self.dev
            self.data["Upper"] = self.data["SMA"] + self.data["price"].
↪rolling(self.SMA).std() * self.dev

    def test_strategy(self):
        ''' Backtests the SMA-based trading strategy.
        '''
        data = self.data.copy().dropna()
        data["position1"] = np.where(data["SMA_S"] > data["SMA_L"], 1, -1)
        data["strategy"] = data["position1"].shift(1) * data["returns"]
        data["position1"] = data.position1.ffill().fillna(0)
        data["distance"] = data.price - data.SMA
        data["position2"] = np.where(data.price < data.Lower, 1, np.nan)
        data["position2"] = np.where(data.price > data.Upper, -1,␣
↪data["position2"])
        data["position2"] = np.where(data.distance * data.distance.shift(1) <␣
↪0, 0, data["position2"])
        data["position2"] = data.position2.ffill().fillna(0)
        data["position3"] = np.where(data.position1 == data.position2, data.
↪position1, 0)
        #data["position3"] = np.sign(data.position1 + data.position2)
        data["strategy"] = data.position3.shift(1) * data["returns"]
        data.dropna(inplace=True)

        # determine when a trade takes place
        data["trades"] = data.position3.diff().fillna(0).abs()

        # subtract transaction costs from return when trade takes place
        data.strategy = data.strategy - data.trades * self.tc

        data["creturns"] = data["returns"].cumsum().apply(np.exp)
        data["cstrategy"] = data["strategy"].cumsum().apply(np.exp)
        self.results = data

        perf = data["cstrategy"].iloc[-1] # absolute performance of the strategy
        outperf = perf - data["creturns"].iloc[-1] # out-/underperformance of␣
↪strategy
        return round(perf, 6), round(outperf, 6)

    def plot_results(self):
        ''' Plots the performance of the trading strategy and compares to "buy␣
↪and hold".
        '''
        if self.results is None:
            print("No results to plot yet. Run a strategy.")
        else:
            title = "{} | SMA_S = {} | SMA_L = {} | SMA = {} | dev = {} | TC =␣
↪{}".format(self.symbol, self.SMA_S, self.SMA_L, self.SMA, self.dev, self.tc)
            self.results[["creturns", "cstrategy"]].plot(title=title,␣
↪figsize=(12, 8))
```

[35]:

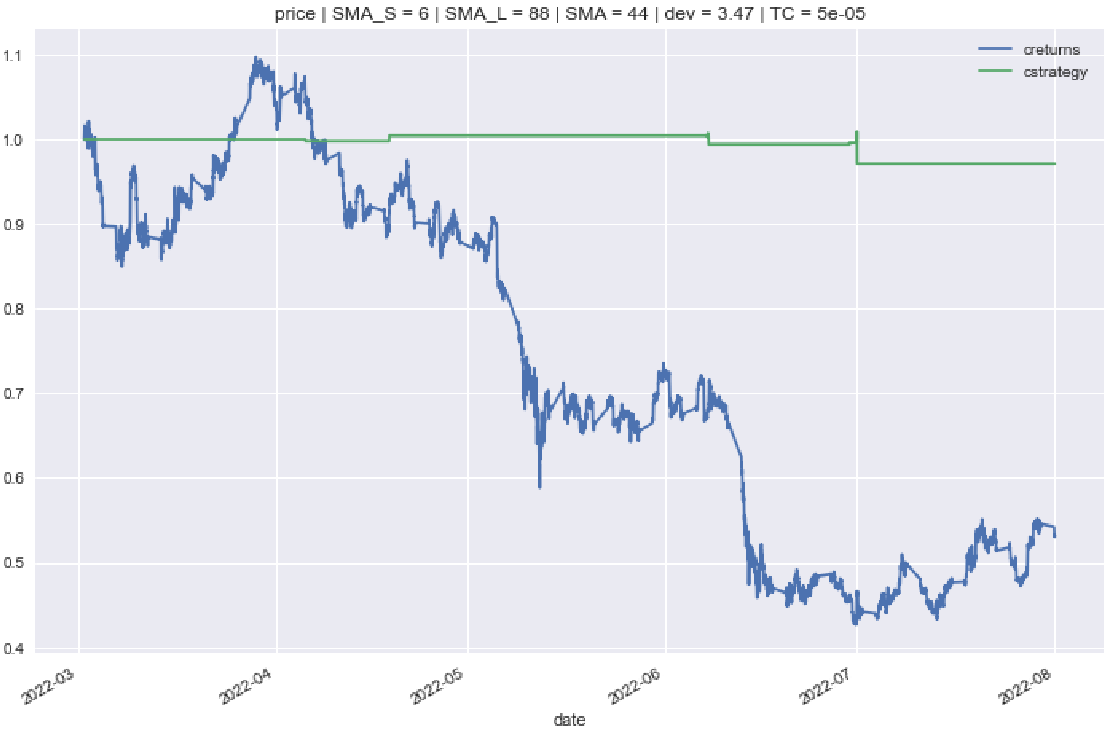
```
test_strategy1 = CombStrategy(symbol="price", SMA_S= 6, SMA_L=88, SMA=44, dev=3.
↪47, tc=0.00005) # testing with best optimised values
```

[36]:

```
test_strategy1.test_strategy() # our strategy : $1 -> $0.97 , buy and hold : $1␣
↪-> $ 0.53 | our strategy much better and stable than buy and hold
```

[36]: (0.971298, 0.44097)

[37]:
```
test_strategy1.plot_results()
```



[38]:
```
test_strategy1.results.trades.value_counts() # only 10 trades taken
```

[38]:
```
0.0    10316
1.0       10
Name: trades, dtype: int64
```

1.8 Strategy2

[39]:
```
def optimal_strategy(parameters):

    symbol = "price"
    tc = 0.00005

    # SMA
    tester1 = SMA.SMABacktester(symbol, int(parameters[0]), int(parameters[1]),␣
 ↪tc)
    tester1.test_strategy()

    # Bollinger
    tester2 = MeanRev.MeanRevBacktester(symbol,  int(parameters[2]), ␣
↪int(parameters[3]), tc)
    tester2.test_strategy()

    # Create comb
    comb = tester1.results.loc[:, ["returns", "position"]].copy()
    comb.rename(columns = {"position":"position_SMA"}, inplace = True)
    comb["position_MR"] = tester2.results.position

    # 2 Methods
    #comb["position_comb"] = np.where(comb.position_MR == comb.position_SMA,␣
↪comb.position_MR, 0)
    comb["position_comb"] = np.sign(comb.position_MR + comb.position_SMA)

    # Backtest
    comb["strategy"] = comb["position_comb"].shift(1) * comb["returns"]
    comb.dropna(inplace=True)
    comb["trades"] = comb.position_comb.diff().fillna(0).abs()
    comb.strategy = comb.strategy - comb.trades * tc
    comb["creturns"] = comb["returns"].cumsum().apply(np.exp)
    comb["cstrategy"] = comb["strategy"].cumsum().apply(np.exp)

    return -comb["cstrategy"].iloc[-1] # negative absolute performance to be␣
↪minimized

# this function optimises our strategy
```

[40]:
```
bnds =  ((5, 75), (20, 200), (10, 100), (1, 5))
start_par = (5, 20, 10, 1)
opts = minimize(optimal_strategy, start_par, method = "Powell" , bounds = bnds)
opts

# finding the best parameters for Strategy 2
```

[40]:
```
   direc: array([[1., 0., 0., 0.],
       [0., 1., 0., 0.],
       [0., 0., 1., 0.],
       [0., 0., 0., 1.]])
     fun: -1.8020878596292877
 message: 'Optimization terminated successfully.'
    nfev: 300
     nit: 3
  status: 0
 success: True
       x: array([ 53.45570833, 109.09475214,  31.24617595,   2.52792754])
```

[41]:

```
# class for backtesting strategy2

class CombStrategy():
    ''' Class for the vectorized backtesting of SMA-based trading strategies.
    '''

    def __init__(self, symbol, SMA_S, SMA_L, SMA, dev, tc):
        '''
        Parameters
        ----------
        symbol: str
            ticker symbol (instrument) to be backtested
        SMA_S: int
            moving window in bars (e.g. days) for shorter SMA
        SMA_L: int
            moving window in bars (e.g. days) for longer SMA
        '''
        self.symbol = symbol
        self.SMA_S = SMA_S
        self.SMA_L = SMA_L
        self.SMA = SMA
        self.dev = dev
        self.tc = tc
        self.results = None
        self.get_data()

    def __repr__(self):
        return "SMABacktester(symbol = {}, SMA_S = {}, SMA_L = {} )".
 ↪format(self.symbol, self.SMA_S, self.SMA_L)

    def get_data(self):
        ''' Imports the data from BTCUSD.csv (source can be changed).
        '''
        raw = pd.read_csv("BTCUSD_m15.csv", parse_dates = ["date"], index_col =␣
 ↪"date", usecols = ['date','bidclose'])
        raw.rename(columns = {'bidclose':'price'}, inplace = True)
        raw = raw[self.symbol].to_frame().dropna()
        raw.rename(columns={self.symbol: "price"}, inplace=True)
        raw["returns"] = np.log(raw / raw.shift(1))
        raw["SMA_S"] = raw["price"].rolling(self.SMA_S).mean()
        raw["SMA_L"] = raw["price"].rolling(self.SMA_L).mean()
        raw["SMA"] = raw["price"].rolling(self.SMA).mean()
        raw["Lower"] = raw["SMA"] - raw["price"].rolling(self.SMA).std() * self.
 ↪dev
        raw["Upper"] = raw["SMA"] + raw["price"].rolling(self.SMA).std() * self.
 ↪dev
        self.data = raw
        return raw

    def set_parameters(self, SMA_S = None, SMA_L = None, SMA = None, dev =␣
↪None):
        ''' Updates SMA parameters and the prepared dataset.
        '''
        if SMA_S is not None:
            self.SMA_S = SMA_S
            self.data["SMA_S"] = self.data["price"].rolling(self.SMA_S).mean()
        if SMA_L is not None:
            self.SMA_L = SMA_L
            self.data["SMA_L"] = self.data["price"].rolling(self.SMA_L).mean()
        if SMA is not None:
            self.SMA = SMA
            self.data["SMA"] = self.data["price"].rolling(self.SMA).mean()
            self.data["Lower"] = self.data["SMA"] - self.data["price"].
↪rolling(self.SMA).std() * self.dev
            self.data["Upper"] = self.data["SMA"] + self.data["price"].
↪rolling(self.SMA).std() * self.dev
        if dev is not None:
            self.dev = dev
            self.data["Lower"] = self.data["SMA"] - self.data["price"].
↪rolling(self.SMA).std() * self.dev
            self.data["Upper"] = self.data["SMA"] + self.data["price"].
↪rolling(self.SMA).std() * self.dev

    def test_strategy(self):
        ''' Backtests the SMA-based trading strategy.
        '''
        data = self.data.copy().dropna()
        data["position1"] = np.where(data["SMA_S"] > data["SMA_L"], 1, -1)
        data["strategy"] = data["position1"].shift(1) * data["returns"]
        data["position1"] = data.position1.ffill().fillna(0)
        data["distance"] = data.price - data.SMA
        data["position2"] = np.where(data.price < data.Lower, 1, np.nan)
        data["position2"] = np.where(data.price > data.Upper, -1,␣
↪data["position2"])
        data["position2"] = np.where(data.distance * data.distance.shift(1) <␣
↪0, 0, data["position2"])
        data["position2"] = data.position2.ffill().fillna(0)
        #data["position3"] = np.where(data.position1 == data.position2, data.
↪position1, 0)
        data["position3"] = np.sign(data.position1 + data.position2)
        data["strategy"] = data.position3.shift(1) * data["returns"]
        data.dropna(inplace=True)
        # determine when a trade takes place
        data["trades"] = data.position3.diff().fillna(0).abs()

        # subtract transaction costs from return when trade takes place
        data.strategy = data.strategy - data.trades * self.tc

        data["creturns"] = data["returns"].cumsum().apply(np.exp)
        data["cstrategy"] = data["strategy"].cumsum().apply(np.exp)
        self.results = data

        perf = data["cstrategy"].iloc[-1] # absolute performance of the strategy
        outperf = perf - data["creturns"].iloc[-1] # out-/underperformance of␣
↪strategy
        return round(perf, 6), round(outperf, 6)

    def plot_results(self):
        ''' Plots the performance of the trading strategy and compares to "buy␣
↪and hold".
        '''
        if self.results is None:
            print("No results to plot yet. Run a strategy.")
        else:
            title = "{} | SMA_S = {} | SMA_L = {} | SMA = {} | dev = {} | TC =␣
↪{}".format(self.symbol, self.SMA_S, self.SMA_L, self.SMA, self.dev, self.tc)
            self.results[["creturns", "cstrategy"]].plot(title=title,␣
↪figsize=(12, 8))
```

[42]:

```
test_strategy2 = CombStrategy(symbol="price", SMA_S= 53, SMA_L=109, SMA=31,␣
↪dev=2.52, tc=0.00005) # testing with best optimised values
```

[44]:

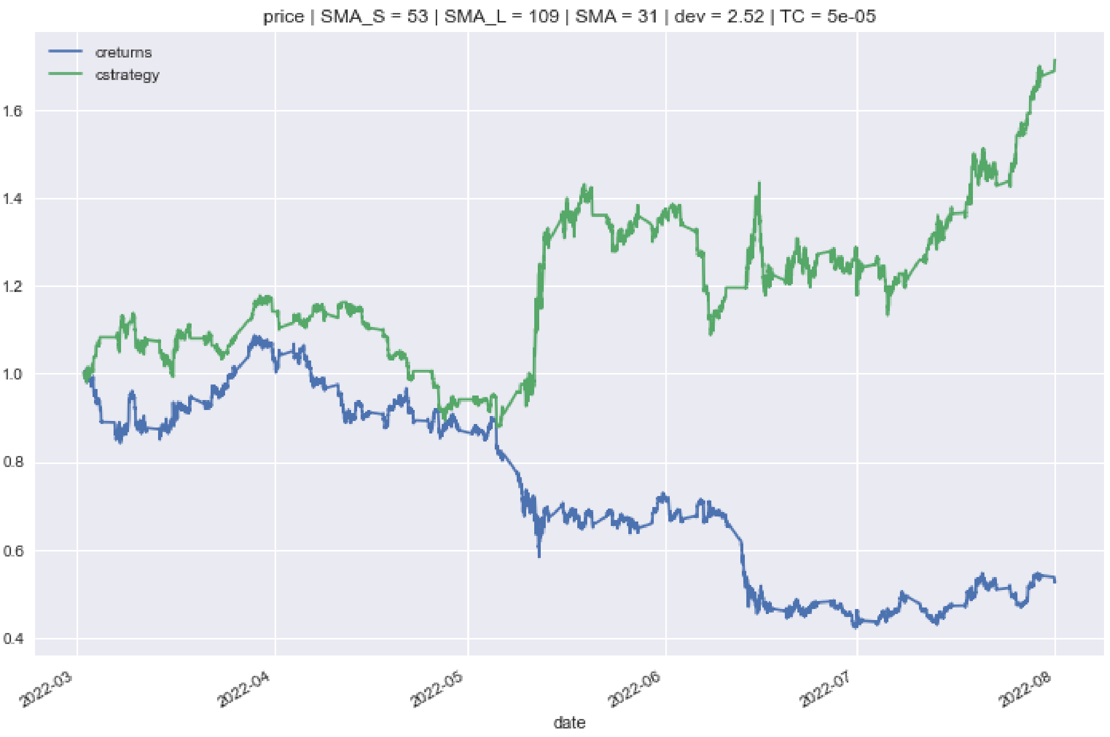
```
test_strategy2.test_strategy() # our strategy : $1 -> $1.71 , buy and hold : $1␣
↪-> $ 0.53 | our strategy much better than buy and hold
```

[44]:

```
(1.712942, 1.187178)
```

[45]:

```
test_strategy2.plot_results()
```



```
[46]: test_strategy2.results.trades.value_counts() # 56 long, 279 short positions␣
       ↪taken by this strategy
```

```
[46]: 0.0    9970
      1.0     279
      2.0      56
      Name: trades, dtype: int64
```

1.9 Implementing Strategy 2 in FXCM

```
[1]: import pandas as pd
     import numpy as np
     import fxcmpy
     from datetime import datetime, timedelta
     import time
```

```
[2]: api = fxcmpy.fxcmpy(config_file= "fxcm.cfg")
```

```
[3]: col = ["tradeId", "amountK", "currency", "grossPL", "isBuy"]
```

```
[12]: datetime.utcnow().time()
```

```
[12]: datetime.time(11, 10, 24, 355871)
```

[15]:
```
pd.to_datetime("11:15").time() # desired end of trading session (in utc time)->␣
 ↪2am indian local time
```

[15]:
```
datetime.time(11, 15)
```

[16]:
```
if datetime.utcnow().time() >= pd.to_datetime("11:15").time():
    print("Stop the Trading Session!")
```

[17]:
```
class Trader():

    def __init__(self, instrument, bar_length, SMA, dev, SMA_S, SMA_L, units):
        self.instrument = instrument
        self.bar_length = pd.to_timedelta(bar_length)
        self.tick_data = None
        self.raw_data = None
        self.data = None
        self.ticks = 0
        self.last_bar = None
        self.units = units
        self.position = 0

        #*****************add strategy-specific attributes␣
 ↪here******************
        self.SMA = SMA
        self.dev = dev
        self.SMA_S = SMA_S
        self.SMA_L = SMA_L
       ␣
 ↪#************************************************************************   ␣
 ↪

    def get_most_recent(self, period = "m1", number = 10000):
        while True:
            time.sleep(5)
            df = api.get_candles(self.instrument, number = number, period =␣
 ↪period, columns = ["bidclose", "askclose"])
            df[self.instrument] = (df.bidclose + df.askclose) / 2
            df = df[self.instrument].to_frame()
            df = df.resample(self.bar_length, label = "right").last().dropna().
 ↪iloc[:-1]
            self.raw_data = df.copy()
            self.last_bar = self.raw_data.index[-1]
            if pd.to_datetime(datetime.utcnow()) - self.last_bar < self.
 ↪bar_length:
                break

    def get_tick_data(self, data, dataframe):
        self.ticks += 1
        print(self.ticks, end = " ", flush = True)

        recent_tick = pd.to_datetime(data["Updated"], unit = "ms")

        if recent_tick - self.last_bar > self.bar_length:
            self.tick_data = dataframe.loc[self.last_bar:, ["Bid", "Ask"]]
            self.tick_data[self.instrument] = (self.tick_data.Ask + self.
↪tick_data.Bid)/2
            self.tick_data = self.tick_data[self.instrument].to_frame()
            self.resample_and_join()
            self.define_strategy()
            self.execute_trades()

    def resample_and_join(self):
        self.raw_data = self.raw_data.append(self.tick_data.resample(self.
↪bar_length,
                                                              label="right").
↪last().ffill().iloc[:-1])
        self.last_bar = self.raw_data.index[-1]

    def define_strategy(self): # "strategy-specific"
        df = self.raw_data.copy()

        #******************** define your strategy here ************************
        df = df.append(self.tick_data.iloc[-1]) # append latest tick (== open␣
↪price of current bar)
        df["returns"] = np.log(df[self.instrument] / df[self.instrument].
↪shift())
        df["SMA_S"] = df[self.instrument].rolling(self.SMA_S).mean()
        df["SMA_L"] = df[self.instrument].rolling(self.SMA_L).mean()
        df["SMA"] = df[self.instrument].rolling(self.SMA).mean()
        df["Lower"] = df["SMA"] - df[self.instrument].rolling(self.SMA).std() *␣
↪self.dev
        df["Upper"] = df["SMA"] + df[self.instrument].rolling(self.SMA).std() *␣
↪self.dev
        df["distance"] = df.self.instrument - df.SMA
        df["Lower"] = df["SMA"] - df[self.instrument].rolling(self.SMA).std() *␣
↪self.dev
        df["Upper"] = df["SMA"] + df[self.instrument].rolling(self.SMA).std() *␣
↪self.dev
        df.dropna(inplace = True)


        #determine positions
        df = df.loc[self.start_time:].copy() # starting with first live_stream␣
↪bar (removing historical bars)
        df["position_SMA"] = np.where(df["SMA_S"] > df["SMA_L"], 1, -1 )
        df["position_BB"] = np.where(df.self.instrument < df.Lower, 1, np.nan)
        df["position_BB"] = np.where(df.self.instrument > df.Upper, -1,␣
↪df["position_BB"])
        df["position_BB"] = np.where(df.distance * df.distance.shift(1) < 0, 0,␣
↪df["position_BB"])

        df["position_comb"] = np.sign(df.position_MR + df.position_SMA)
        df["position_comb"] = df.position.ffill().fillna(0) # start with␣
↪neutral position if no strong signal
        #*************************************************************************

        self.data = df.copy()

    def execute_trades(self):
        if self.data["position_comb"].iloc[-1] == 1:
            if self.position == 0:
                order = api.create_market_buy_order(self.instrument, self.units)
                self.report_trade(order, "GOING LONG")
            elif self.position == -1:
                order = api.create_market_buy_order(self.instrument, self.units␣
↪* 2)
                self.report_trade(order, "GOING LONG")
            self.position = 1
        elif self.data["position_comb"].iloc[-1] == -1:
            if self.position == 0:
                order = api.create_market_sell_order(self.instrument, self.
↪units)
                self.report_trade(order, "GOING SHORT")
            elif self.position == 1:
                order = api.create_market_sell_order(self.instrument, self.
↪units * 2)
                self.report_trade(order, "GOING SHORT")
            self.position = -1
        elif self.data["position_comb"].iloc[-1] == 0:
            if self.position == -1:
                order = api.create_market_buy_order(self.instrument, self.units)
                self.report_trade(order, "GOING NEUTRAL")
            elif self.position == 1:
                order = api.create_market_sell_order(self.instrument, self.
↪units)
                self.report_trade(order, "GOING NEUTRAL")
            self.position = 0
    def report_trade(self, order, going):
        time = order.get_time()
        units = api.get_open_positions().amountK.iloc[-1]
        price = api.get_open_positions().open.iloc[-1]
        unreal_pl = api.get_open_positions().grossPL.sum()
        print("\n" + 100* "-")
        print("{} | {}".format(time, going))
        print("{} | units = {} | price = {} | Unreal. P&L = {}".format(time,␣
  ↪units, price, unreal_pl))
        print(100 * "-" + "\n")
```

[18]:
```
trader = Trader("BTC/USD", bar_length = "5min",SMA = 31, dev = 2.52, SMA_S =␣
  ↪53, SMA_L = 109, units = 100)
```

[19]:
```
trader.get_most_recent()
api.subscribe_market_data(trader.instrument, (trader.get_tick_data, ))
```

[20]:
```
api.unsubscribe_market_data(trader.instrument)
if len(api.get_open_positions()) != 0: # if we have final open position(s)␣
  ↪(netting and hedging)
    api.close_all_for_symbol(trader.instrument)
    print(2*"\n" + "{} | GOING NEUTRAL".format(str(datetime.utcnow())) + "\n")
    time.sleep(20)
    print(api.get_closed_positions_summary()[col])
    trader.position = 0
```

```
637 638 639
```

[21]:
```
trader.data
```

[22]:
```
api.close()
```