CME_Tick_Changes_CAD

October 9, 2019

1 The Robert and Rosenbaum Uncertainty Zones model

2 An application to EURUSD FX Futures at CME

2.1 Implementation by

2.2 Marcos Costa Santos Carreira (École Polytechnique - CMAP)

2.3 and

2.4 Florian Huchedé (CME)

2.5 Aug-2019

2.6 Import packages

[420]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
import statsmodels.api as sm
import glob
```

[421]:
```
pd.set_option('display.max_columns', 50)
```

[422]:
```
pd.set_option('display.max_rows', 200)
```

[423]:
```
import cme_processing as cme
```

2.7 File paths and initial values

[424]:
```
PATHPROJ = '/Users/marcoscscarreira/Documents/X/CME project/CME_data/'
URL_ROOT = 'https://raw.githubusercontent.com/MarcosCarreira/UZStats/master/
 ↪CME_data/'
```

[425]:
```
CURR = 'CAD'
```

[426]:
```
PATH_PRIOR = PATHPROJ+CURR+'/prior/'
PATH_AFTER = PATHPROJ+CURR+'/after/'
URL_1 = CURR+'/prior/'
URL_2 = CURR+'/after/'
#PATH_PRIOR = URL_ROOT+URL_1
#PATH_AFTER = URL_ROOT+URL_2
```

[427]:
```
TRADING_HOURS = 8
```

[428]:
```
TICK_PRIOR = 1.0
TICK_AFTER = 0.5
```

[429]:
```
PRIOR_CDATES_LIST = [['6CH6', '010416'], ['6CH6', '010516'], ['6CH6',␣
↪'010616'],\
   ['6CH6', '010716'], ['6CH6', '010816'], ['6CH6', '011116'], ['6CH6',␣
↪'011216'],\
   ['6CH6', '011316'], ['6CH6', '011416'], ['6CH6', '011516'], ['6CH6',␣
↪'011816'],\
   ['6CH6', '011916'], ['6CH6', '012016'], ['6CH6', '012116'], ['6CH6',␣
↪'012216'],\
   ['6CH6', '012516'], ['6CH6', '012616'], ['6CH6', '012716'], ['6CH6',␣
↪'012816'],\
   ['6CH6', '012916'], ['6CH6', '20160201'], ['6CH6', '20160202'], ['6CH6',␣
↪'20160203'],\
   ['6CH6', '20160204'], ['6CH6', '20160205'], ['6CH6', '20160208'], ['6CH6',␣
↪'20160209'],\
   ['6CH6', '20160210'], ['6CH6', '20160211'], ['6CH6', '20160212'], ['6CH6',␣
↪'20160215'],\
   ['6CH6', '20160216'], ['6CH6', '20160217'], ['6CH6', '20160218'], ['6CH6',␣
↪'20160219'],\
   ['6CH6', '20160222'], ['6CH6', '20160223'], ['6CH6', '20160224'], ['6CH6',␣
↪'20160225'],\
   ['6CH6', '20160226'], ['6CH6', '20160229'], ['6CH6', '20160301'], ['6CH6',␣
↪'20160302'],\
   ['6CH6', '20160303'], ['6CH6', '20160304'], ['6CH6', '20160307'], ['6CH6',␣
↪'20160308'],\
   ['6CH6', '20160309'], ['6CH6', '20160310'], ['6CH6', '20160311'], ['6CM6',␣
↪'20160314'],\
   ['6CM6', '20160315'], ['6CM6', '20160316'], ['6CM6', '20160317'], ['6CM6',␣
↪'20160318'],\
   ['6CM6', '20160321'], ['6CM6', '20160322'], ['6CM6', '20160323'], ['6CM6',␣
↪'20160324'],\
   ['6CM6', '20160328'], ['6CM6', '20160329'], ['6CM6', '20160330'], ['6CM6',␣
↪'20160331'],\
```

```
   ['6CM6', '20160401'], ['6CM6', '20160404'], ['6CM6', '20160405'], ['6CM6',␣
↪'20160406'],\
   ['6CM6', '20160407'], ['6CM6', '20160408'], ['6CM6', '20160411'], ['6CM6',␣
↪'20160412'],\
   ['6CM6', '20160413'], ['6CM6', '20160414'], ['6CM6', '20160415'], ['6CM6',␣
↪'20160418'],\
   ['6CM6', '20160419'], ['6CM6', '20160420'], ['6CM6', '20160421'], ['6CM6',␣
↪'20160422'],\
   ['6CM6', '20160425'], ['6CM6', '20160426'], ['6CM6', '20160427'], ['6CM6',␣
↪'20160428'],\
   ['6CM6', '20160429'], ['6CM6', '20160502'], ['6CM6', '20160503'], ['6CM6',␣
↪'20160504'],\
   ['6CM6', '20160505'], ['6CM6', '20160506'], ['6CM6', '20160509'], ['6CM6',␣
↪'20160510'],\
   ['6CM6', '20160511'], ['6CM6', '20160512'], ['6CM6', '20160513'], ['6CM6',␣
↪'20160516'],\
   ['6CM6', '20160517'], ['6CM6', '20160518'], ['6CM6', '20160519'], ['6CM6',␣
↪'20160520'],\
   ['6CM6', '20160523'], ['6CM6', '20160524'], ['6CM6', '20160525'], ['6CM6',␣
↪'20160526'],\
   ['6CM6', '20160527'], ['6CM6', '20160530'], ['6CM6', '20160531'], ['6CM6',␣
↪'20160601'],\
   ['6CM6', '20160602'], ['6CM6', '20160603'], ['6CM6', '20160606'], ['6CM6',␣
↪'20160607'],\
   ['6CM6', '20160608'], ['6CM6', '20160609'], ['6CU6', '061016'], ['6CU6',␣
↪'061316'],\
   ['6CU6', '061416'], ['6CU6', '061516'], ['6CU6', '061616'], ['6CU6',␣
↪'061716'],\
   ['6CU6', '062016'], ['6CU6', '062116'], ['6CU6', '062216'], ['6CU6',␣
↪'062316'],\
   ['6CU6', '062416'], ['6CU6', '062716'], ['6CU6', '062816'], ['6CU6',␣
↪'062916'],\
   ['6CU6', '063016'], ['6CU6', '070116'], ['6CU6', '070416'], ['6CU6',␣
↪'070516'],\
   ['6CU6', '070616'], ['6CU6', '070716'], ['6CU6', '070816']]
```

[430]:
```
AFTER_CDATES_LIST = [['6CU6', '071116'], ['6CU6', '071216'], ['6CU6',␣
↪'071316'],\
   ['6CU6', '071416'], ['6CU6', '071516'], ['6CU6', '071816'], ['6CU6',␣
↪'071916'],\
   ['6CU6', '072016'], ['6CU6', '072116'], ['6CU6', '072216'], ['6CU6',␣
↪'072516'],\
   ['6CU6', '072616'], ['6CU6', '072716'], ['6CU6', '072816'], ['6CU6',␣
↪'072916'],\
```

```
   ['6CU6', '080116'], ['6CU6', '080216'], ['6CU6', '080316'], ['6CU6',␣
↪'080416'],\
   ['6CU6', '080516'], ['6CU6', '080816'], ['6CU6', '080916'], ['6CU6',␣
↪'081016'],\
   ['6CU6', '081116'], ['6CU6', '081216'], ['6CU6', '081516'], ['6CU6',␣
↪'081616'],\
   ['6CU6', '081716'], ['6CU6', '081816'], ['6CU6', '081916'], ['6CU6',␣
↪'082216'],\
   ['6CU6', '082316'], ['6CU6', '082416'], ['6CU6', '082516'], ['6CU6',␣
↪'082616'],\
   ['6CU6', '082916'], ['6CU6', '083016'], ['6CU6', '083116'], ['6CU6',␣
↪'090116'],\
   ['6CU6', '090216'], ['6CU6', '090516'], ['6CU6', '090616'], ['6CU6',␣
↪'090716'],\
   ['6CU6', '090816'], ['6CU6', '090916'], ['6CU6', '091216'], ['6CU6',␣
↪'091316'],\
   ['6CU6', '091416'], ['6CU6', '091516'], ['6CZ6', '20160916'], ['6CZ6',␣
↪'20160919'],\
   ['6CZ6', '20160920'], ['6CZ6', '20160921'], ['6CZ6', '20160922'], ['6CZ6',␣
↪'20160923'],\
   ['6CZ6', '20160926'], ['6CZ6', '20160927'], ['6CZ6', '20160928'], ['6CZ6',␣
↪'20160929'],\
   ['6CZ6', '20160930'], ['6CZ6', '20161003'], ['6CZ6', '20161004'], ['6CZ6',␣
↪'20161005'],\
   ['6CZ6', '20161006'], ['6CZ6', '20161007'], ['6CZ6', '20161010'], ['6CZ6',␣
↪'20161011'],\
   ['6CZ6', '20161012'], ['6CZ6', '20161013'], ['6CZ6', '20161014'], ['6CZ6',␣
↪'20161017'],\
   ['6CZ6', '20161018'], ['6CZ6', '20161019'], ['6CZ6', '20161020'], ['6CZ6',␣
↪'20161021'],\
   ['6CZ6', '20161024'], ['6CZ6', '20161025'], ['6CZ6', '20161026'], ['6CZ6',␣
↪'20161027'],\
   ['6CZ6', '20161028'], ['6CZ6', '20161031'], ['6CZ6', '20161101'], ['6CZ6',␣
↪'20161102'],\
   ['6CZ6', '20161103'], ['6CZ6', '20161104'], ['6CZ6', '20161107'], ['6CZ6',␣
↪'20161108'],\
   ['6CZ6', '20161109'], ['6CZ6', '20161110'], ['6CZ6', '20161111'], ['6CZ6',␣
↪'20161114'],\
   ['6CZ6', '20161115'], ['6CZ6', '20161116'], ['6CZ6', '20161117'], ['6CZ6',␣
↪'20161118'],\
   ['6CZ6', '20161121'], ['6CZ6', '20161122'], ['6CZ6', '20161123'], ['6CZ6',␣
↪'20161124'],\
   ['6CZ6', '20161125'], ['6CZ6', '20161128'], ['6CZ6', '20161129'], ['6CZ6',␣
↪'20161130'],\
```

```
   ['6CZ6', '20161201'], ['6CZ6', '20161202'], ['6CZ6', '20161205'], ['6CZ6',␣
↪'20161206'],\
   ['6CZ6', '20161207'], ['6CZ6', '20161208'], ['6CZ6', '20161209'], ['6CZ6',␣
↪'20161212'],\
   ['6CZ6', '20161213'], ['6CZ6', '20161214'], ['6CZ6', '20161215'], ['6CZ6',␣
↪'20161216'],\
   ['w6CH7', '20161219'], ['w6CH7', '20161220'], ['w6CH7', '20161221'],␣
↪['w6CH7', '20161222'],\
   ['w6CH7', '20161223'], ['w6CH7', '20161227'], ['w6CH7', '20161228'],␣
↪['w6CH7', '20161229'],\
   ['w6CH7', '20161230'], ['x6CH7', '010317'], ['x6CH7', '010417'], ['x6CH7',␣
↪'010517'],\
   ['x6CH7', '010617'], ['x6CH7', '010917'], ['x6CH7', '011017'], ['x6CH7',␣
↪'011117'],\
   ['x6CH7', '011217'], ['x6CH7', '011317'], ['x6CH7', '011617'], ['x6CH7',␣
↪'011717'],\
   ['x6CH7', '011817'], ['x6CH7', '011917'], ['x6CH7', '012017'], ['x6CH7',␣
↪'012317'],\
   ['x6CH7', '012417'], ['x6CH7', '012517'], ['x6CH7', '012617'], ['x6CH7',␣
↪'012717'],\
   ['x6CH7', '013017']]
```

2.7.1 Processing files

Prior

[431]:
```
#PRIOR_CDATES_LIST = cme.list_files(PATH_PRIOR)
```

[432]:
```
#PRIOR_CDATES_LIST
```

[433]:
```
PRIOR_CDATES, FILES_PRIOR_CAticks, FILES_PRIOR_COSTtrades,\
    FILES_PRIOR_OBstats, FILES_PRIOR_OTtrans,\
    FILES_PRIOR_RDFtrans, FILES_PRIOR_UZstats = \
    cme.process_files(PATH_PRIOR, PRIOR_CDATES_LIST, 'prior', TICK_PRIOR)
```

[434]:
```
PRIOR_OB_UZ_STATS = cme.ob_uz_stats(PRIOR_CDATES, FILES_PRIOR_OBstats,\
    FILES_PRIOR_UZstats, FILES_PRIOR_CAticks, TRADING_HOURS)
```

[435]:
```
PRIOR_IMBAL_STATS = cme.imbal_stats(PRIOR_CDATES, FILES_PRIOR_OTtrans)
```

[436]:
```
PRIOR_IMBAL_STATS_TS = cme.time_series_imbal(PRIOR_IMBAL_STATS, pd.
↪to_datetime(PRIOR_CDATES['Date']), 'prior')
```

[437]:
```
PRIOR_IMBAL_STATS_TS['eta1'] = PRIOR_OB_UZ_STATS['eta1'].values
```

[438]:
```
PRIOR_TRADE_STATS_TS = cme.time_series_imbal_trd(PRIOR_IMBAL_STATS, pd.
↪to_datetime(PRIOR_CDATES['Date']), 'prior')
```

[439]:
```
PRIOR_DEPL_STATS = cme.depl_stats(PRIOR_CDATES, FILES_PRIOR_RDFtrans)
```

[440]:
```
PRIOR_DEPL_STATS_TS = cme.time_series_depl(PRIOR_DEPL_STATS, pd.
↪to_datetime(PRIOR_CDATES['Date']), 'prior')
```

[441]:
```
PRIOR_DEPL_STATS_TS['eta1'] = PRIOR_OB_UZ_STATS['eta1'].values
```

[442]:
```
PRIOR_ABSDEPL_STATS_TS = cme.time_series_absdepl(PRIOR_DEPL_STATS, pd.
↪to_datetime(PRIOR_CDATES['Date']), 'prior')
```

[443]:
```
PRIOR_ABSDEPL_STATS_TS['eta1'] = PRIOR_OB_UZ_STATS['eta1'].values
PRIOR_ABSDEPL_STATS_TS['M'] = PRIOR_OB_UZ_STATS['M'].values
```

[444]:
```
PRIOR_COST_STATS = cme.cost_stats(PRIOR_CDATES, FILES_PRIOR_COSTtrades)
```

[445]:
```
PRIOR_COST_STATS['Status'] = 'prior'
```

After

[446]:
```
#AFTER_CDATES_LIST = cme.list_files(PATH_AFTER)
```

[447]:
```
#AFTER_CDATES_LIST
```

[448]:
```
AFTER_CDATES, FILES_AFTER_CAticks, FILES_AFTER_COSTtrades,\
    FILES_AFTER_OBstats, FILES_AFTER_OTtrans,\
    FILES_AFTER_RDFtrans, FILES_AFTER_UZstats = \
    cme.process_files(PATH_AFTER, AFTER_CDATES_LIST, 'after', TICK_AFTER)
```

[449]:
```
AFTER_OB_UZ_STATS = cme.ob_uz_stats(AFTER_CDATES, FILES_AFTER_OBstats,\
    FILES_AFTER_UZstats, FILES_AFTER_CAticks, TRADING_HOURS)
```

[450]:
```
AFTER_IMBAL_STATS = cme.imbal_stats(AFTER_CDATES, FILES_AFTER_OTtrans)
```

[451]:
```
AFTER_IMBAL_STATS_TS = cme.time_series_imbal(AFTER_IMBAL_STATS, pd.
↪to_datetime(AFTER_CDATES['Date']), 'after')
```

[452]:
```
AFTER_IMBAL_STATS_TS['eta1'] = AFTER_OB_UZ_STATS['eta1'].values
```

[453]:
```
AFTER_TRADE_STATS_TS = cme.time_series_imbal_trd(AFTER_IMBAL_STATS, pd.
↪to_datetime(AFTER_CDATES['Date']), 'after')
```

[454]:
```
AFTER_DEPL_STATS = cme.depl_stats(AFTER_CDATES, FILES_AFTER_RDFtrans)
```

[455]:
```
AFTER_DEPL_STATS_TS = cme.time_series_depl(AFTER_DEPL_STATS, pd.
↪to_datetime(AFTER_CDATES['Date']), 'after')
```

[456]:
```
AFTER_DEPL_STATS_TS['eta1'] = AFTER_OB_UZ_STATS['eta1'].values
```

[457]:
```
AFTER_ABSDEPL_STATS_TS = cme.time_series_absdepl(AFTER_DEPL_STATS, pd.
↪to_datetime(AFTER_CDATES['Date']), 'after')
```

[458]:
```
AFTER_ABSDEPL_STATS_TS['eta1'] = AFTER_OB_UZ_STATS['eta1'].values
AFTER_ABSDEPL_STATS_TS['M'] = AFTER_OB_UZ_STATS['M'].values
```

[459]:
```
AFTER_COST_STATS = cme.cost_stats(AFTER_CDATES, FILES_AFTER_COSTtrades)
```

[460]:
```
AFTER_COST_STATS['Status'] = 'after'
```

Join prior and after

[461]:
```
OB_UZ_STATS = pd.concat([PRIOR_OB_UZ_STATS, AFTER_OB_UZ_STATS], sort=False)
```

[462]:
```
IMBAL_STATS_TS = pd.concat([PRIOR_IMBAL_STATS_TS, AFTER_IMBAL_STATS_TS],␣
↪sort=False)
```

[463]:
```
TRADE_STATS_TS = pd.concat([PRIOR_TRADE_STATS_TS, AFTER_TRADE_STATS_TS],␣
↪sort=False)
```

[464]:
```
DEPL_STATS_TS = pd.concat([PRIOR_DEPL_STATS_TS, AFTER_DEPL_STATS_TS],␣
↪sort=False)
```

[465]:
```
ABSDEPL_STATS_TS = pd.concat([PRIOR_ABSDEPL_STATS_TS, AFTER_ABSDEPL_STATS_TS],␣
↪sort=False)
```

2.7.2 Tables

[466]:
```
TABLE_MATHIEU = cme.table_mathieu(OB_UZ_STATS)
TABLE_MATHIEU_ERR = cme.table_mathieu_err(OB_UZ_STATS)
```

[467]:
```
TABLE_MATHIEU
```

[467]:

Status	Tick	chgavg	ndfpr_pred	ndfpr	M	Volume	\
prior	1.0	1.02277	2438.51840	2185.92537	13803.09701	47213.98507	
after	0.5	0.53664	5942.51167	4167.02083	15321.84028	42244.48611	

Status	eta1	S1	lambda1	twspr1	duration	dt_avg	rvxe	\

```
prior   0.34475  0.98419  0.98195  1.1588  14.23491  14.68797  0.00534
after   0.38756  0.91061  0.94132  1.4512   6.66623   8.01438  0.00428

          spot_avg
Status
prior   7537.40442
after   7577.81324
```

[468]:
```
TABLE_MATHIEU_ERR
```

[468]:
```
        Tick   chgavg  ndfpr_pred       ndfpr           M       Volume  \
Status
prior    0.0  0.02993  1044.90182   727.89507  4509.27540  16095.24557
after    0.0  0.02957  4030.54127  1573.27168  5541.41443  13972.79885

           eta1       S1  lambda1   twspr1  duration   dt_avg     rvxe  \
Status
prior   0.03674  0.00841  0.01942  0.29678   8.64882  5.98536  0.00122
after   0.04048  0.05451  0.03624  0.46617   4.22656  3.80094  0.00128

         spot_avg
Status
prior   292.71547
after   104.14234
```

[469]:
```
cme.avg_perc_mat(PRIOR_IMBAL_STATS, pd.to_datetime(PRIOR_CDATES['Date']))
```

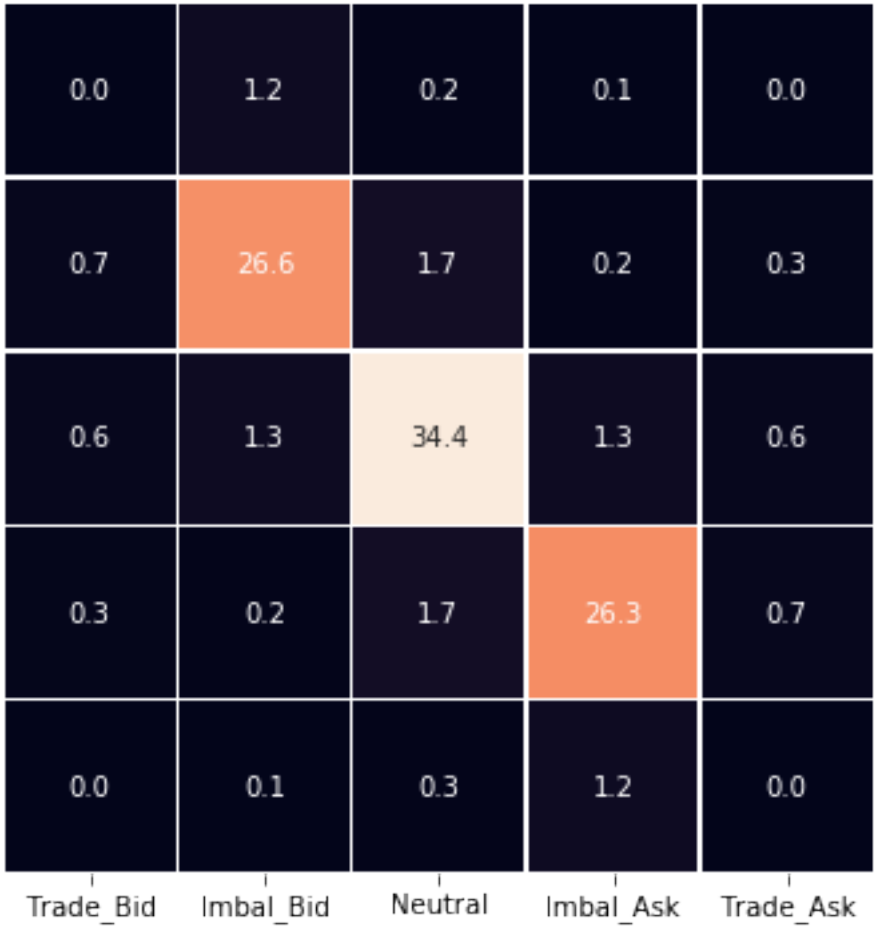
[469]:
```
            Trade_Bid  Imbal_Bid  Neutral  Imbal_Ask  Trade_Ask  Total Cols
Trade_Bid        0.03       1.24     0.25       0.06       0.00        1.58
Imbal_Bid        0.65      26.58     1.71       0.20       0.28       29.41
Neutral          0.62       1.33    34.42       1.33       0.63       38.34
Imbal_Ask        0.28       0.19     1.70      26.26       0.65       29.08
Trade_Ask        0.00       0.06     0.26       1.24       0.03        1.59
Total Rows       1.58      29.41    38.34      29.08       1.59      100.00
```

[470]:
```
cme.avg_perc_mat(AFTER_IMBAL_STATS, pd.to_datetime(AFTER_CDATES['Date']))
```

[470]:
```
            Trade_Bid  Imbal_Bid  Neutral  Imbal_Ask  Trade_Ask  Total Cols
Trade_Bid        0.04       1.18     0.50       0.14       0.00        1.87
Imbal_Bid        0.59      22.53     2.64       0.86       0.55       27.17
Neutral          0.67       2.47    35.89       2.48       0.68       42.19
Imbal_Ask        0.55       0.85     2.65      22.26       0.59       26.91
Trade_Ask        0.00       0.14     0.51       1.18       0.04        1.86
Total Rows       1.87      27.17    42.19      26.91       1.86      100.00
```

[471]:
```
AVG_IMBAL_PRIOR = cme.avg_perc_mat(PRIOR_IMBAL_STATS, pd.
↪to_datetime(PRIOR_CDATES['Date']))
```

```
plt.figure(figsize=(9, 6))
sns.heatmap(AVG_IMBAL_PRIOR.iloc[:-1].drop(columns=['Total Cols']),\
    annot=True, fmt=".1f",\
    linewidths=.5, square=True,\
    xticklabels=True,\
    yticklabels=False,\
    cbar=False);
```



[472]:
```
cme.avg_perc_mat_2(PRIOR_DEPL_STATS, pd.to_datetime(PRIOR_CDATES['Date']))
```

[472]:

	same				oppo				Total Cols
	D C	D T	D T+F	F	D C	D T	D T+F	F	
D C	0.01	0.01	0.06	22.02	0.01	0.01	0.97	0.84	23.92
D T	0.01	0.05	0.34	17.78	0.01	0.01	1.95	4.04	24.18
D T+F	0.01	0.01	0.11	2.62	0.01	0.01	0.44	0.66	3.86
F	16.63	9.73	0.00	0.03	7.23	14.35	0.00	0.05	48.04
Total Rows	16.66	9.80	0.51	42.45	7.26	14.38	3.35	5.59	100.00

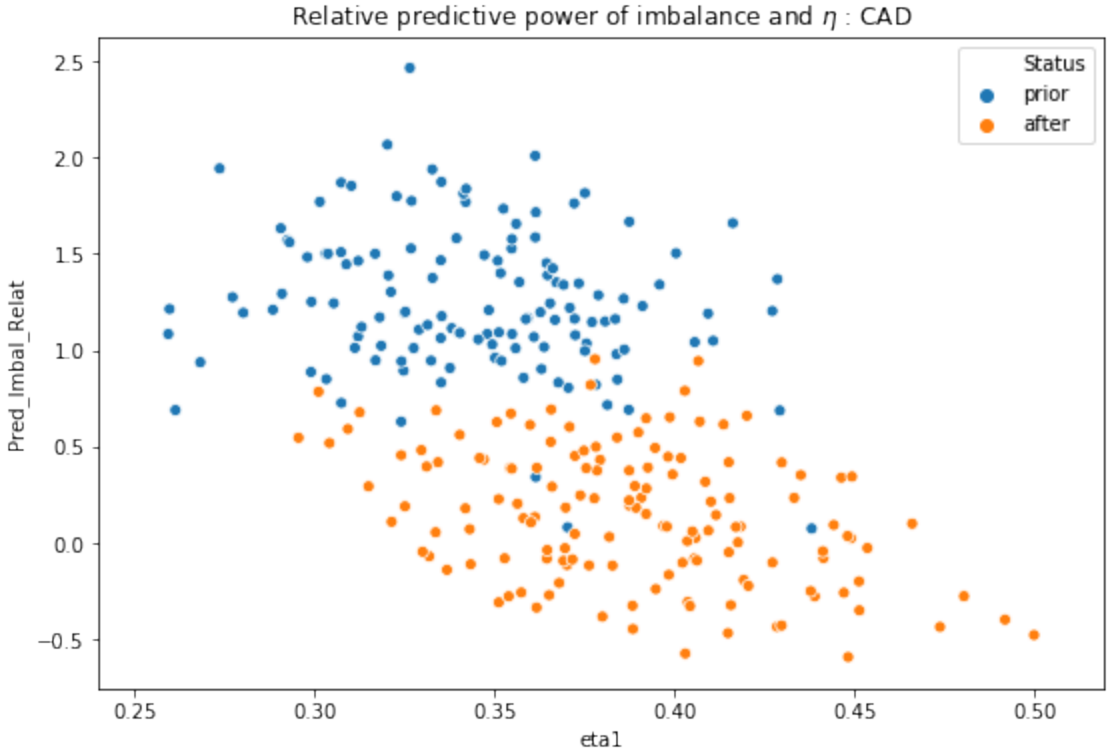
[473]:
```
cme.avg_perc_mat_2(AFTER_DEPL_STATS, pd.to_datetime(AFTER_CDATES['Date']))
```

[473]:

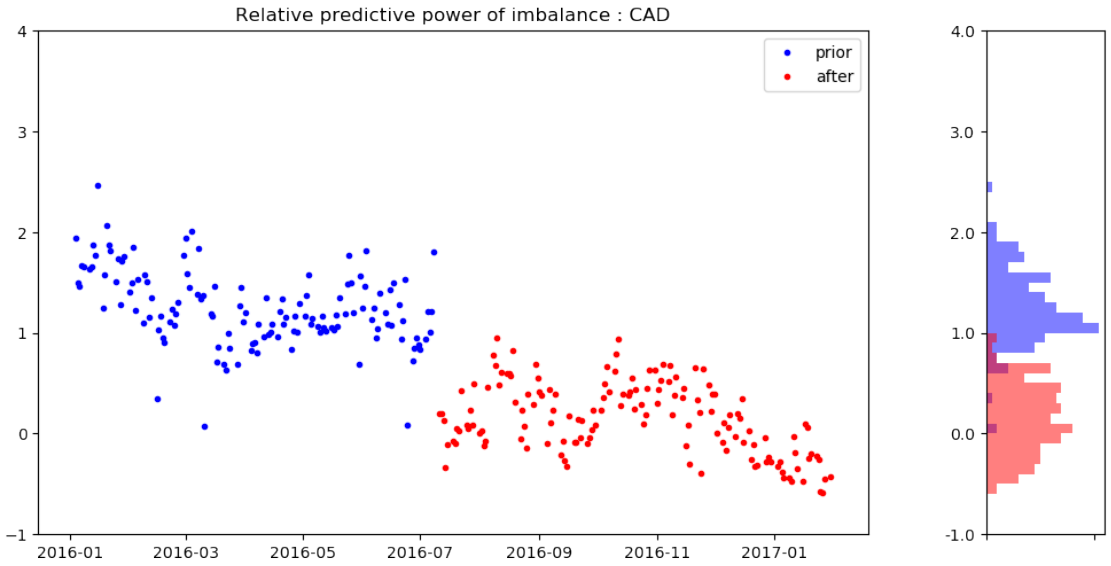
	same				oppo				Total Cols
	D C	D T	D T+F	F	D C	D T	D T+F	F	
D C	0.04	0.07	0.09	21.94	0.07	0.04	0.46	3.23	25.94
D T	0.06	0.26	0.31	14.16	0.14	0.13	1.53	6.30	22.89
D T+F	0.04	0.06	0.10	1.39	0.07	0.06	0.16	0.77	2.66
F	19.08	9.54	0.01	0.30	6.43	12.73	0.00	0.42	48.51
Total Rows	19.23	9.93	0.50	37.79	6.71	12.96	2.16	10.72	100.00

2.8 Charts and Regressions

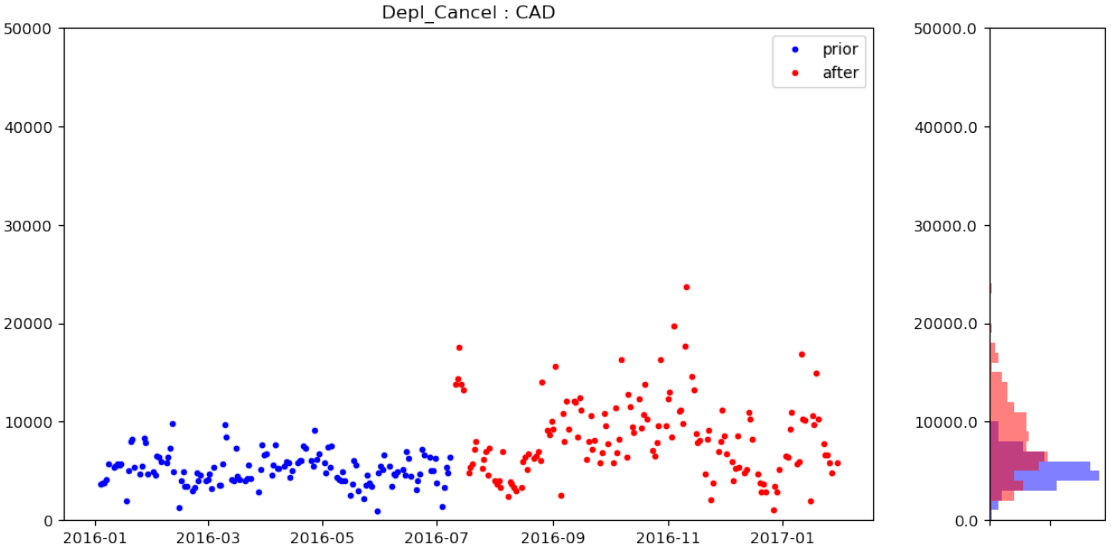
[474]:
```
plt.figure(figsize=(9, 6))
sns.scatterplot(x='eta1', y='Pred_Imbal_Relat', hue='Status',\
           data=IMBAL_STATS_TS);
plt.title('Relative predictive power of imbalance and $\eta$ : '+CURR);
```



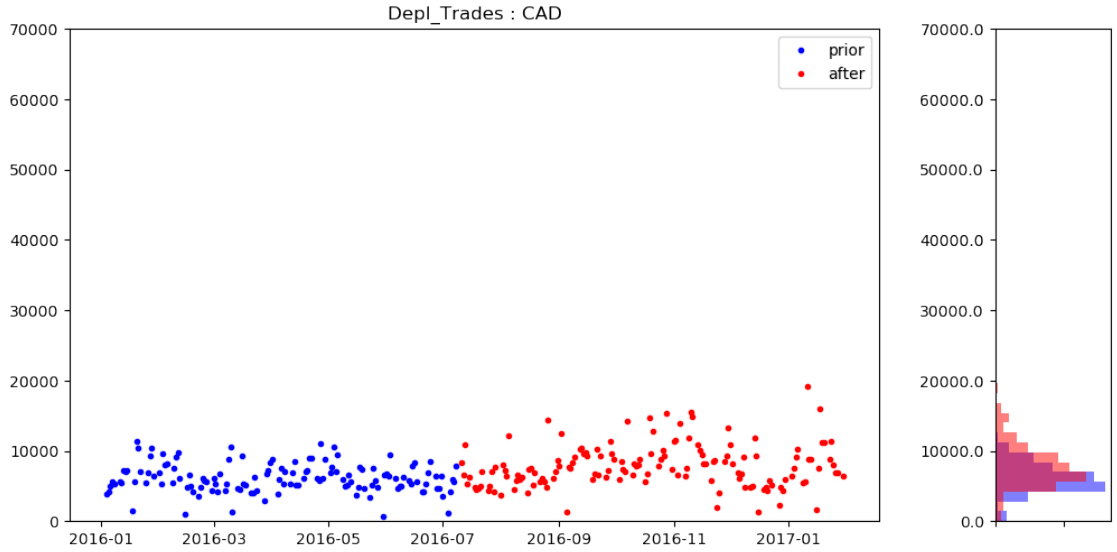
[475]:
```
cme.time_series_hist_plot(IMBAL_STATS_TS, 'Pred_Imbal_Relat',\
    'Relative predictive power of imbalance : '+CURR, -1.0, 4.0, 50)
```



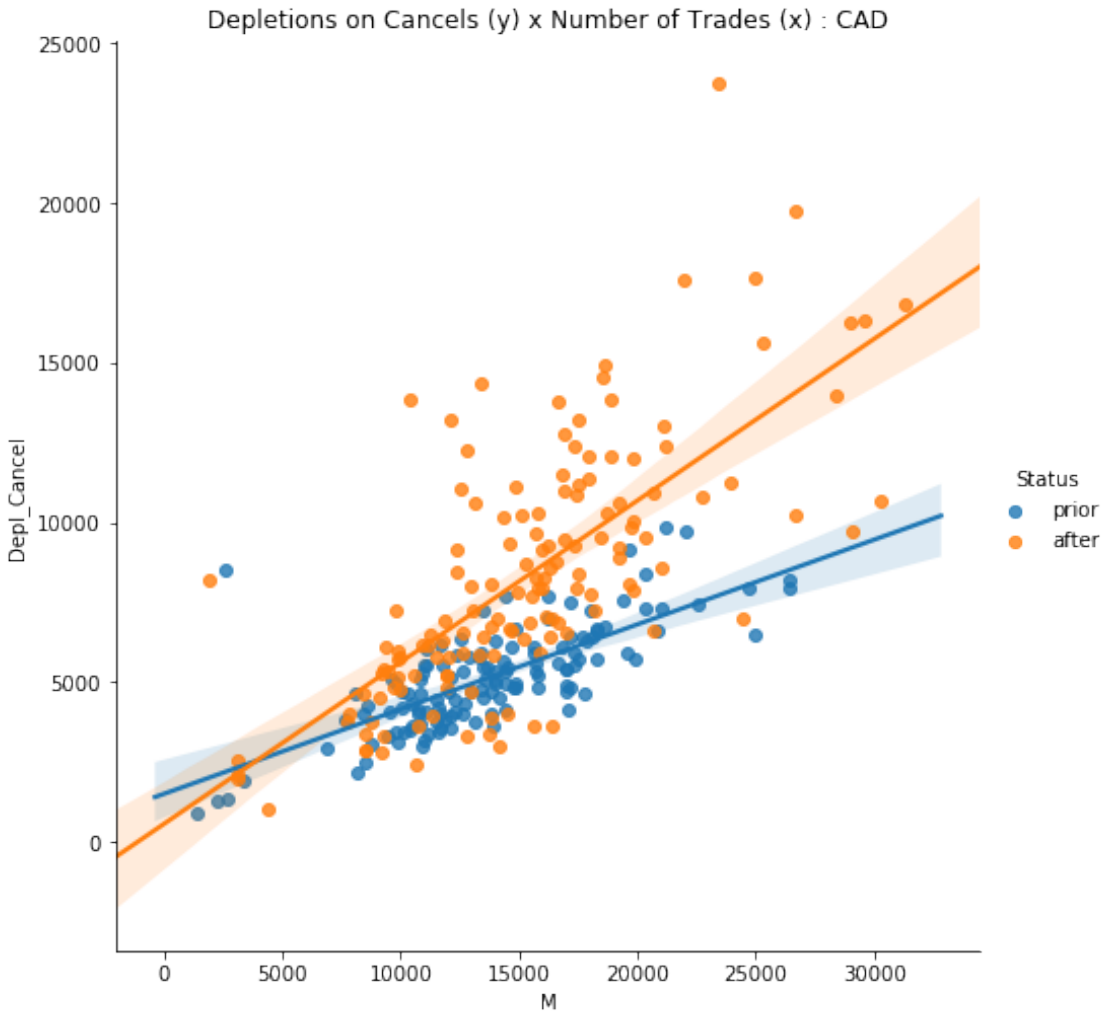
[476]:
```
cme.time_series_hist_plot(ABSDEPL_STATS_TS, 'Depl_Cancel',\
    'Depl_Cancel : '+CURR, 0.0, 50000.0, 50)
```



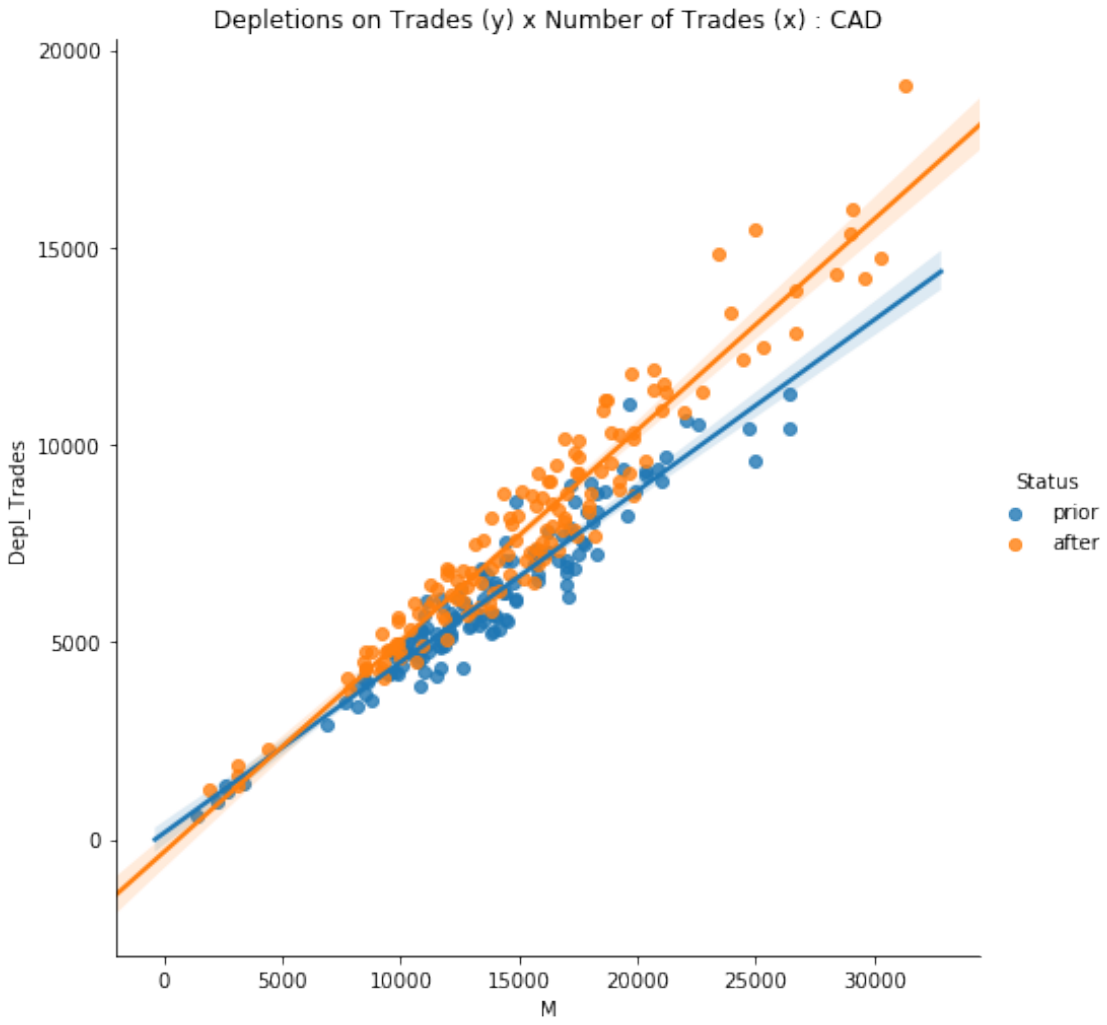
[477]:
```
cme.time_series_hist_plot(ABSDEPL_STATS_TS, 'Depl_Trades',\
    'Depl_Trades : '+CURR, 0.0, 70000.0, 50)
```



[478]:
```
cme.regr_plot(ABSDEPL_STATS_TS, 'M', 'Depl_Cancel',\
    'Depletions on Cancels (y) x Number of Trades (x) : '+CURR)
```



[479]:
```
cme.regr_plot(ABSDEPL_STATS_TS, 'M', 'Depl_Trades',\
    'Depletions on Trades (y) x Number of Trades (x) : '+CURR)
```



[480]:
```
cme.lin_reg(ABSDEPL_STATS_TS, ['M'], 'Depl_Cancel')
```

```
                            OLS Regression Results
==============================================================================
Dep. Variable:            Depl_Cancel   R-squared:                       0.454
Model:                            OLS   Adj. R-squared:                  0.452
Method:                 Least Squares   F-statistic:                     229.5
Date:                Wed, 09 Oct 2019   Prob (F-statistic):           3.81e-38
Time:                        15:05:53   Log-Likelihood:                -2572.6
No. Observations:                 278   AIC:                             5149.
Df Residuals:                     276   BIC:                             5156.
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
```

```
const        220.5059    460.312      0.479      0.632    -685.662    1126.674
M              0.4511      0.030     15.150      0.000       0.393       0.510
==============================================================================
Omnibus:                       86.857   Durbin-Watson:                   0.810
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              224.140
Skew:                           1.450   Prob(JB):                     2.13e-49
Kurtosis:                       6.308   Cond. No.                     4.68e+04
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
[2] The condition number is large, 4.68e+04. This might indicate that there are
strong multicollinearity or other numerical problems.
```

[481]:
```
cme.lin_reg(ABSDEPL_STATS_TS, ['M'], 'Depl_Trades')
```

```
                            OLS Regression Results
==============================================================================
Dep. Variable:            Depl_Trades   R-squared:                       0.892
Model:                            OLS   Adj. R-squared:                  0.891
Method:                 Least Squares   F-statistic:                     2276.
Date:                Wed, 09 Oct 2019   Prob (F-statistic):          2.58e-135
Time:                        15:05:53   Log-Likelihood:                -2287.8
No. Observations:                 278   AIC:                             4580.
Df Residuals:                     276   BIC:                             4587.
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const       -401.6821    165.295     -2.430      0.016    -727.082     -76.283
M              0.5101      0.011     47.703      0.000       0.489       0.531
==============================================================================
Omnibus:                       18.210   Durbin-Watson:                   0.449
Prob(Omnibus):                  0.000   Jarque-Bera (JB):               28.200
Skew:                           0.429   Prob(JB):                     7.52e-07
Kurtosis:                       4.303   Cond. No.                     4.68e+04
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
[2] The condition number is large, 4.68e+04. This might indicate that there are
strong multicollinearity or other numerical problems.
```

[482]:
```
cme.lin_reg(PRIOR_ABSDEPL_STATS_TS, ['M'], 'Depl_Trades')
```

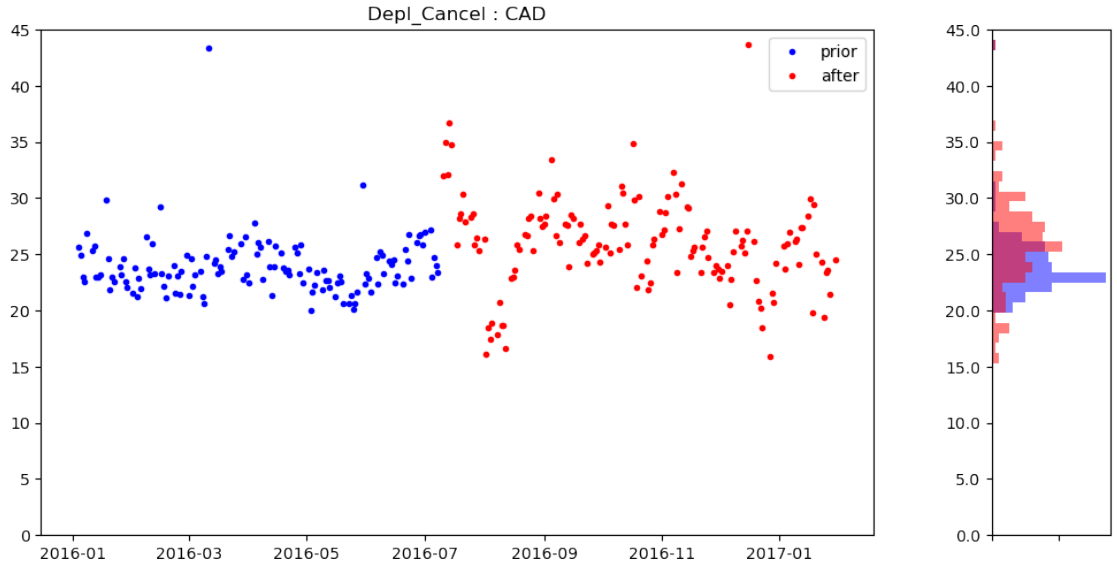
```
                            OLS Regression Results
==============================================================================
Dep. Variable:            Depl_Trades   R-squared:                       0.910
Model:                            OLS   Adj. R-squared:                  0.910
Method:                 Least Squares   F-statistic:                     1343.
Date:                Wed, 09 Oct 2019   Prob (F-statistic):           4.81e-71
Time:                        15:05:53   Log-Likelihood:                -1049.6
No. Observations:                 134   AIC:                             2103.
Df Residuals:                     132   BIC:                             2109.
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const        164.2664    171.675      0.957      0.340    -175.325     503.857
M              0.4334      0.012     36.644      0.000       0.410       0.457
==============================================================================
Omnibus:                       11.096   Durbin-Watson:                   0.629
Prob(Omnibus):                  0.004   Jarque-Bera (JB):               15.174
Skew:                           0.461   Prob(JB):                     0.000507
Kurtosis:                       4.367   Cond. No.                     4.69e+04
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
[2] The condition number is large, 4.69e+04. This might indicate that there are
strong multicollinearity or other numerical problems.
```

[483]:
```
cme.lin_reg(AFTER_ABSDEPL_STATS_TS, ['M'], 'Depl_Trades')
```

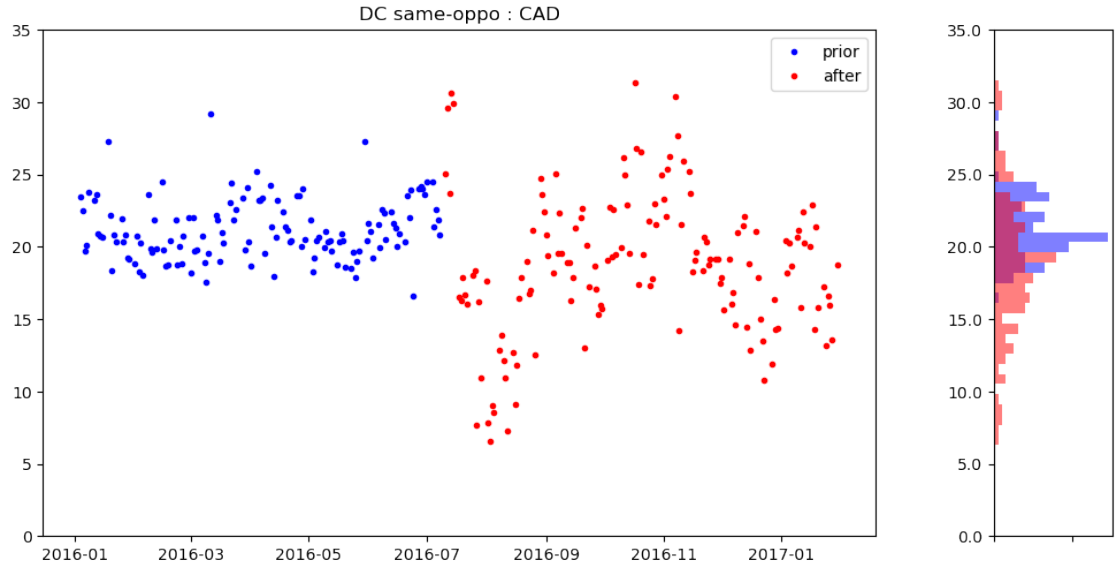
```
                            OLS Regression Results
==============================================================================
Dep. Variable:            Depl_Trades   R-squared:                       0.928
Model:                            OLS   Adj. R-squared:                  0.927
Method:                 Least Squares   F-statistic:                     1823.
Date:                Wed, 09 Oct 2019   Prob (F-statistic):           6.61e-83
Time:                        15:05:53   Log-Likelihood:                -1171.1
No. Observations:                 144   AIC:                             2346.
Df Residuals:                     142   BIC:                             2352.
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const       -316.9926    203.863     -1.555      0.122    -719.992      86.006
M              0.5345      0.013     42.700      0.000       0.510       0.559
==============================================================================
```

```
Omnibus:                        7.660   Durbin-Watson:                   0.535
Prob(Omnibus):                  0.022   Jarque-Bera (JB):                7.354
Skew:                           0.497   Prob(JB):                       0.0253
Kurtosis:                       3.487   Cond. No.                     4.80e+04
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
[2] The condition number is large, 4.8e+04. This might indicate that there are
strong multicollinearity or other numerical problems.
```

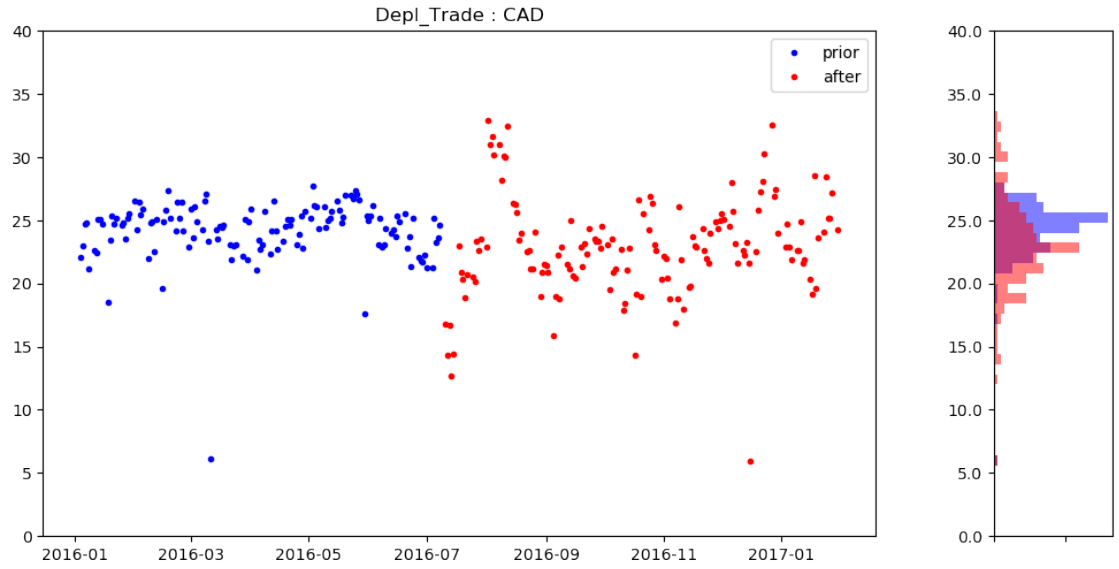
[587]:
```
cme.time_series_hist_plot(DEPL_STATS_TS, 'Depl_Cancel',\
    'Depl_Cancel : '+CURR, 0, 45, 50)
```



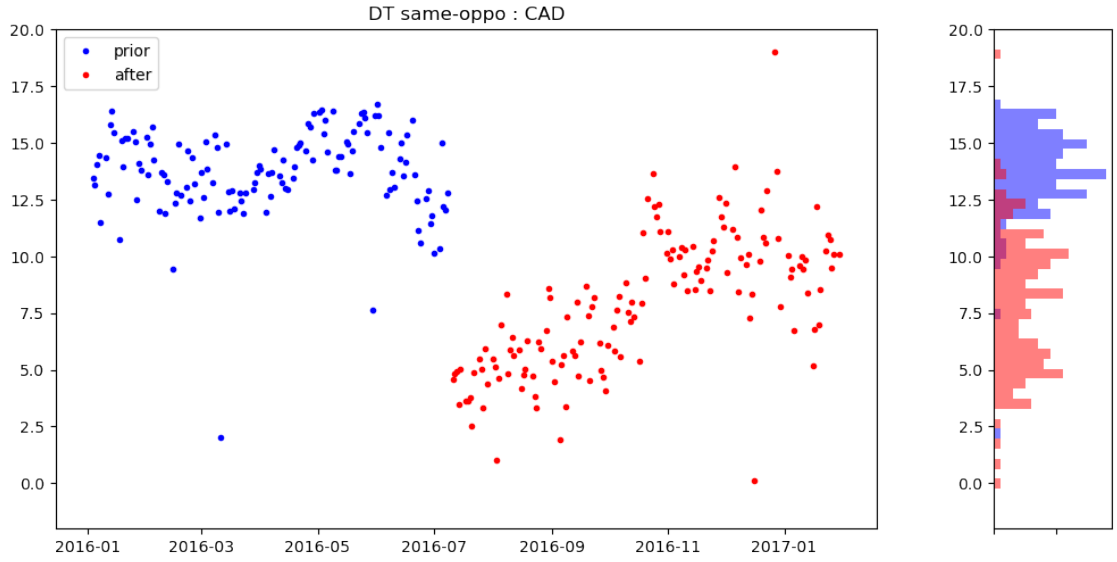
[586]:
```
cme.time_series_hist_plot(DEPL_STATS_TS, 'DC same-oppo',\
    'DC same-oppo : '+CURR, 0, 35, 50)
```



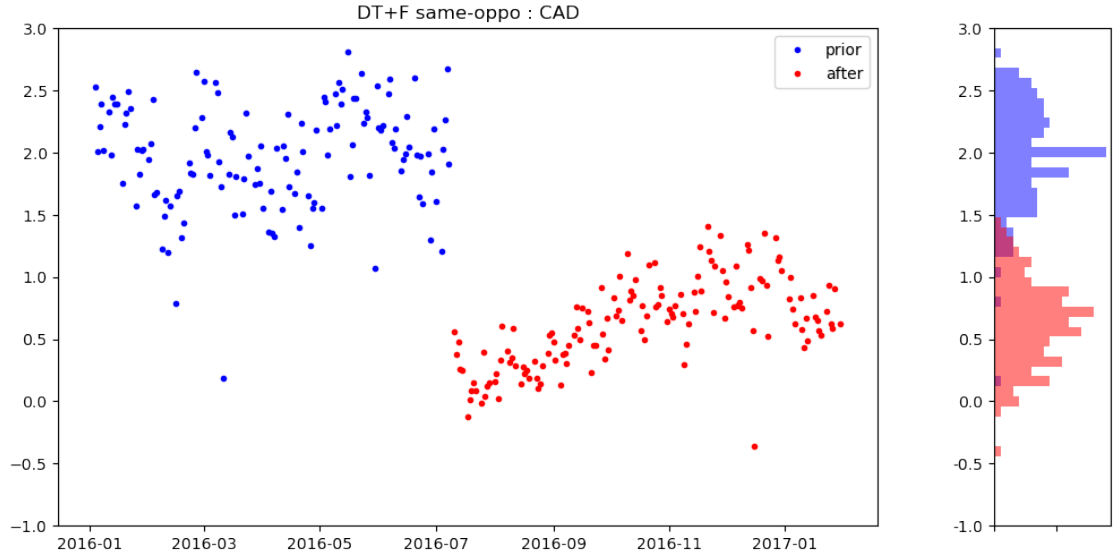
[486]:
```
cme.time_series_hist_plot(DEPL_STATS_TS, 'Depl_Trade',\
    'Depl_Trade : '+CURR, 0, 40, 50)
```



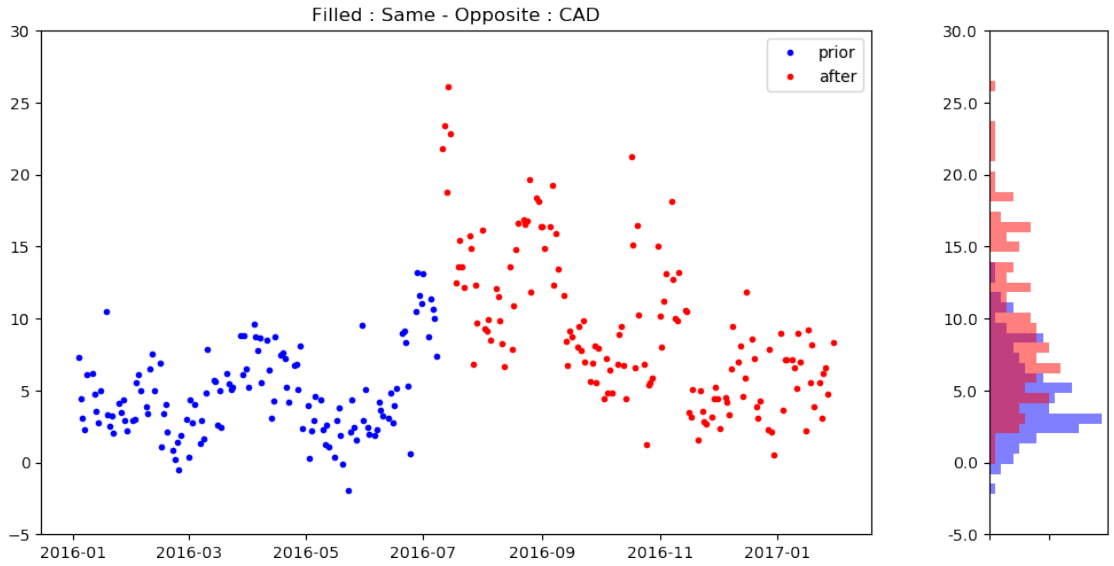
[589]:
```
cme.time_series_hist_plot(DEPL_STATS_TS, 'DT same-oppo',\
    'DT same-oppo : '+CURR, -2, 20, 50)
```



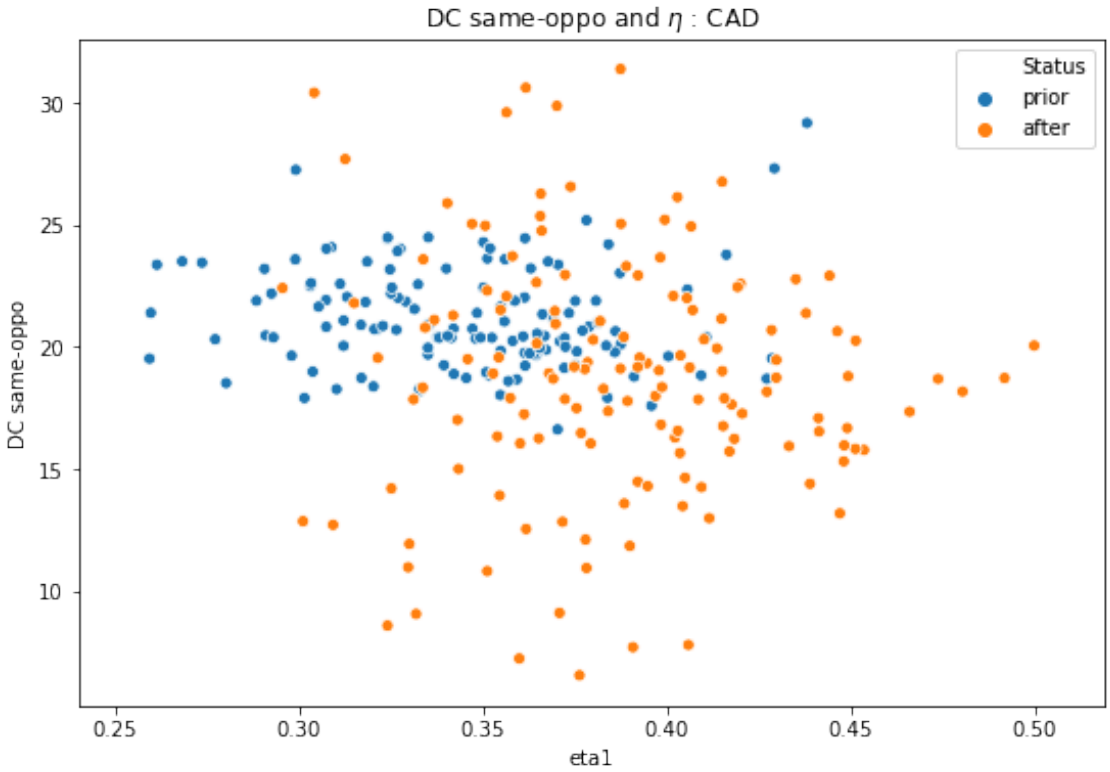
[591]:
```
cme.time_series_hist_plot(DEPL_STATS_TS, 'DT+F same-oppo',\
    'DT+F same-oppo : '+CURR, -1, 3, 50)
```



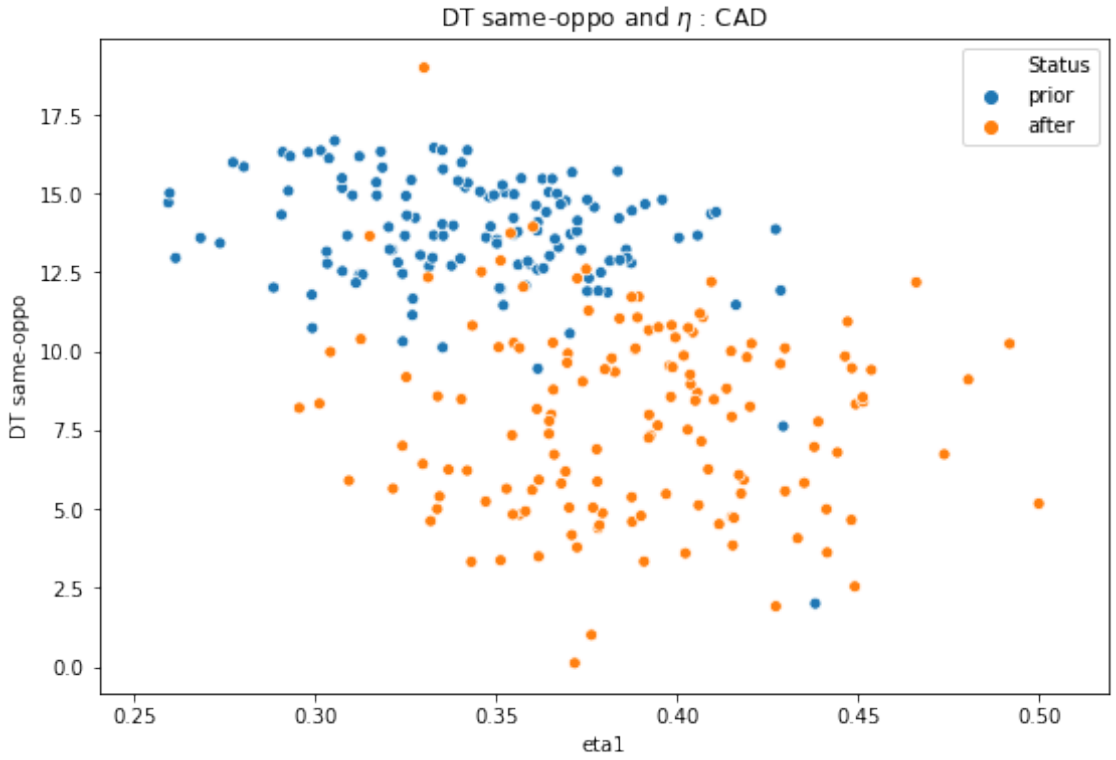
[593]:
```
cme.time_series_hist_plot(DEPL_STATS_TS, 'Fill same-oppo',\
    'Filled : Same - Opposite : '+CURR, -5, 30, 50)
```



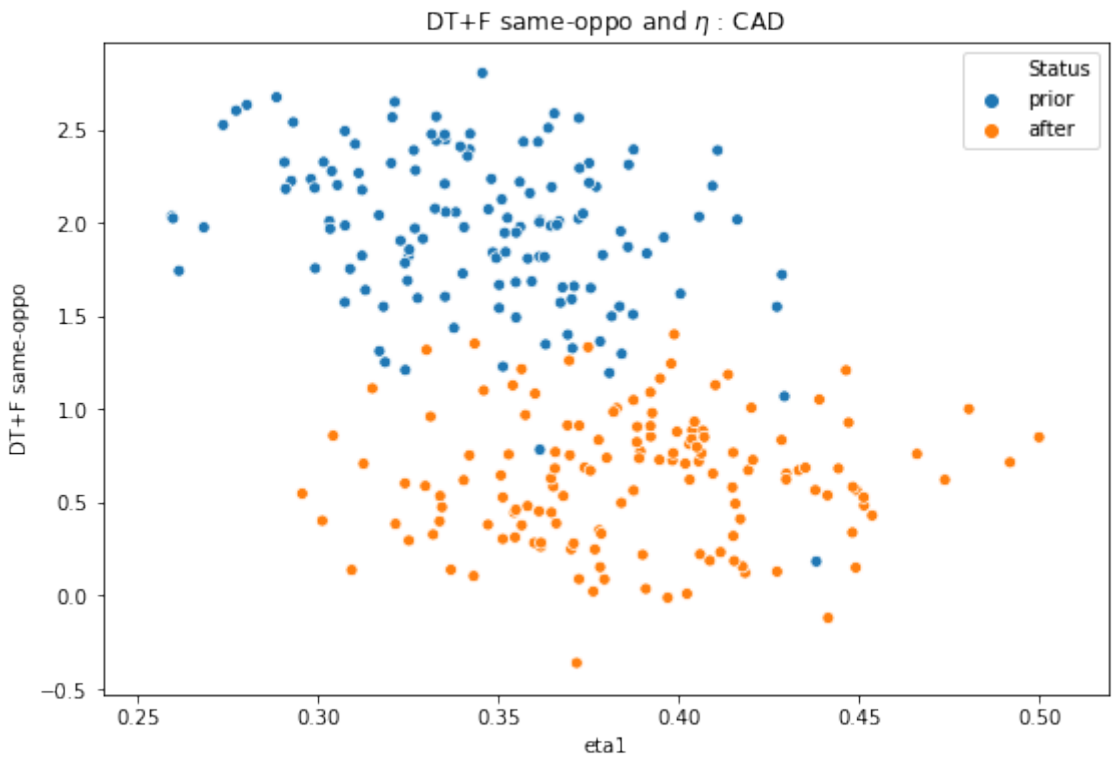
[490]:
```
plt.figure(figsize=(9, 6))
sns.scatterplot(x='eta1', y='DC same-oppo', hue='Status',\
           data=DEPL_STATS_TS);
plt.title('DC same-oppo and $\eta$ : '+CURR);
```



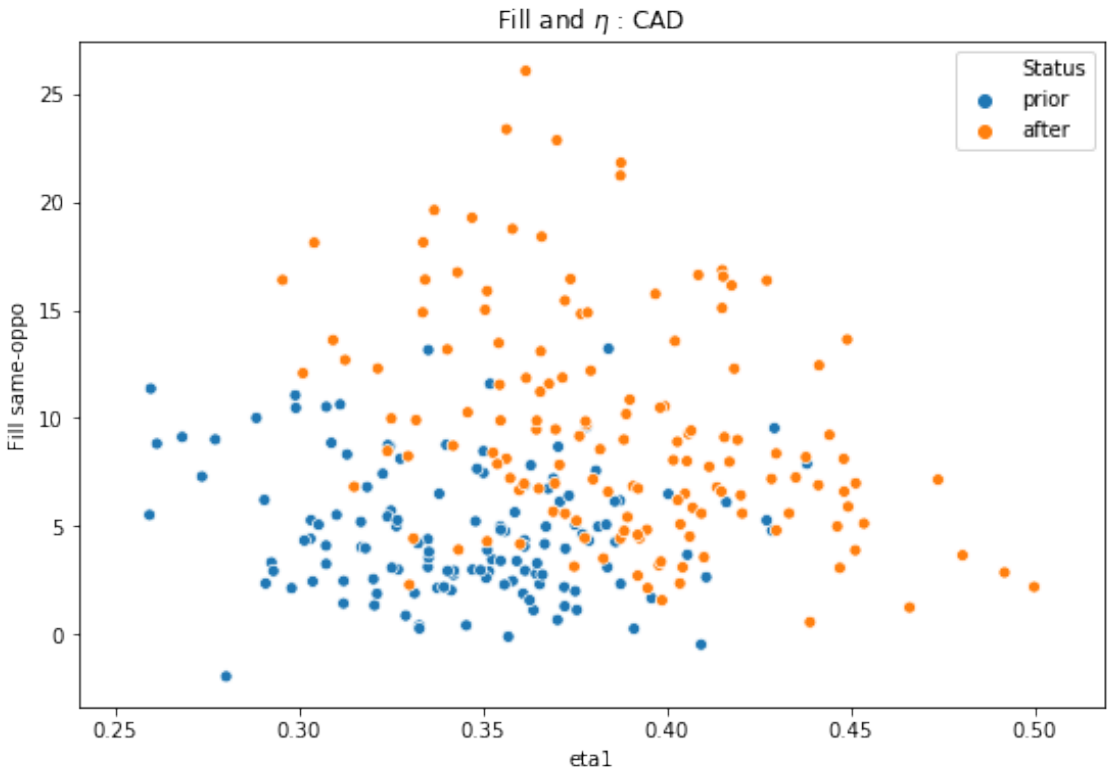
[491]:
```
plt.figure(figsize=(9, 6))
sns.scatterplot(x='eta1', y='DT same-oppo', hue='Status',\
            data=DEPL_STATS_TS);
plt.title('DT same-oppo and $\eta$ : '+CURR);
```



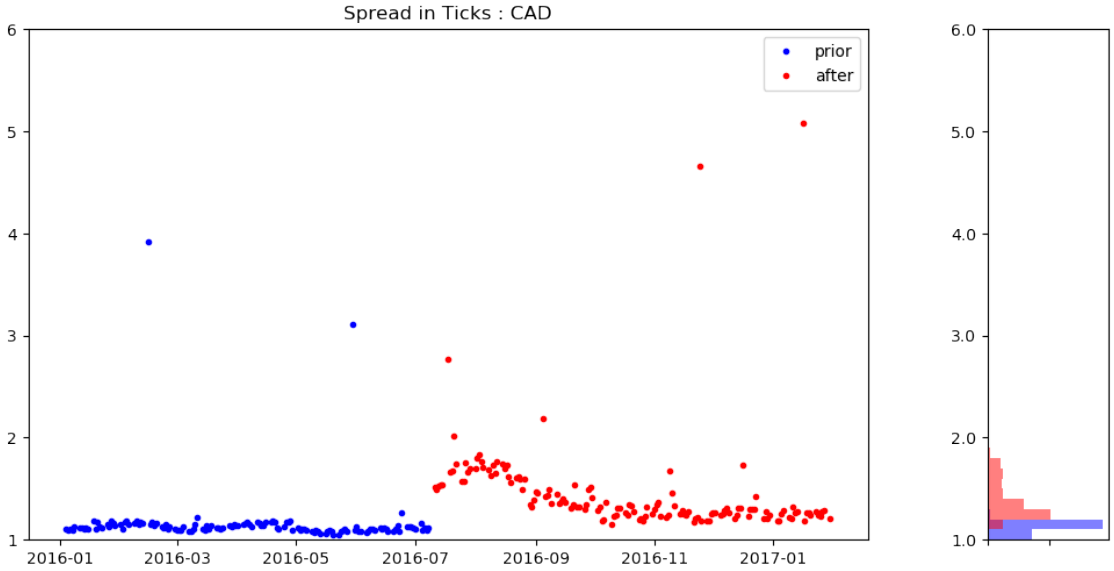
[492]:
```
plt.figure(figsize=(9, 6))
sns.scatterplot(x='eta1', y='DT+F same-oppo', hue='Status',\
            data=DEPL_STATS_TS);
plt.title('DT+F same-oppo and $\eta$ : '+CURR);
```



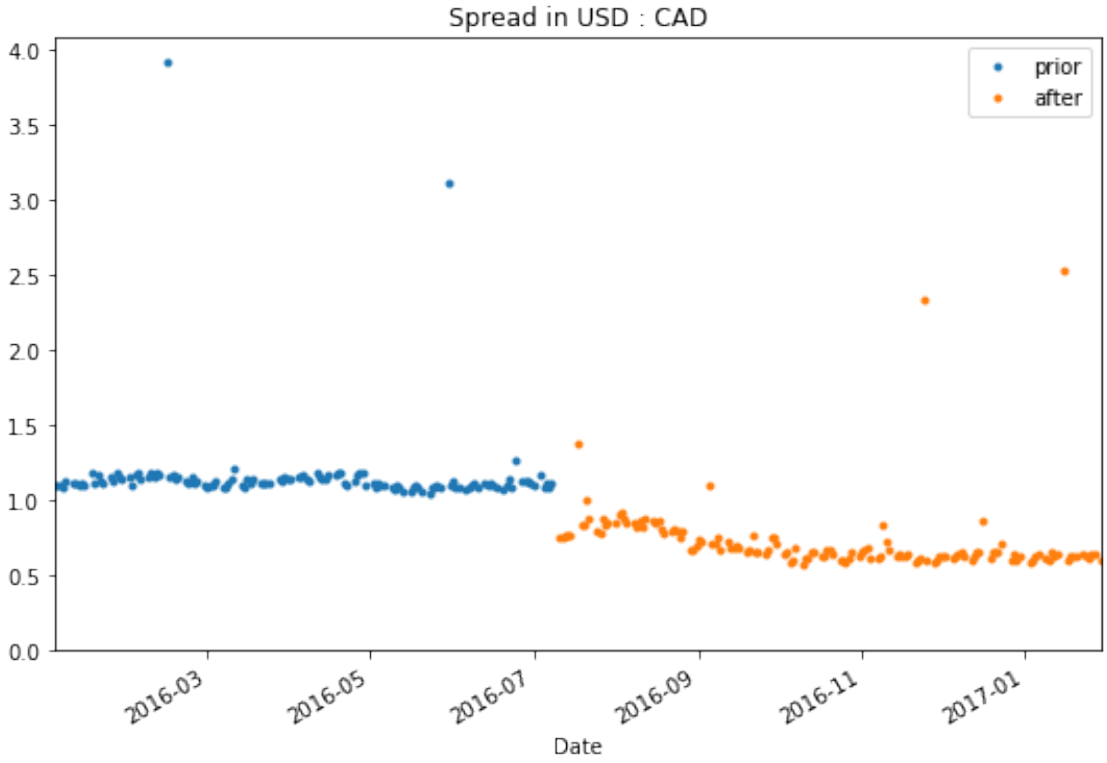
[493]:
```
plt.figure(figsize=(9, 6))
sns.scatterplot(x='eta1', y='Fill same-oppo', hue='Status',\
           data=DEPL_STATS_TS);
plt.title('Fill and $\eta$ : '+CURR);
```



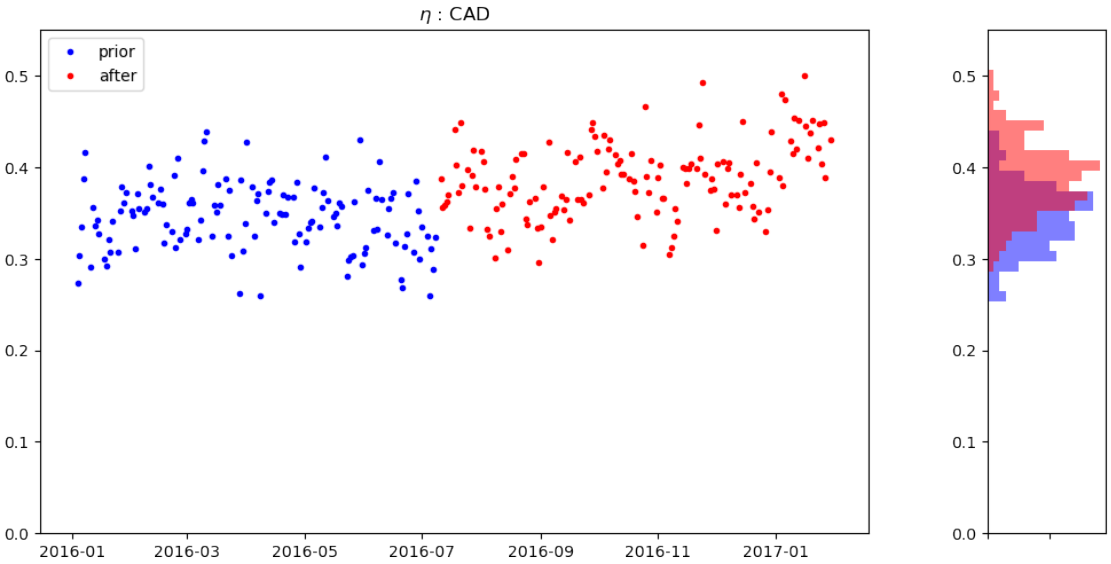
[597]:
```
cme.time_series_hist_plot(OB_UZ_STATS, 'twspr1',\
    'Spread in Ticks : '+CURR, 1, 6, 50)
```



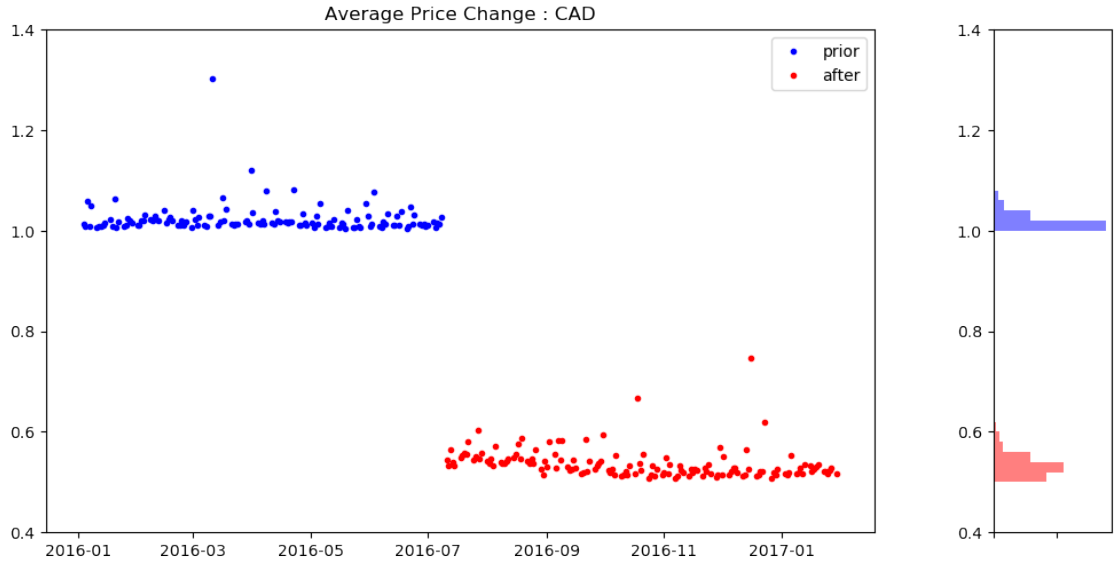
[495]:
```
cme.twspr_plot_USD(OB_UZ_STATS, CURR)
```



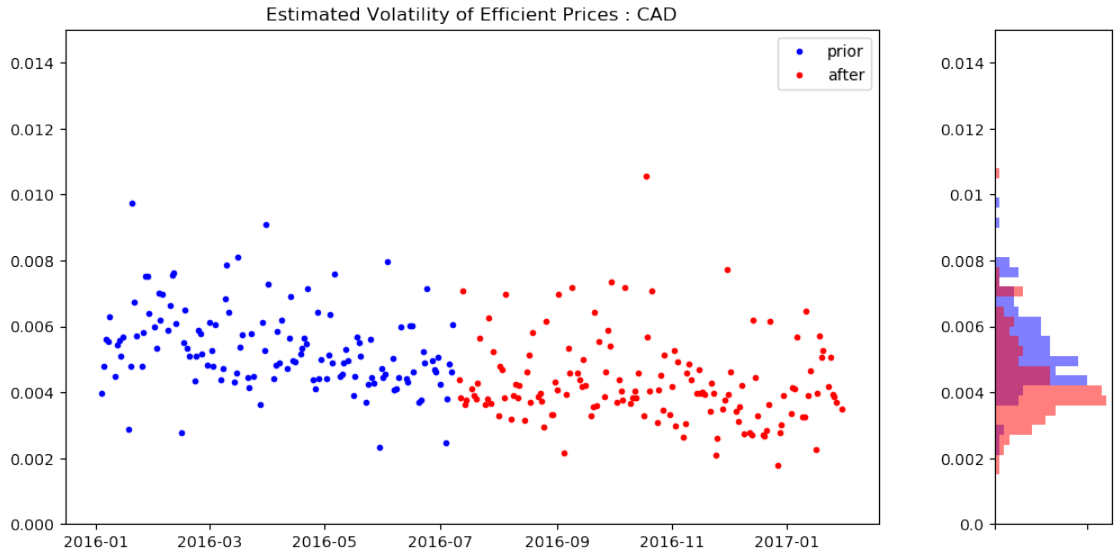
[599]:
```
cme.time_series_hist_plot(OB_UZ_STATS, 'eta1',\
    '$\eta$ : '+CURR, 0, 0.55, 50)
```



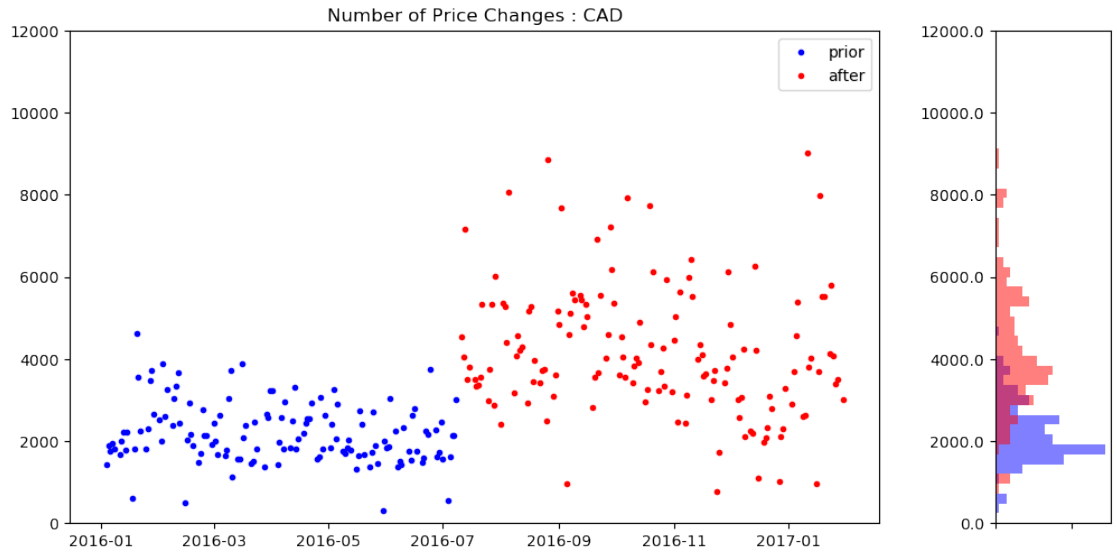
[601]:
```
cme.time_series_hist_plot(OB_UZ_STATS, 'chgavg',\
    'Average Price Change : '+CURR, 0.4, 1.4, 50)
```



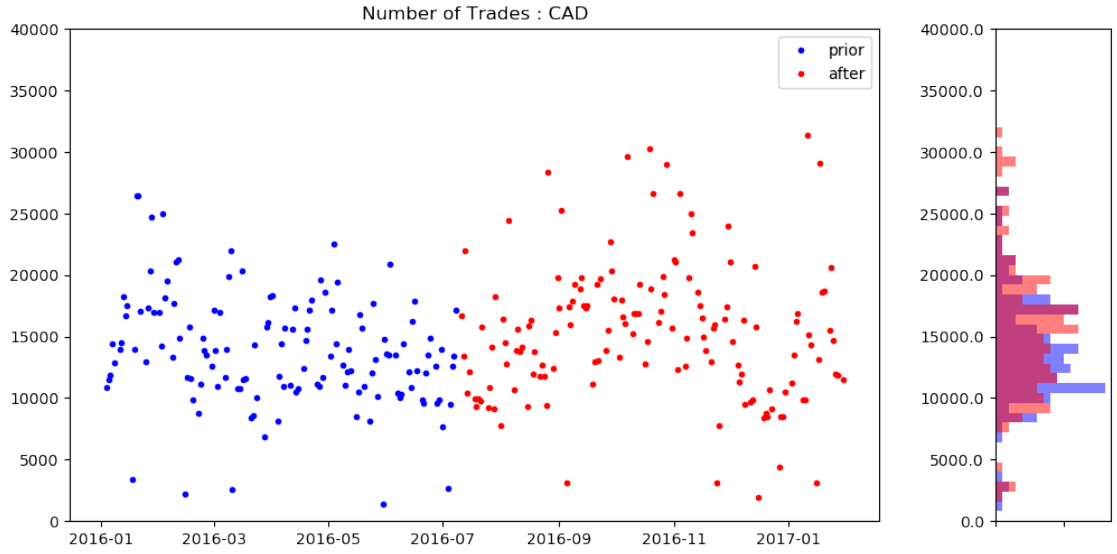
[498]:
```
cme.time_series_hist_plot(OB_UZ_STATS, 'rvxe',\
    'Estimated Volatility of Efficient Prices : '+CURR, 0, 0.015, 50)
```



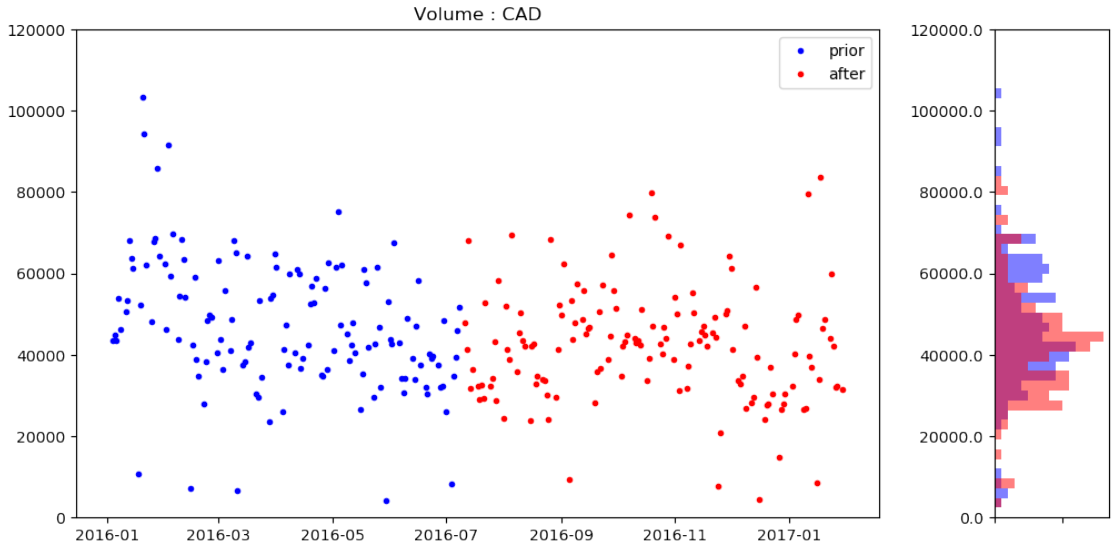
[602]:
```
cme.time_series_hist_plot(OB_UZ_STATS, 'ndfpr',\
    'Number of Price Changes : '+CURR, 0, 12000, 50)
```



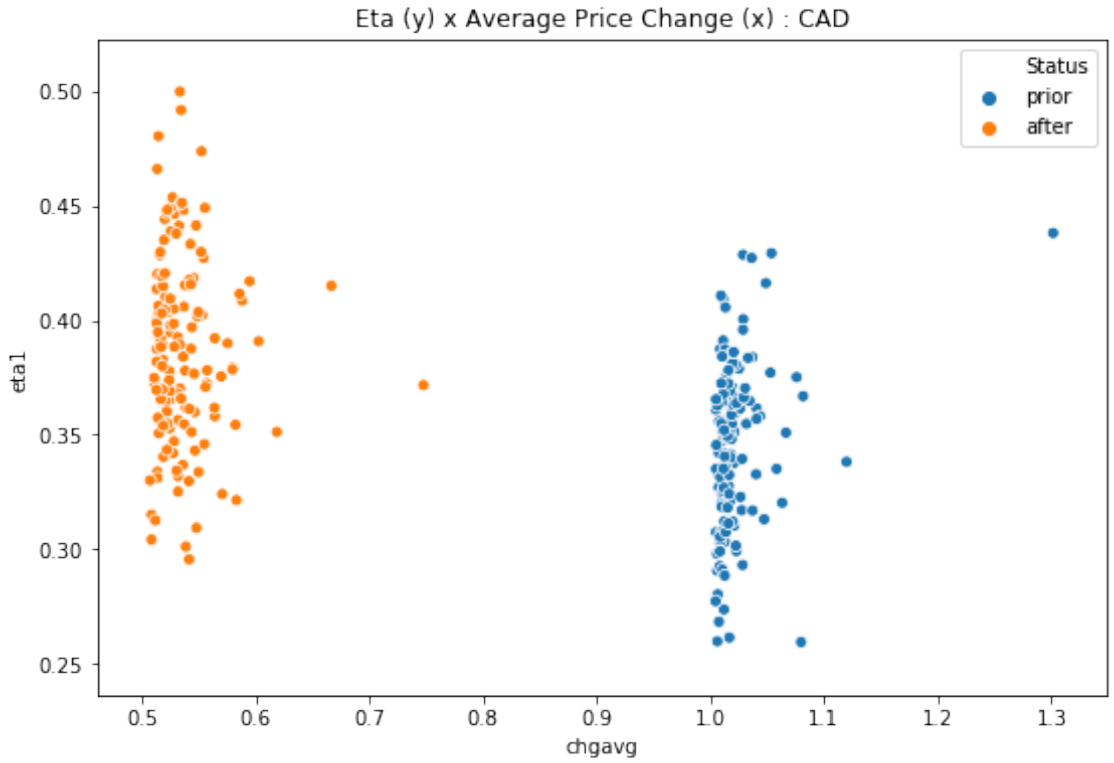
[603]:
```
cme.time_series_hist_plot(OB_UZ_STATS, 'M',\
    'Number of Trades : '+CURR, 0, 40000, 50)
```



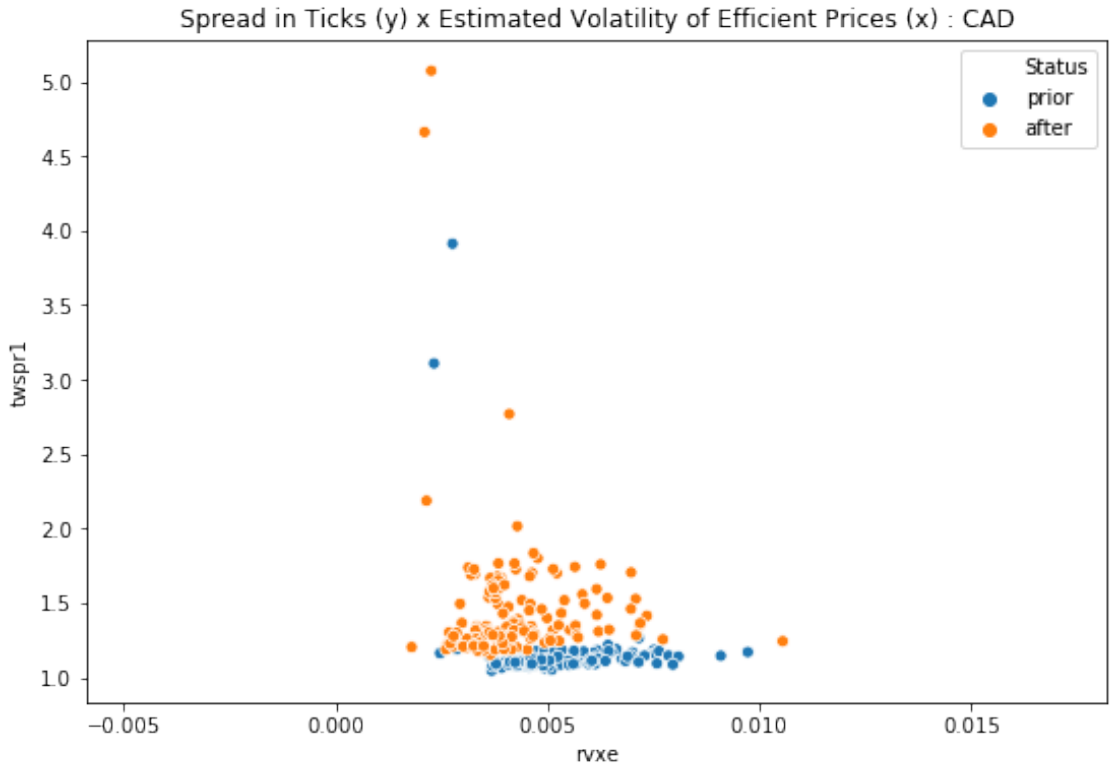
[604]:
```
cme.time_series_hist_plot(OB_UZ_STATS, 'Volume',\
    'Volume : '+CURR, 0, 120000, 50)
```



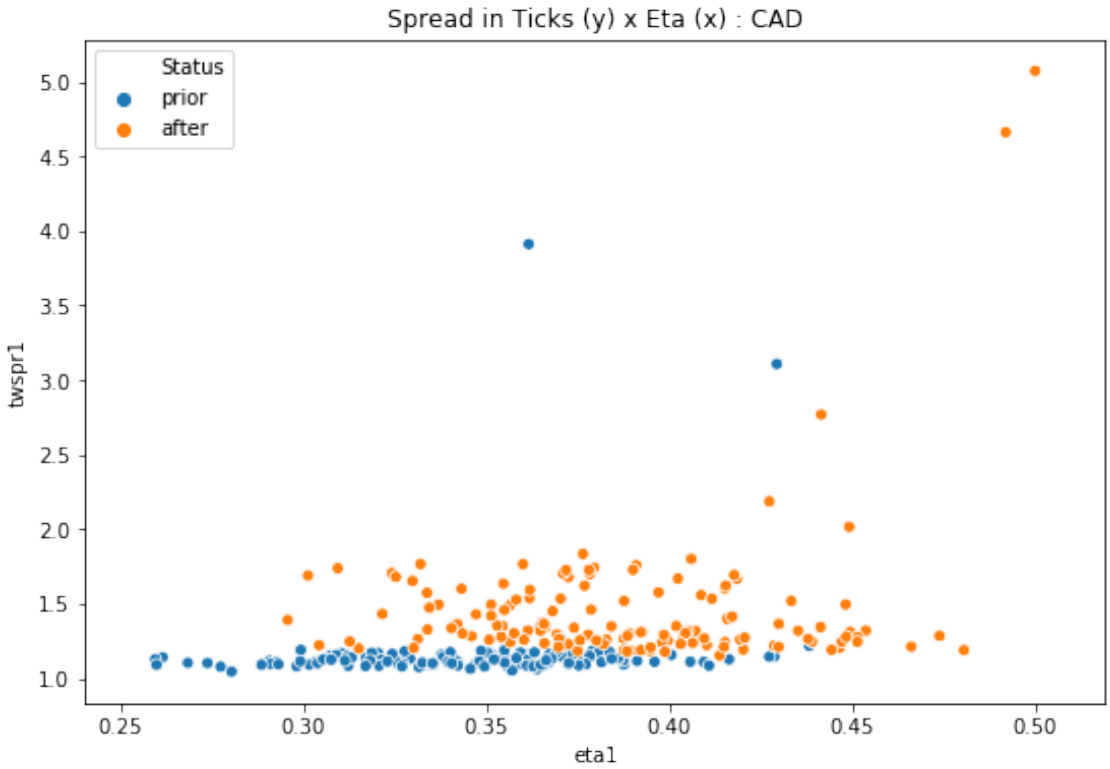
[502]:
```
cme.scatter_plot(OB_UZ_STATS, 'chgavg', 'eta1',\
    'Eta (y) x Average Price Change (x) : '+CURR)
```



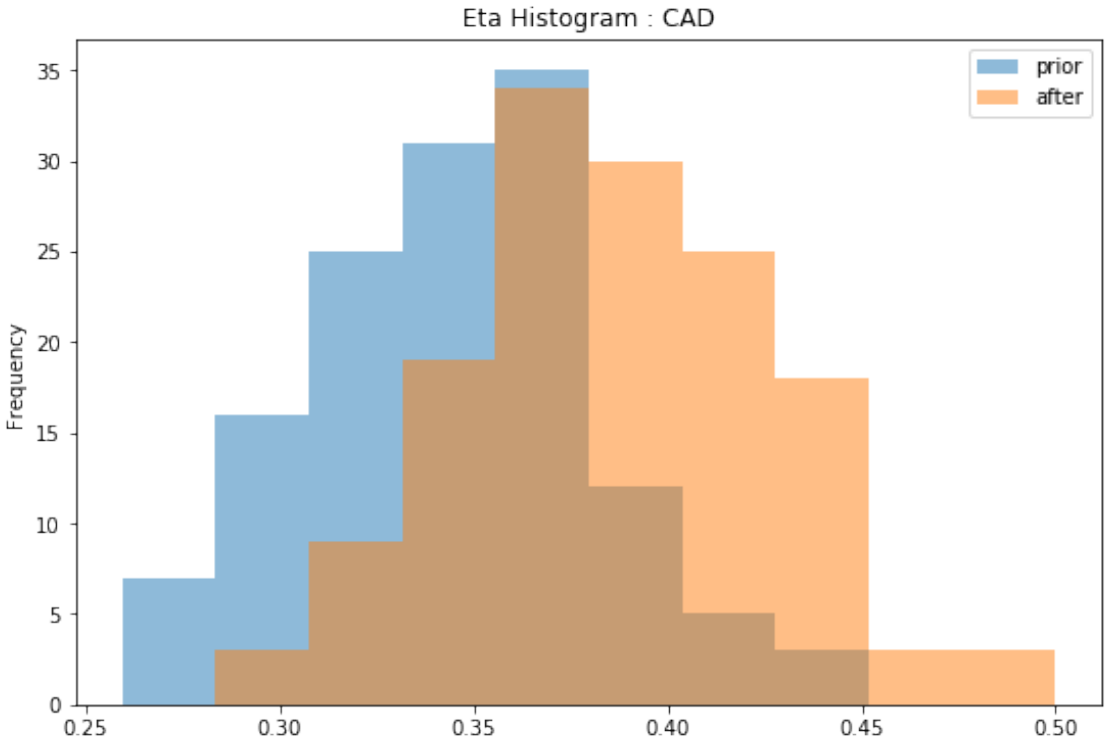
[503]:
```
cme.scatter_plot(OB_UZ_STATS, 'rvxe', 'twspr1',\
    'Spread in Ticks (y) x Estimated Volatility of Efficient Prices (x) :␣
↪'+CURR)
```



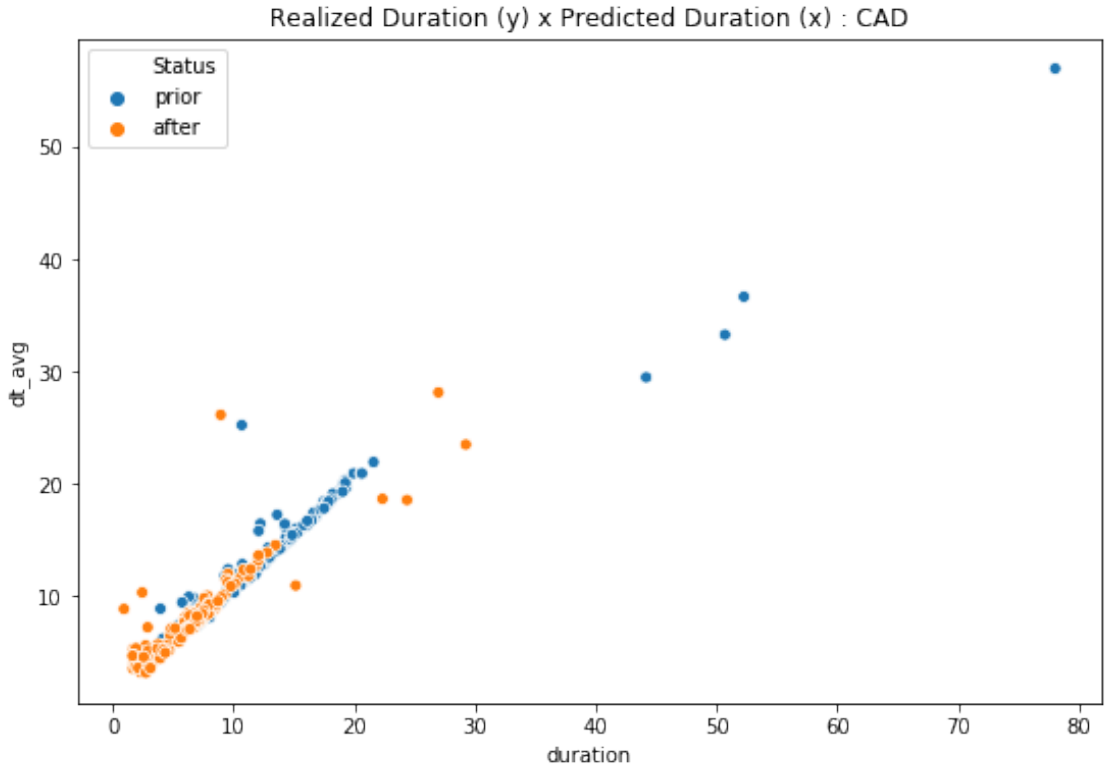
[504]:
```
cme.scatter_plot(OB_UZ_STATS, 'eta1', 'twspr1',\
    'Spread in Ticks (y) x Eta (x) : '+CURR)
```



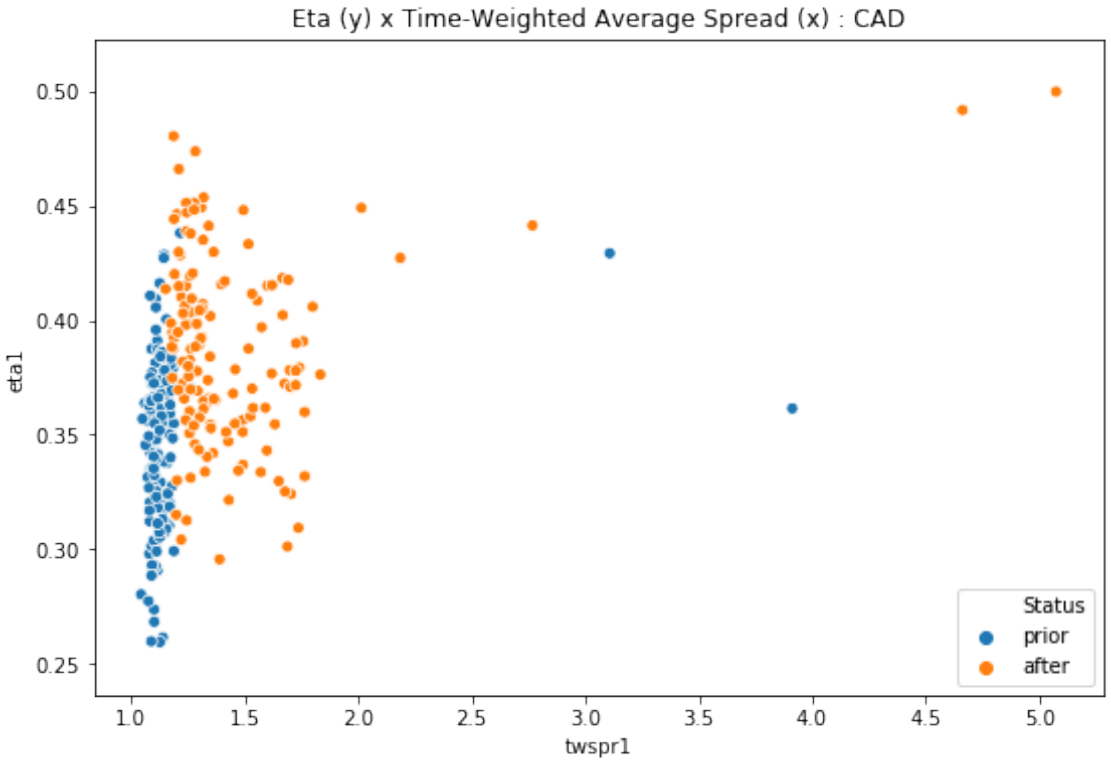
[505]:
```
cme.time_series_hist(OB_UZ_STATS, 'eta1',\
    'Eta Histogram : '+CURR)
```



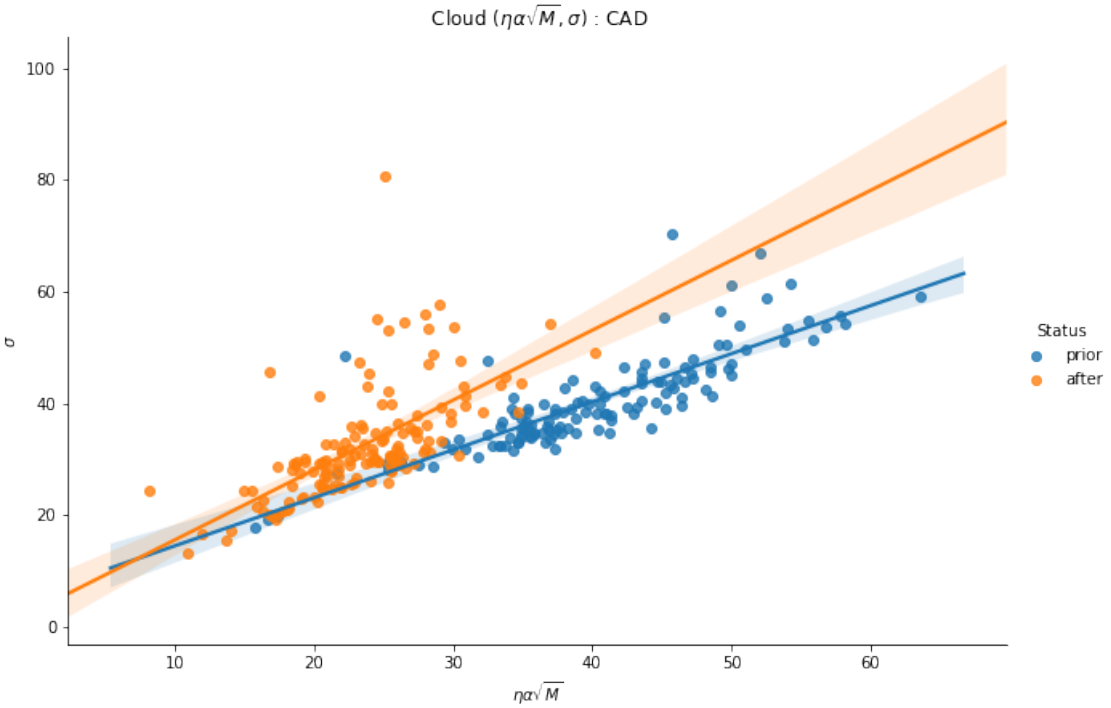
[506]:
```
cme.scatter_plot(OB_UZ_STATS, 'duration', 'dt_avg',\
    'Realized Duration (y) x Predicted Duration (x) : '+CURR)
```



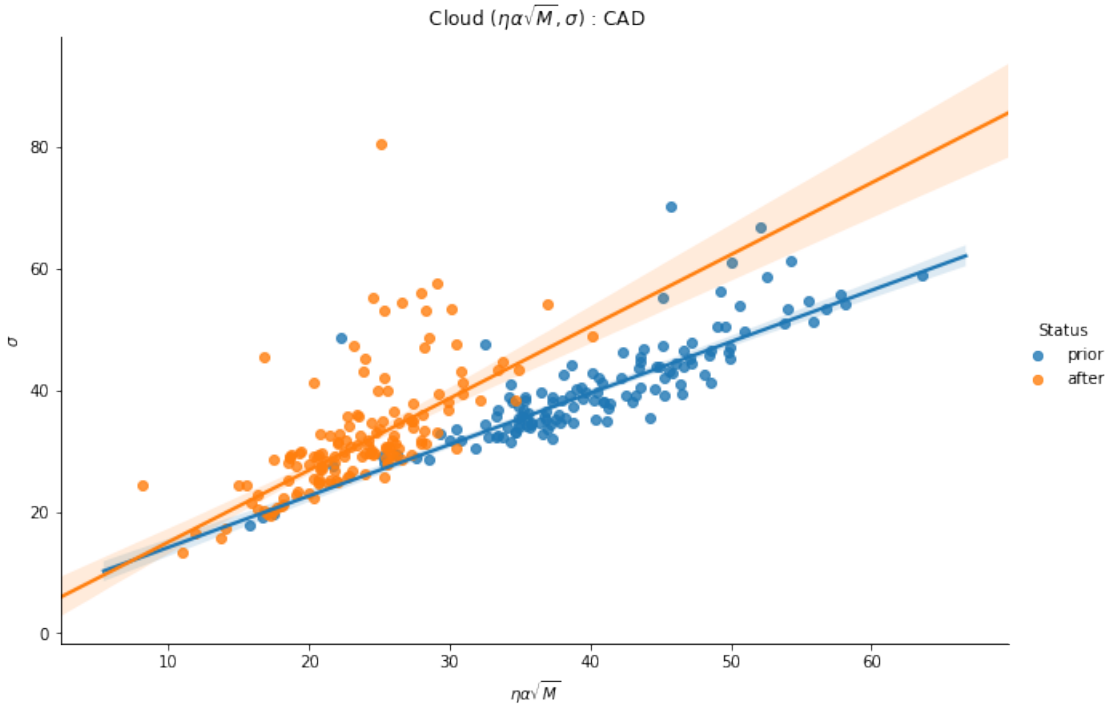
[507]:
```
cme.scatter_plot(OB_UZ_STATS, 'twspr1', 'eta1',\
    'Eta (y) x Time-Weighted Average Spread (x) : '+CURR)
```



[508]:
```
cme.cloud1(OB_UZ_STATS, CURR)
```



[509]:
```
cme.cloud1(OB_UZ_STATS, CURR, True)
```



[510]:
```
cme.lin_reg(PRIOR_OB_UZ_STATS, ['eta*alpha*sqrt(M)', 'S*sqrt(M)'], 'sigma')
```

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                  sigma   R-squared:                       0.717
Model:                            OLS   Adj. R-squared:                  0.712
Method:                 Least Squares   F-statistic:                     165.6
Date:                Wed, 09 Oct 2019   Prob (F-statistic):           1.38e-36
Time:                        15:06:12   Log-Likelihood:                -397.89
No. Observations:                 134   AIC:                             801.8
Df Residuals:                     131   BIC:                             810.5
Df Model:                           2
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const          2.6686      2.438      1.094      0.276      -2.155
```

```
7.492
eta*alpha*sqrt(M)     0.7355      0.075      9.870      0.000       0.588
0.883
S*sqrt(M)             0.0621      0.029      2.170      0.032       0.005
0.119
==============================================================================
Omnibus:                      102.979   Durbin-Watson:                   1.998
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              830.805
Skew:                           2.717   Prob(JB):                    3.92e-181
Kurtosis:                      13.921   Cond. No.                         825.
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
```

[511]:
```
cme.lin_reg_rob(PRIOR_OB_UZ_STATS, ['eta*alpha*sqrt(M)', 'S*sqrt(M)'], 'sigma')
```

```
                    Robust linear Model Regression Results
==============================================================================
Dep. Variable:                  sigma   No. Observations:                  134
Model:                            RLM   Df Residuals:                      131
Method:                          IRLS   Df Model:                            2
Norm:                         HuberT
Scale Est.:                      mad
Cov Type:                         H1
Date:                Wed, 09 Oct 2019
Time:                        15:06:12
No. Iterations:                    22
==============================================================================
=====
                         coef    std err          z      P>|z|      [0.025
0.975]
------------------------------------------------------------------------------
-----
const                  2.4615      1.498      1.643      0.100      -0.475
5.398
eta*alpha*sqrt(M)      0.7102      0.046     15.508      0.000       0.620
0.800
S*sqrt(M)              0.0660      0.018      3.758      0.000       0.032
0.100
==============================================================================
=====

If the model instance has been used for another fit with different fit
parameters, then the fit options might not be the correct ones anymore .
```

[512]:
```
cme.lin_reg(AFTER_OB_UZ_STATS, ['eta*alpha*sqrt(M)', 'S*sqrt(M)'], 'sigma')
```

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                  sigma   R-squared:                       0.486
Model:                            OLS   Adj. R-squared:                  0.479
Method:                 Least Squares   F-statistic:                     66.79
Date:                Wed, 09 Oct 2019   Prob (F-statistic):           3.93e-21
Time:                        15:06:12   Log-Likelihood:                -483.79
No. Observations:                 144   AIC:                             973.6
Df Residuals:                     141   BIC:                             982.5
Df Model:                           2
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const         -3.5672      3.203     -1.114      0.267      -9.900       2.765
eta*alpha*sqrt(M)     0.9876      0.132      7.481      0.000       0.727       1.249
S*sqrt(M)      0.1484      0.035      4.221      0.000       0.079       0.218
==============================================================================
Omnibus:                      127.454   Durbin-Watson:                   2.051
Prob(Omnibus):                  0.000   Jarque-Bera (JB):             1748.373
Skew:                           3.116   Prob(JB):                         0.00
Kurtosis:                      18.892   Cond. No.                         499.
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.
```

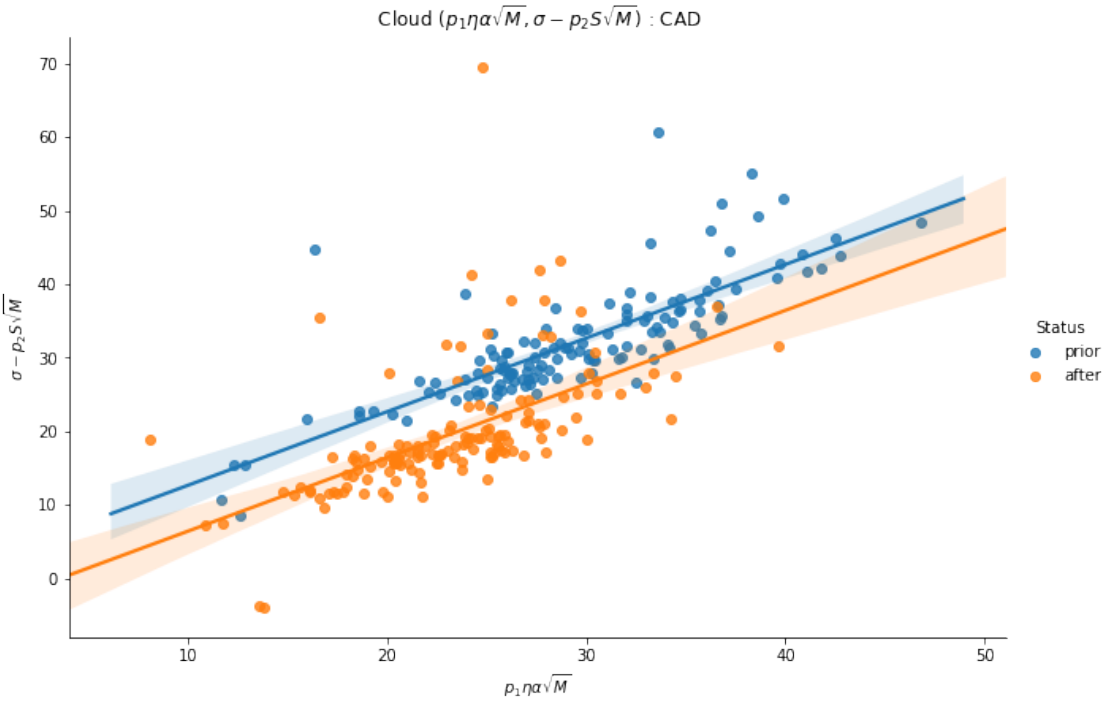
[513]:
```
cme.lin_reg_rob(AFTER_OB_UZ_STATS, ['eta*alpha*sqrt(M)', 'S*sqrt(M)'], 'sigma')
```

```
                    Robust linear Model Regression Results
==============================================================================
Dep. Variable:                  sigma   No. Observations:                  144
Model:                            RLM   Df Residuals:                      141
Method:                          IRLS   Df Model:                            2
Norm:                          HuberT
Scale Est.:                       mad
Cov Type:                          H1
Date:                Wed, 09 Oct 2019
Time:                        15:06:12
```

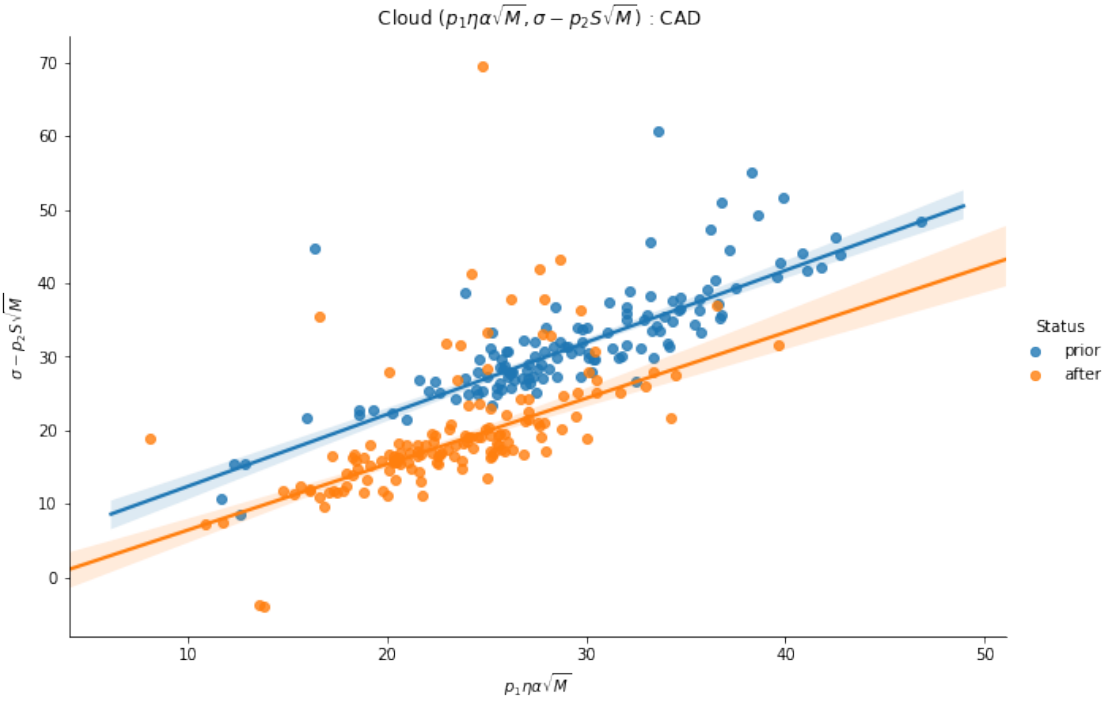
```
No. Iterations:                    18
==============================================================================
=====
                         coef    std err          z      P>|z|      [0.025
0.975]
------------------------------------------------------------------------------
-----
const                 -3.7997      1.334     -2.848      0.004      -6.415
-1.185
eta*alpha*sqrt(M)      0.8039      0.055     14.618      0.000       0.696
0.912
S*sqrt(M)              0.1863      0.015     12.725      0.000       0.158
0.215
==============================================================================
=====

If the model instance has been used for another fit with different fit
parameters, then the fit options might not be the correct ones anymore .
```

[514]:
```
OB_UZ_STATS['p1*eta*alpha*sqrt(M)'] = np.where(OB_UZ_STATS['Status']=='prior',\
    cme.lin_reg_params(PRIOR_OB_UZ_STATS, ['eta*alpha*sqrt(M)', 'S*sqrt(M)'],␣
 ↪'sigma')['eta*alpha*sqrt(M)'],\
    cme.lin_reg_params(AFTER_OB_UZ_STATS, ['eta*alpha*sqrt(M)', 'S*sqrt(M)'],␣
 ↪'sigma')['eta*alpha*sqrt(M)'])\
    *OB_UZ_STATS['eta*alpha*sqrt(M)']
OB_UZ_STATS['sigma-p2*S*sqrt(M)'] = OB_UZ_STATS['sigma']-\
    np.where(OB_UZ_STATS['Status']=='prior',\
    cme.lin_reg_params(PRIOR_OB_UZ_STATS, ['eta*alpha*sqrt(M)', 'S*sqrt(M)'],␣
 ↪'sigma')['S*sqrt(M)'],\
    cme.lin_reg_params(AFTER_OB_UZ_STATS, ['eta*alpha*sqrt(M)', 'S*sqrt(M)'],␣
 ↪'sigma')['S*sqrt(M)'])*\
    OB_UZ_STATS['S*sqrt(M)']
```

[515]:
```
cme.cloud2(OB_UZ_STATS, CURR)
```



[516]:
```
cme.cloud2(OB_UZ_STATS, CURR, True)
```



[517]:
```
cme.lin_reg(OB_UZ_STATS[OB_UZ_STATS['Status']=='prior'],␣
↪['p1*eta*alpha*sqrt(M)'], 'sigma-p2*S*sqrt(M)')
```

```
                            OLS Regression Results
==============================================================================
Dep. Variable:     sigma-p2*S*sqrt(M)   R-squared:                       0.646
Model:                            OLS   Adj. R-squared:                  0.643
Method:                 Least Squares   F-statistic:                     240.6
Date:                Wed, 09 Oct 2019   Prob (F-statistic):           1.55e-31
Time:                        15:06:24   Log-Likelihood:                -397.89
No. Observations:                 134   AIC:                             799.8
Df Residuals:                     132   BIC:                             805.6
Df Model:                           1
Covariance Type:            nonrobust
================================================================================
========
                               coef    std err          t      P>|t|      [0.025
0.975]
--------------------------------------------------------------------------------
--------
const                     2.6686      1.936      1.378      0.170      -1.162
6.499
p1*eta*alpha*sqrt(M)      1.0000      0.064     15.511      0.000       0.872
1.128
==============================================================================
Omnibus:                      102.979   Durbin-Watson:                   1.998
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              830.805
Skew:                           2.717   Prob(JB):                    3.92e-181
Kurtosis:                      13.921   Cond. No.                         142.
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
```

[518]:
```
cme.lin_reg_rob(OB_UZ_STATS[OB_UZ_STATS['Status']=='prior'],␣
↪['p1*eta*alpha*sqrt(M)'], 'sigma-p2*S*sqrt(M)')
```

```
                    Robust linear Model Regression Results
==============================================================================
Dep. Variable:     sigma-p2*S*sqrt(M)   No. Observations:                  134
Model:                            RLM   Df Residuals:                      132
Method:                          IRLS   Df Model:                           1
Norm:                          HuberT
Scale Est.:                       mad
Cov Type:                          H1
Date:                Wed, 09 Oct 2019
Time:                        15:06:24
```

```
No. Iterations:                    13
==============================================================================
========
                             coef    std err          z      P>|z|      [0.025
0.975]
------------------------------------------------------------------------------
--------
const                      2.6278      1.190      2.208      0.027       0.295
4.961
p1*eta*alpha*sqrt(M)       0.9776      0.040     24.668      0.000       0.900
1.055
==============================================================================
========

If the model instance has been used for another fit with different fit
parameters, then the fit options might not be the correct ones anymore .
```

[519]:
```
cme.lin_reg(OB_UZ_STATS[OB_UZ_STATS['Status']=='after'],␣
↪['p1*eta*alpha*sqrt(M)'], 'sigma-p2*S*sqrt(M)')
```

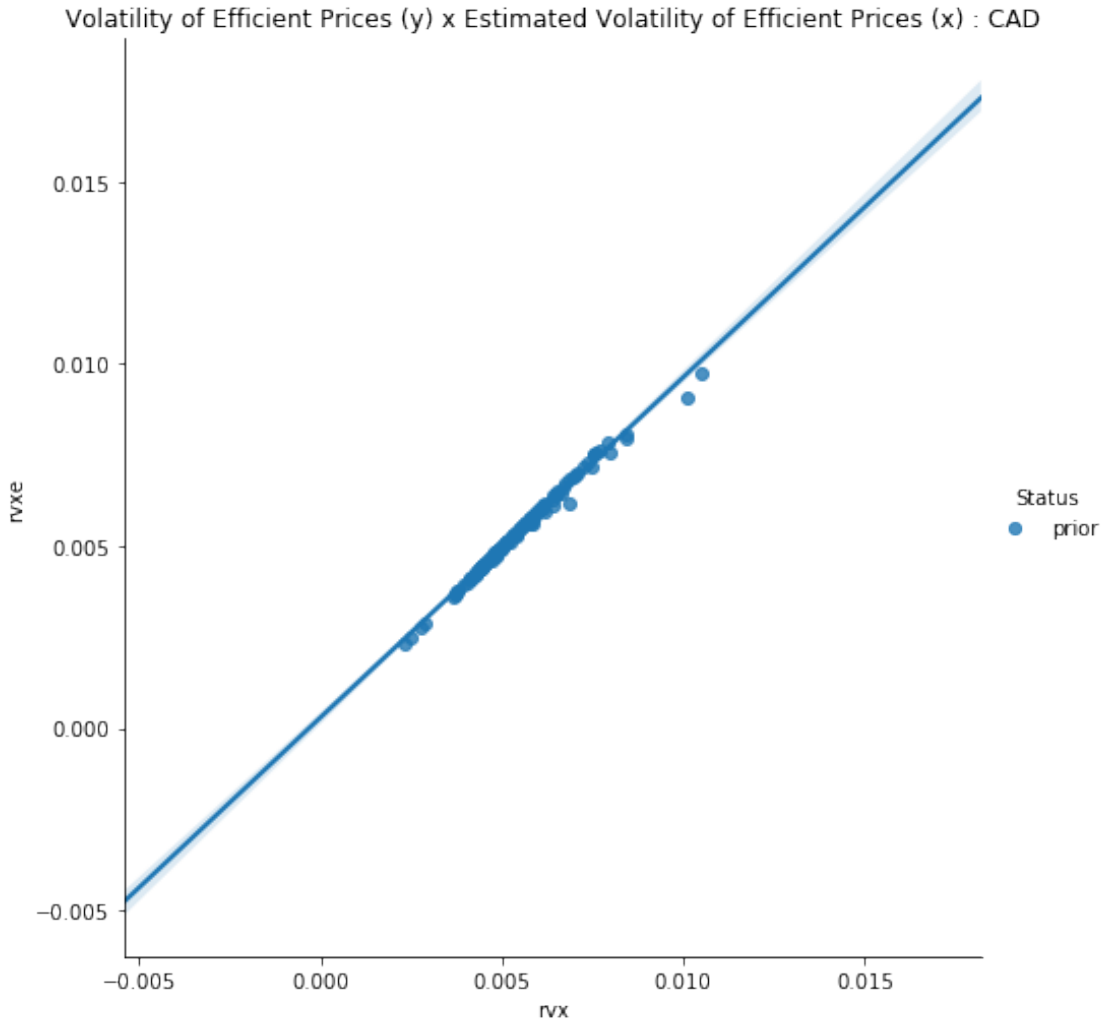
```
                            OLS Regression Results
==============================================================================
Dep. Variable:     sigma-p2*S*sqrt(M)   R-squared:                       0.338
Model:                            OLS   Adj. R-squared:                  0.334
Method:                 Least Squares   F-statistic:                     72.62
Date:                Wed, 09 Oct 2019   Prob (F-statistic):           2.08e-14
Time:                        15:06:24   Log-Likelihood:                -483.79
No. Observations:                 144   AIC:                             971.6
Df Residuals:                     142   BIC:                             977.5
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
========
                             coef    std err          t      P>|t|      [0.025
0.975]
------------------------------------------------------------------------------
--------
const                     -3.5672      2.789     -1.279      0.203      -9.080
1.946
p1*eta*alpha*sqrt(M)       1.0000      0.117      8.522      0.000       0.768
1.232
==============================================================================
Omnibus:                      127.454   Durbin-Watson:                   2.051
Prob(Omnibus):                  0.000   Jarque-Bera (JB):             1748.373
Skew:                           3.116   Prob(JB):                         0.00
Kurtosis:                      18.892   Cond. No.                         114.
==============================================================================
```

```
Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
```

[520]:
```
cme.lin_reg_rob(OB_UZ_STATS[OB_UZ_STATS['Status']=='after'],␣
↪['p1*eta*alpha*sqrt(M)'], 'sigma-p2*S*sqrt(M)')
```

```
                    Robust linear Model Regression Results
==============================================================================
Dep. Variable:     sigma-p2*S*sqrt(M)   No. Observations:                  144
Model:                            RLM   Df Residuals:                      142
Method:                          IRLS   Df Model:                            1
Norm:                         HuberT
Scale Est.:                      mad
Cov Type:                         H1
Date:                Wed, 09 Oct 2019
Time:                        15:06:24
No. Iterations:                    17
==============================================================================
========
                             coef    std err          z      P>|z|      [0.025
0.975]
------------------------------------------------------------------------------
--------
const                    -2.4930      1.214     -2.053      0.040      -4.873
-0.113
p1*eta*alpha*sqrt(M)      0.8951      0.051     17.519      0.000       0.795
0.995
==============================================================================
========

If the model instance has been used for another fit with different fit
parameters, then the fit options might not be the correct ones anymore .
```

[521]:
```
cme.regr_plot(PRIOR_OB_UZ_STATS, 'rvx', 'rvxe',\
    'Volatility of Efficient Prices (y) x Estimated Volatility of Efficient␣
↪Prices (x) : '+CURR)
```

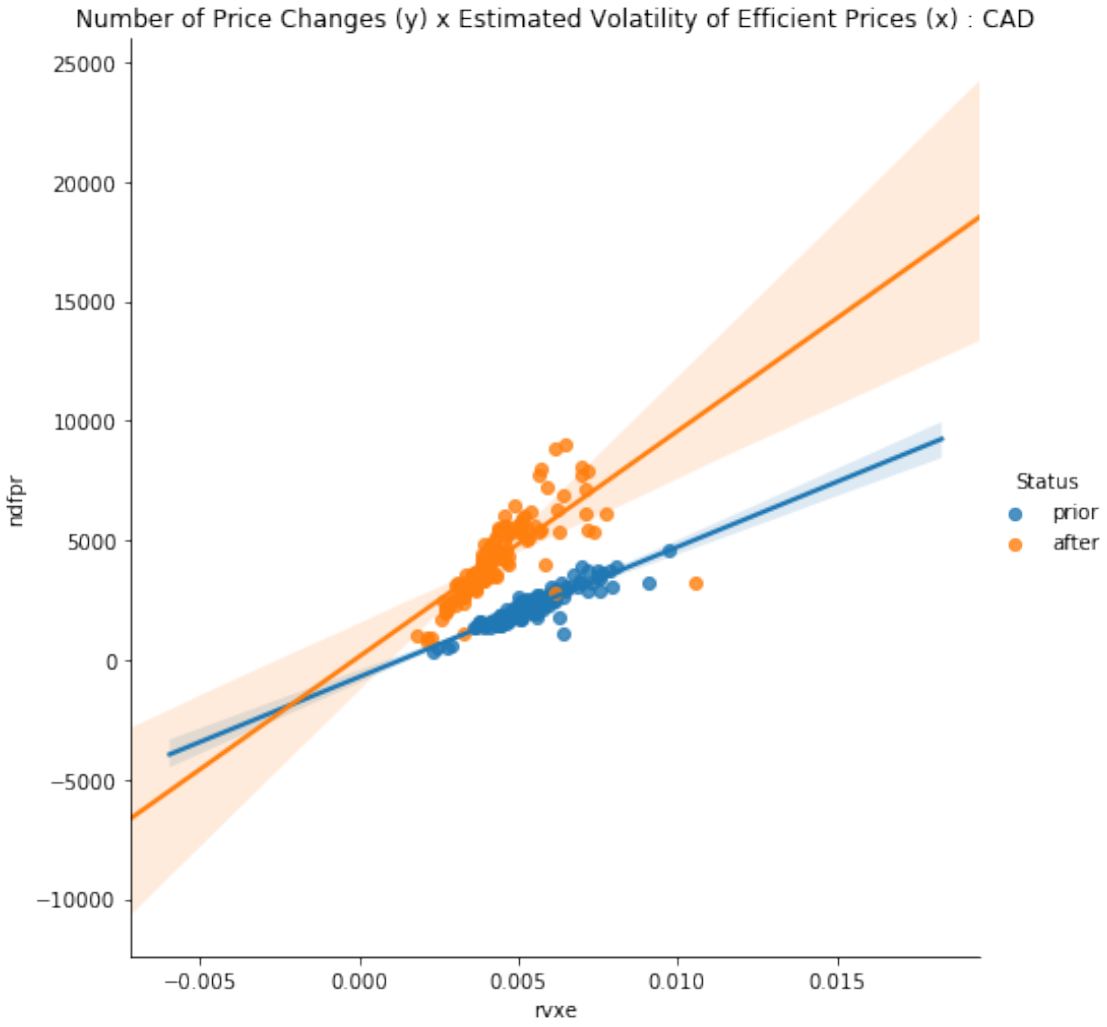


[522]:
```
cme.lin_reg(PRIOR_OB_UZ_STATS, 'rvx', 'rvxe', True)
```

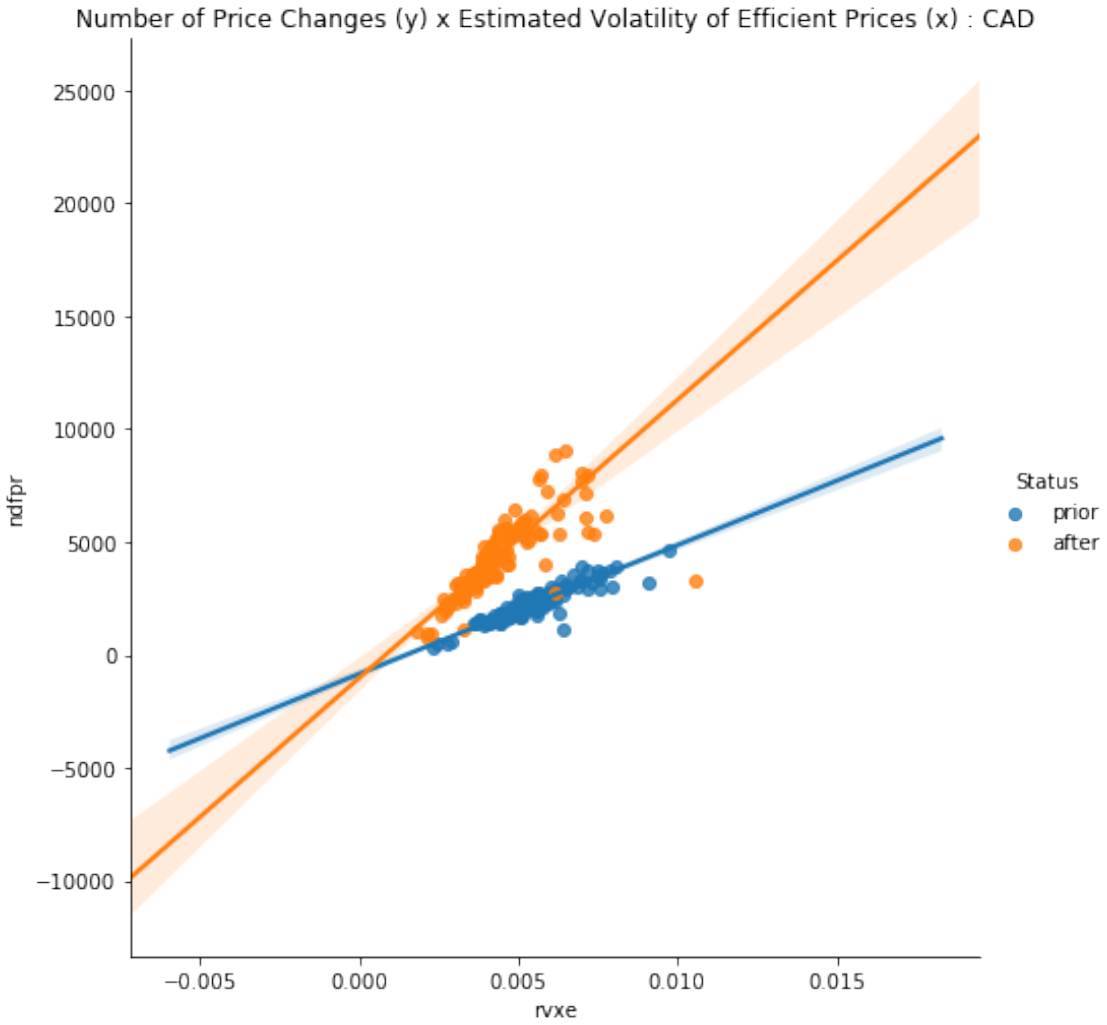
```
                            OLS Regression Results
==============================================================================
Dep. Variable:                   rvxe   R-squared:                       0.996
Model:                            OLS   Adj. R-squared:                  0.996
Method:                 Least Squares   F-statistic:                 3.364e+04
Date:                Wed, 09 Oct 2019   Prob (F-statistic):          8.23e-161
Time:                        15:06:24   Log-Likelihood:                378.28
No. Observations:                 134   AIC:                            -752.6
Df Residuals:                     132   BIC:                            -746.8
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
```

```
const          -0.1838      0.028     -6.638      0.000      -0.239      -0.129
rvx             0.9670      0.005    183.411      0.000       0.957       0.977
==============================================================================
Omnibus:                      105.700   Durbin-Watson:                   2.113
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              892.905
Skew:                          -2.795   Prob(JB):                    1.28e-194
Kurtosis:                      14.343   Cond. No.                        120.
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
```

[523]:
```
cme.regr_plot(OB_UZ_STATS, 'rvxe', 'ndfpr',\
    'Number of Price Changes (y) x Estimated Volatility of Efficient Prices (x)␣
↪: '+CURR)
```



[524]:
```
cme.regr_plot(OB_UZ_STATS, 'rvxe', 'ndfpr',\
    'Number of Price Changes (y) x Estimated Volatility of Efficient Prices (x)␣
↪: '+CURR, True)
```



[525]:
```
cme.lin_reg(PRIOR_OB_UZ_STATS, 'rvxe', 'ndfpr', True)
```

OLS Regression Results

Dep. Variable:	ndfpr	R-squared:	0.825
Model:	OLS	Adj. R-squared:	0.823
Method:	Least Squares	F-statistic:	621.3
Date:	Wed, 09 Oct 2019	Prob (F-statistic):	9.12e-52
Time:	15:06:32	Log-Likelihood:	55.535
No. Observations:	134	AIC:	-107.1

```
Df Residuals:                      132   BIC:                            -101.3
Df Model:                            1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const         15.5556      0.318     48.856      0.000      14.926      16.185
rvxe           1.5079      0.060     24.926      0.000       1.388       1.628
==============================================================================
Omnibus:                       84.792   Durbin-Watson:                   1.792
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              533.998
Skew:                          -2.189   Prob(JB):                    1.11e-116
Kurtosis:                      11.745   Cond. No.                         125.
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
```

[526]:
```
cme.lin_reg_rob(PRIOR_OB_UZ_STATS, 'rvxe', 'ndfpr', True)
```

```
                    Robust linear Model Regression Results
==============================================================================
Dep. Variable:                  ndfpr   No. Observations:                  134
Model:                            RLM   Df Residuals:                      132
Method:                          IRLS   Df Model:                            1
Norm:                          HuberT
Scale Est.:                       mad
Cov Type:                          H1
Date:                Wed, 09 Oct 2019
Time:                        15:06:32
No. Iterations:                    20
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
const         15.1708      0.236     64.242      0.000      14.708      15.634
rvxe           1.4312      0.045     31.896      0.000       1.343       1.519
==============================================================================

If the model instance has been used for another fit with different fit
parameters, then the fit options might not be the correct ones anymore .
```

[527]:
```
cme.lin_reg(AFTER_OB_UZ_STATS, 'rvxe', 'ndfpr', True)
```

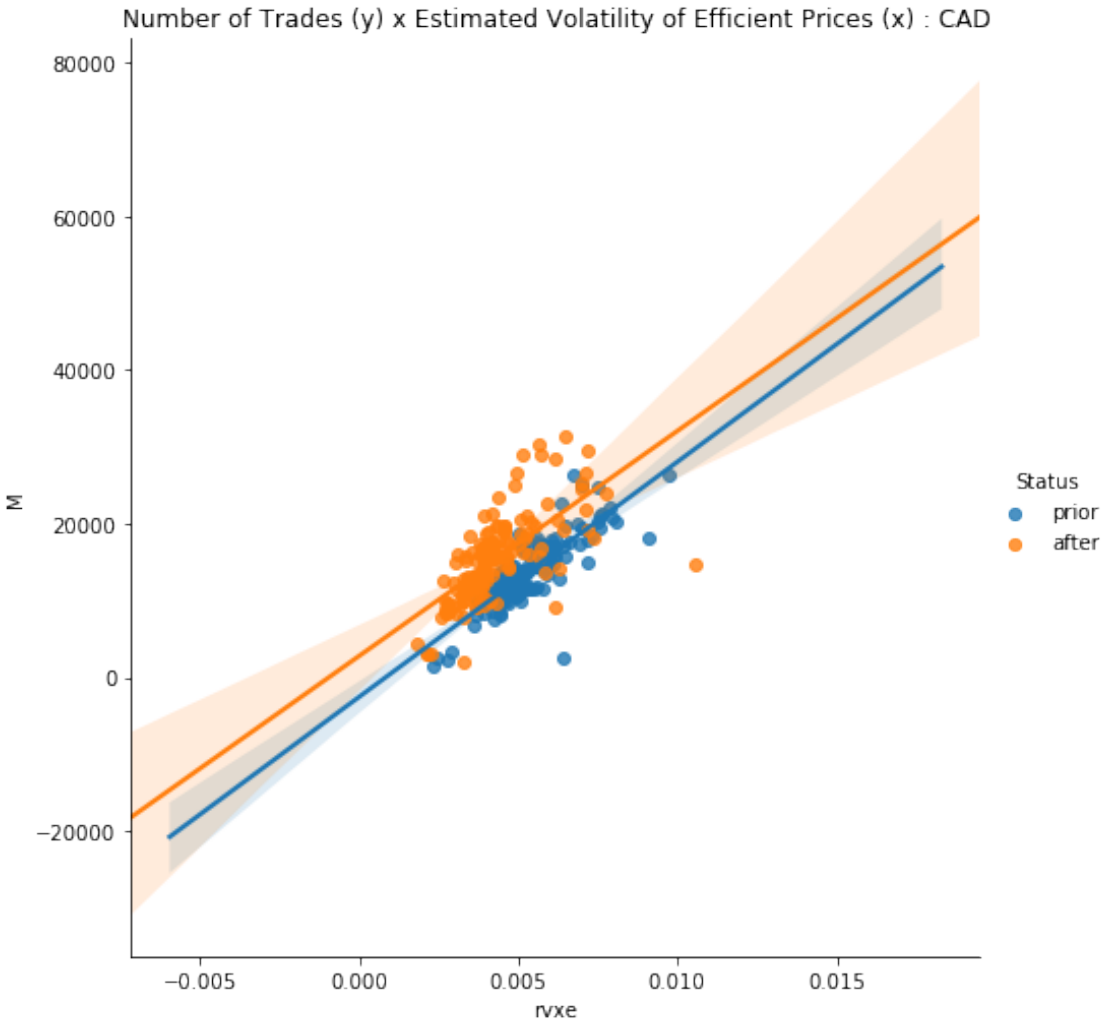
```
                            OLS Regression Results
==============================================================================
Dep. Variable:                  ndfpr   R-squared:                       0.698
Model:                            OLS   Adj. R-squared:                  0.695
```

```
Method:                 Least Squares   F-statistic:                     327.4
Date:                Wed, 09 Oct 2019   Prob (F-statistic):           1.08e-38
Time:                        15:06:32   Log-Likelihood:                 5.9724
No. Observations:                 144   AIC:                            -7.945
Df Residuals:                     142   BIC:                            -2.005
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const         15.2354      0.386     39.450      0.000      14.472      15.999
rvxe           1.2705      0.070     18.095      0.000       1.132       1.409
==============================================================================
Omnibus:                      106.271   Durbin-Watson:                   1.872
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              827.244
Skew:                          -2.652   Prob(JB):                    2.32e-180
Kurtosis:                      13.476   Cond. No.                        113.
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
```

[528]:
```
cme.lin_reg_rob(AFTER_OB_UZ_STATS, 'rvxe', 'ndfpr', True)
```

```
                    Robust linear Model Regression Results
==============================================================================
Dep. Variable:                  ndfpr   No. Observations:                  144
Model:                            RLM   Df Residuals:                      142
Method:                          IRLS   Df Model:                            1
Norm:                          HuberT
Scale Est.:                       mad
Cov Type:                          H1
Date:                Wed, 09 Oct 2019
Time:                        15:06:32
No. Iterations:                    23
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
const         15.7933      0.250     63.074      0.000      15.303      16.284
rvxe           1.3657      0.046     30.001      0.000       1.277       1.455
==============================================================================

If the model instance has been used for another fit with different fit
parameters, then the fit options might not be the correct ones anymore .
```

[529]:
```
cme.regr_plot(OB_UZ_STATS, 'rvxe', 'M',\
    'Number of Trades (y) x Estimated Volatility of Efficient Prices (x) :␣
↪'+CURR)
```



[530]:
```
cme.regr_plot(OB_UZ_STATS, 'rvxe', 'M',\
    'Number of Trades (y) x Estimated Volatility of Efficient Prices (x) :␣
↪'+CURR, True)
```

[531]:
```
cme.lin_reg(PRIOR_OB_UZ_STATS, 'rvxe', 'M', True)
```

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                      M   R-squared:                       0.632
Model:                            OLS   Adj. R-squared:                  0.629
Method:                 Least Squares   F-statistic:                     226.3
Date:                Wed, 09 Oct 2019   Prob (F-statistic):           2.09e-30
Time:                        15:06:38   Log-Likelihood:                -10.960
No. Observations:                 134   AIC:                             25.92
Df Residuals:                     132   BIC:                             31.71
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
```

```
const         17.3197      0.523     33.118      0.000      16.285      18.354
rvxe           1.4947      0.099     15.042      0.000       1.298       1.691
==============================================================================
Omnibus:                      137.184   Durbin-Watson:                   1.833
Prob(Omnibus):                  0.000   Jarque-Bera (JB):             2830.301
Skew:                          -3.568   Prob(JB):                         0.00
Kurtosis:                      24.354   Cond. No.                         125.
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
```

[532]:
```
cme.lin_reg_rob(PRIOR_OB_UZ_STATS, 'rvxe', 'M', True)
```

```
                    Robust linear Model Regression Results
==============================================================================
Dep. Variable:                      M   No. Observations:                  134
Model:                            RLM   Df Residuals:                      132
Method:                          IRLS   Df Model:                            1
Norm:                         HuberT
Scale Est.:                      mad
Cov Type:                         H1
Date:                Wed, 09 Oct 2019
Time:                        15:06:38
No. Iterations:                    32
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
const         16.3148      0.325     50.173      0.000      15.678      16.952
rvxe           1.2975      0.062     21.000      0.000       1.176       1.419
==============================================================================

If the model instance has been used for another fit with different fit
parameters, then the fit options might not be the correct ones anymore .
```

[533]:
```
cme.lin_reg(AFTER_OB_UZ_STATS, 'rvxe', 'M', True)
```

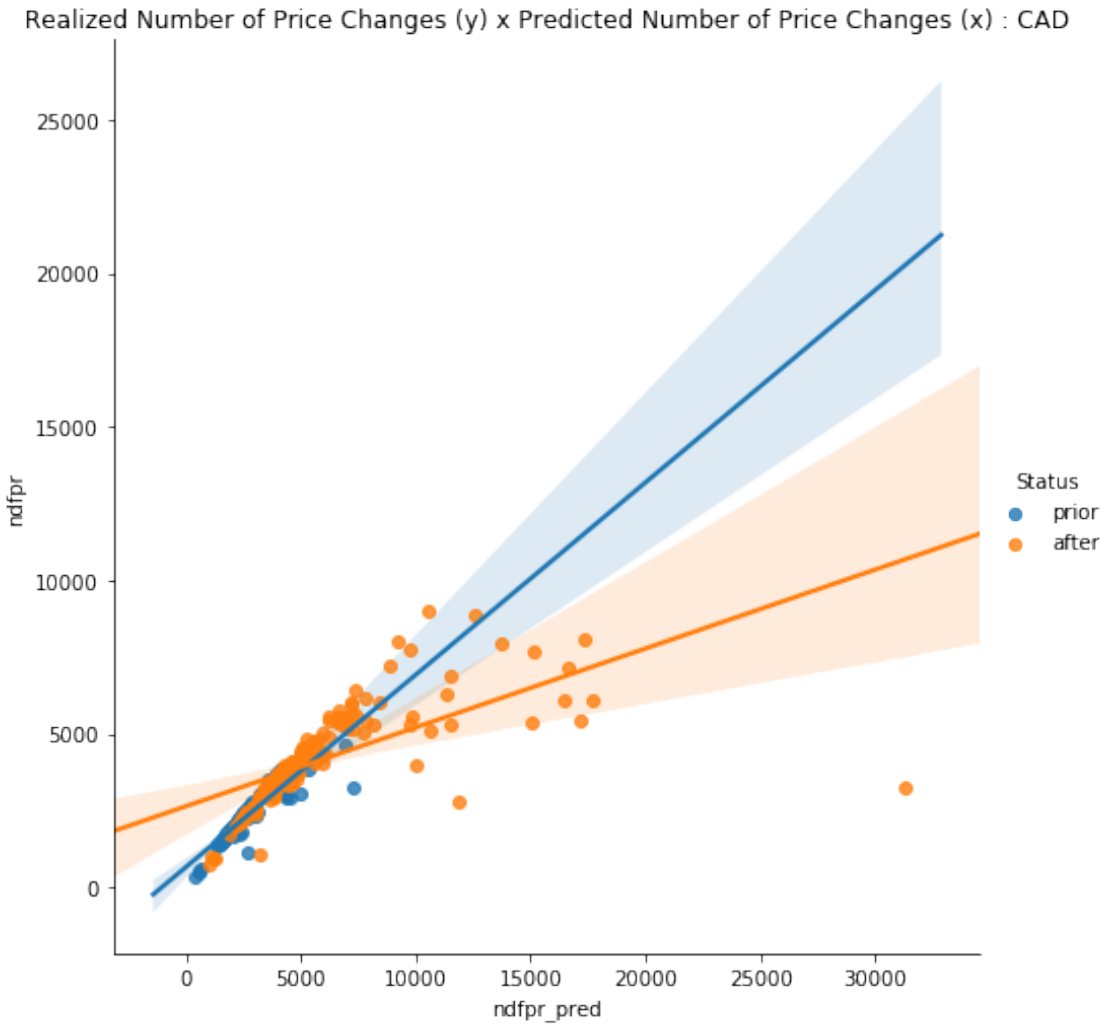
```
                            OLS Regression Results
==============================================================================
Dep. Variable:                      M   R-squared:                       0.515
Model:                            OLS   Adj. R-squared:                  0.512
Method:                 Least Squares   F-statistic:                     151.0
Date:                Wed, 09 Oct 2019   Prob (F-statistic):           4.23e-24
Time:                        15:06:38   Log-Likelihood:                -30.302
No. Observations:                 144   AIC:                             64.60
Df Residuals:                     142   BIC:                             70.54
Df Model:                           1
```

```
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const         15.6581      0.497     31.516      0.000      14.676      16.640
rvxe           1.1101      0.090     12.290      0.000       0.932       1.289
==============================================================================
Omnibus:                       84.255   Durbin-Watson:                   1.528
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              497.246
Skew:                          -2.054   Prob(JB):                    1.06e-108
Kurtosis:                      11.124   Cond. No.                        113.
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
```

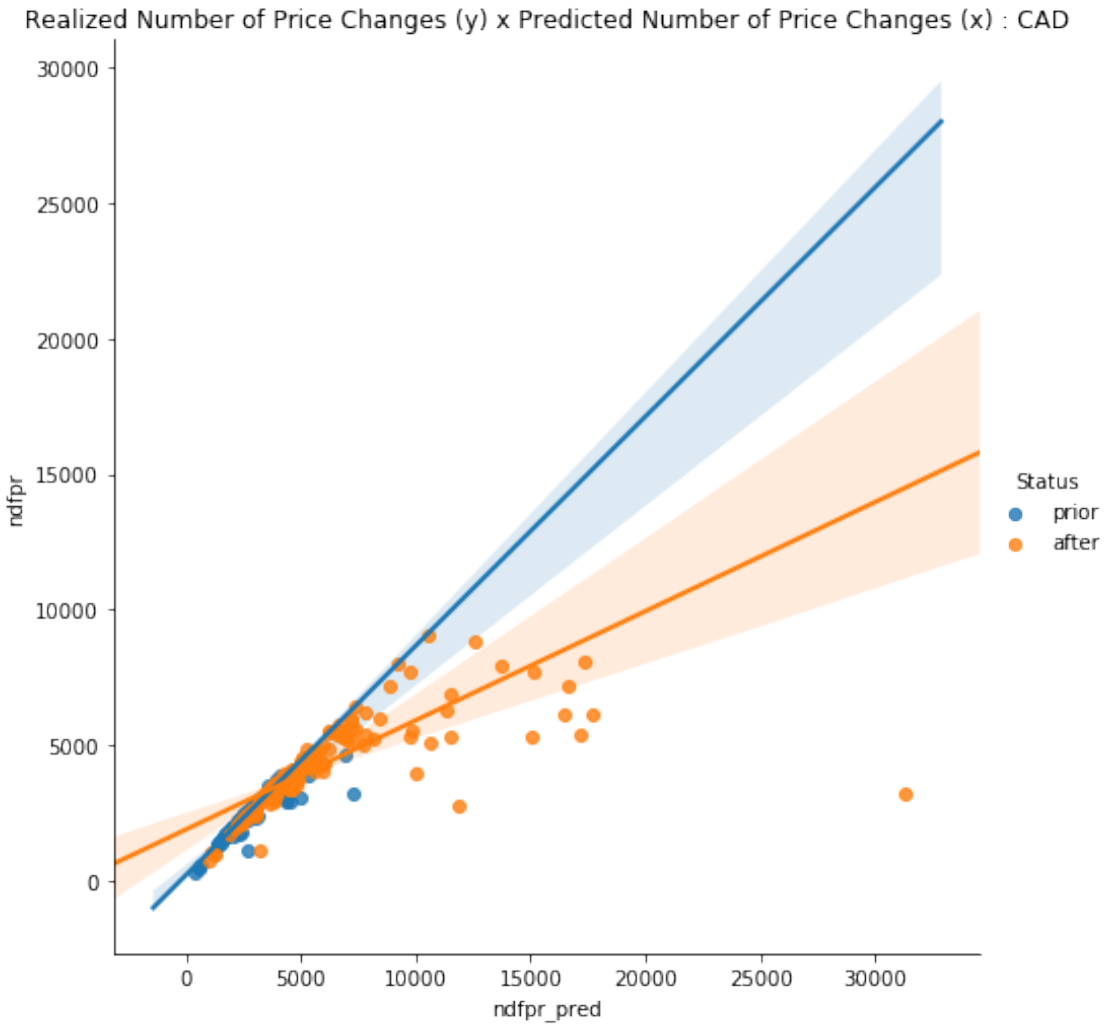
[534]:
```
cme.lin_reg_rob(AFTER_OB_UZ_STATS, 'rvxe', 'M', True)
```

```
                    Robust linear Model Regression Results
==============================================================================
Dep. Variable:                      M   No. Observations:                  144
Model:                            RLM   Df Residuals:                      142
Method:                          IRLS   Df Model:                            1
Norm:                         HuberT
Scale Est.:                      mad
Cov Type:                         H1
Date:                Wed, 09 Oct 2019
Time:                        15:06:38
No. Iterations:                    21
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
const         15.5334      0.386     40.241      0.000      14.777      16.290
rvxe           1.0817      0.070     15.414      0.000       0.944       1.219
==============================================================================

If the model instance has been used for another fit with different fit
parameters, then the fit options might not be the correct ones anymore .
```

[535]:
```
cme.regr_plot(OB_UZ_STATS, 'ndfpr_pred', 'ndfpr',\
    'Realized Number of Price Changes (y) x Predicted Number of Price Changes␣
 ↪(x) : '+CURR)
```



[536]:
```
cme.regr_plot(OB_UZ_STATS, 'ndfpr_pred', 'ndfpr',\
    'Realized Number of Price Changes (y) x Predicted Number of Price Changes␣
↪(x) : '+CURR, True)
```



[537]:
```
cme.lin_reg(PRIOR_OB_UZ_STATS, 'ndfpr_pred', 'ndfpr')
```

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                  ndfpr   R-squared:                       0.809
Model:                            OLS   Adj. R-squared:                  0.808
Method:                 Least Squares   F-statistic:                     559.5
Date:                Wed, 09 Oct 2019   Prob (F-statistic):           2.63e-49
Time:                        15:06:52   Log-Likelihood:                -961.76
No. Observations:                 134   AIC:                             1928.
Df Residuals:                     132   BIC:                             1933.
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
```

```
const        657.9355     70.241      9.367      0.000     518.993     796.878
ndfpr_pred     0.6266      0.026     23.653      0.000       0.574       0.679
==============================================================================
Omnibus:                       92.316   Durbin-Watson:                   1.990
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              885.504
Skew:                          -2.240   Prob(JB):                   5.19e-193
Kurtosis:                      14.770   Cond. No.                    6.75e+03
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
[2] The condition number is large, 6.75e+03. This might indicate that there are
strong multicollinearity or other numerical problems.
```

[538]:
```
cme.lin_reg_rob(PRIOR_OB_UZ_STATS, 'ndfpr_pred', 'ndfpr')
```

```
                    Robust linear Model Regression Results
==============================================================================
Dep. Variable:                  ndfpr   No. Observations:                  134
Model:                            RLM   Df Residuals:                      132
Method:                          IRLS   Df Model:                            1
Norm:                          HuberT
Scale Est.:                       mad
Cov Type:                          H1
Date:                Wed, 09 Oct 2019
Time:                        15:06:52
No. Iterations:                    30
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
const        215.0019     18.438     11.661      0.000     178.863     251.141
ndfpr_pred     0.8462      0.007    121.677      0.000       0.833       0.860
==============================================================================

If the model instance has been used for another fit with different fit
parameters, then the fit options might not be the correct ones anymore .
```

[539]:
```
cme.lin_reg(AFTER_OB_UZ_STATS, 'ndfpr_pred', 'ndfpr')
```

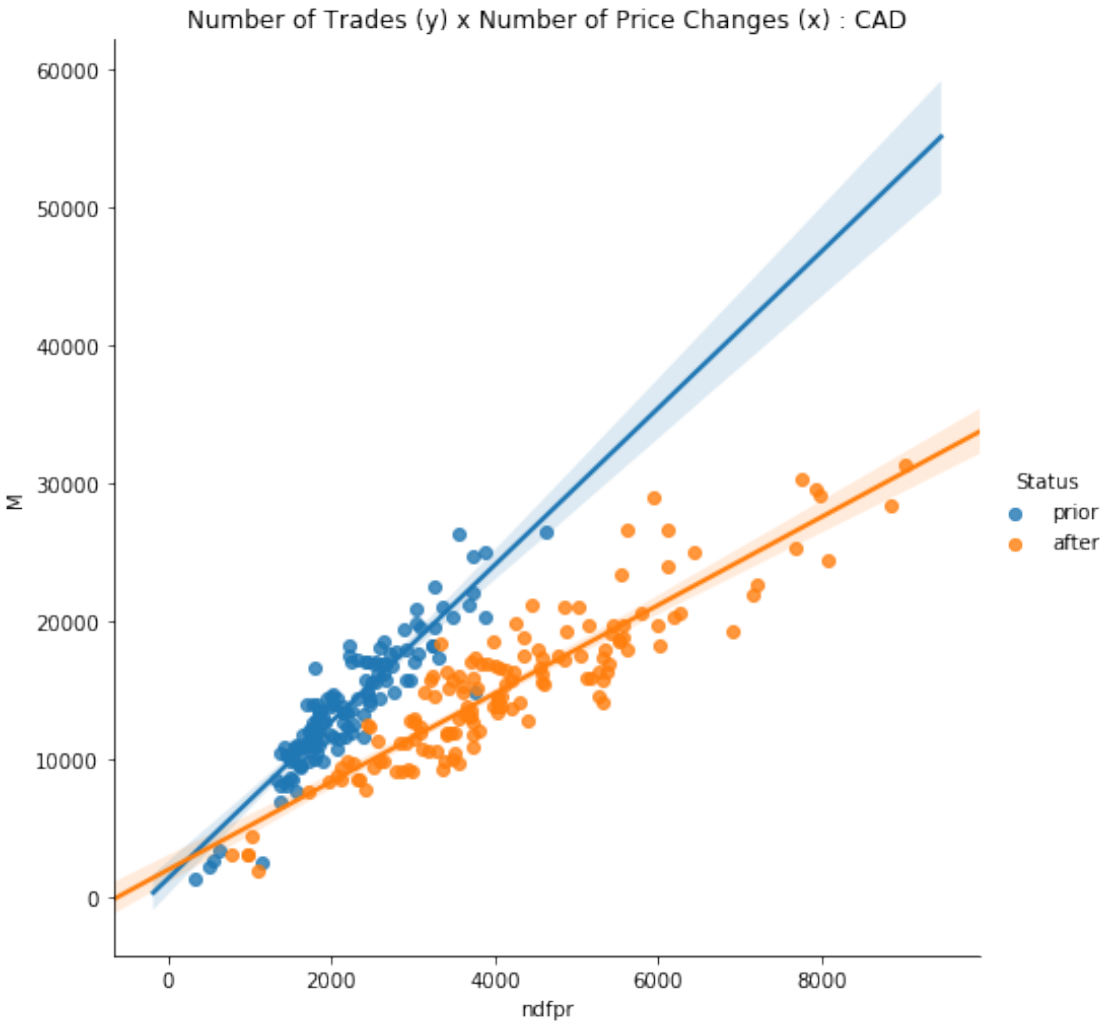
```
                            OLS Regression Results
==============================================================================
Dep. Variable:                  ndfpr   R-squared:                       0.434
Model:                            OLS   Adj. R-squared:                  0.430
Method:                 Least Squares   F-statistic:                     108.7
Date:                Wed, 09 Oct 2019   Prob (F-statistic):           3.00e-19
Time:                        15:06:52   Log-Likelihood:                -1222.9
No. Observations:                 144   AIC:                             2450.
```

```
Df Residuals:                      142   BIC:                             2456.
Df Model:                            1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const       2639.7083    176.829     14.928      0.000    2290.150    2989.266
ndfpr_pred     0.2570      0.025     10.425      0.000       0.208       0.306
==============================================================================
Omnibus:                       69.505   Durbin-Watson:                   1.928
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              693.566
Skew:                          -1.384   Prob(JB):                    2.48e-151
Kurtosis:                      13.389   Cond. No.                     1.28e+04
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
[2] The condition number is large, 1.28e+04. This might indicate that there are
strong multicollinearity or other numerical problems.
```

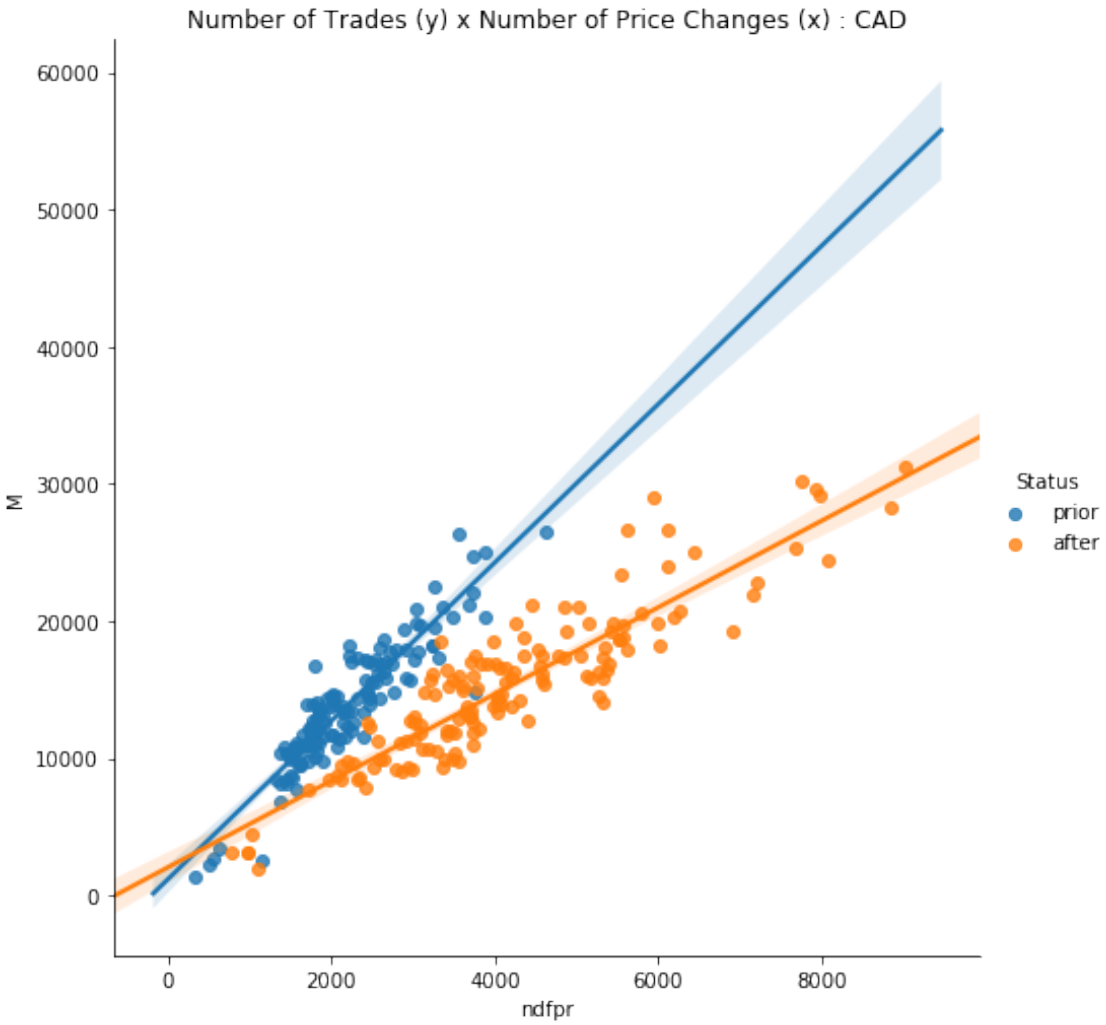
[540]:
```
cme.lin_reg_rob(AFTER_OB_UZ_STATS, 'ndfpr_pred', 'ndfpr')
```

```
                    Robust linear Model Regression Results
==============================================================================
Dep. Variable:                   ndfpr   No. Observations:                  144
Model:                             RLM   Df Residuals:                      142
Method:                           IRLS   Df Model:                            1
Norm:                          HuberT
Scale Est.:                       mad
Cov Type:                          H1
Date:                Wed, 09 Oct 2019
Time:                        15:06:52
No. Iterations:                    24
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
const       1897.5304    100.877     18.810      0.000    1699.815    2095.245
ndfpr_pred     0.4029      0.014     28.645      0.000       0.375       0.430
==============================================================================

If the model instance has been used for another fit with different fit
parameters, then the fit options might not be the correct ones anymore .
```

[541]:
```
cme.regr_plot(OB_UZ_STATS, 'ndfpr', 'M',\
    'Number of Trades (y) x Number of Price Changes (x) : '+CURR)
```



[542]:
```
cme.regr_plot(OB_UZ_STATS, 'ndfpr', 'M',\
    'Number of Trades (y) x Number of Price Changes (x) : '+CURR, True)
```



[545]:
```
cme.lin_reg(PRIOR_OB_UZ_STATS, 'ndfpr', 'M')
```

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                      M   R-squared:                       0.840
Model:                            OLS   Adj. R-squared:                  0.838
Method:                 Least Squares   F-statistic:                     691.3
Date:                Wed, 09 Oct 2019   Prob (F-statistic):           2.57e-54
Time:                        15:07:03   Log-Likelihood:                -1194.5
No. Observations:                 134   AIC:                             2393.
Df Residuals:                     132   BIC:                             2399.
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
```

```
const       1394.3960    497.248      2.804      0.006     410.790    2378.002
ndfpr          5.6766      0.216     26.292      0.000       5.250       6.104
==============================================================================
Omnibus:                       14.713   Durbin-Watson:                   1.066
Prob(Omnibus):                  0.001   Jarque-Bera (JB):               34.291
Skew:                          -0.371   Prob(JB):                     3.58e-08
Kurtosis:                       5.364   Cond. No.                     7.31e+03
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
[2] The condition number is large, 7.31e+03. This might indicate that there are
strong multicollinearity or other numerical problems.
```

[546]:
```
cme.lin_reg_rob(PRIOR_OB_UZ_STATS, 'ndfpr', 'M')
```

```
                    Robust linear Model Regression Results
==============================================================================
Dep. Variable:                      M   No. Observations:                  134
Model:                            RLM   Df Residuals:                      132
Method:                          IRLS   Df Model:                            1
Norm:                         HuberT
Scale Est.:                      mad
Cov Type:                         H1
Date:                Wed, 09 Oct 2019
Time:                        15:07:03
No. Iterations:                     6
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
const       1208.9692    450.252      2.685      0.007     326.491    2091.447
ndfpr          5.7648      0.196     29.487      0.000       5.382       6.148
==============================================================================

If the model instance has been used for another fit with different fit
parameters, then the fit options might not be the correct ones anymore .
```

[547]:
```
cme.lin_reg(AFTER_OB_UZ_STATS, 'ndfpr', 'M')
```

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                      M   R-squared:                       0.822
Model:                            OLS   Adj. R-squared:                  0.821
Method:                 Least Squares   F-statistic:                     657.4
Date:                Wed, 09 Oct 2019   Prob (F-statistic):           3.84e-55
Time:                        15:07:03   Log-Likelihood:                -1320.7
No. Observations:                 144   AIC:                             2645.
```

```
Df Residuals:                      142   BIC:                             2651.
Df Model:                            1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const       2011.9887    554.650      3.627      0.000     915.550    3108.427
ndfpr          3.1941      0.125     25.639      0.000       2.948       3.440
==============================================================================
Omnibus:                        9.651   Durbin-Watson:                   0.474
Prob(Omnibus):                  0.008   Jarque-Bera (JB):                9.614
Skew:                           0.598   Prob(JB):                      0.00817
Kurtosis:                       3.414   Cond. No.                     1.26e+04
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
[2] The condition number is large, 1.26e+04. This might indicate that there are
strong multicollinearity or other numerical problems.
```

[548]:
```
cme.lin_reg_rob(AFTER_OB_UZ_STATS, 'ndfpr', 'M')
```

```
                    Robust linear Model Regression Results
==============================================================================
Dep. Variable:                      M   No. Observations:                  144
Model:                            RLM   Df Residuals:                      142
Method:                          IRLS   Df Model:                            1
Norm:                          HuberT
Scale Est.:                       mad
Cov Type:                          H1
Date:                Wed, 09 Oct 2019
Time:                        15:07:03
No. Iterations:                     6
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
const       2055.0456    563.346      3.648      0.000     950.908    3159.184
ndfpr          3.1546      0.127     24.931      0.000       2.907       3.403
==============================================================================

If the model instance has been used for another fit with different fit
parameters, then the fit options might not be the correct ones anymore .
```

[549]:
```
cme.regr_plot(PRIOR_OB_UZ_STATS, 'M', 'Volume',\
    'Volume (y) x Number of Trades (x) : '+CURR)
```

[550]:
```
cme.regr_plot(PRIOR_OB_UZ_STATS, 'M', 'Volume',\
    'Volume (y) x Number of Trades (x) : '+CURR, True)
```

[551]:
```
cme.lin_reg(PRIOR_OB_UZ_STATS, 'M', 'Volume')
```

OLS Regression Results

Dep. Variable:	Volume	R-squared:	0.942
Model:	OLS	Adj. R-squared:	0.941
Method:	Least Squares	F-statistic:	2136.
Date:	Wed, 09 Oct 2019	Prob (F-statistic):	2.21e-83
Time:	15:07:06	Log-Likelihood:	-1297.1
No. Observations:	134	AIC:	2598.
Df Residuals:	132	BIC:	2604.
Df Model:	1		
Covariance Type:	nonrobust		

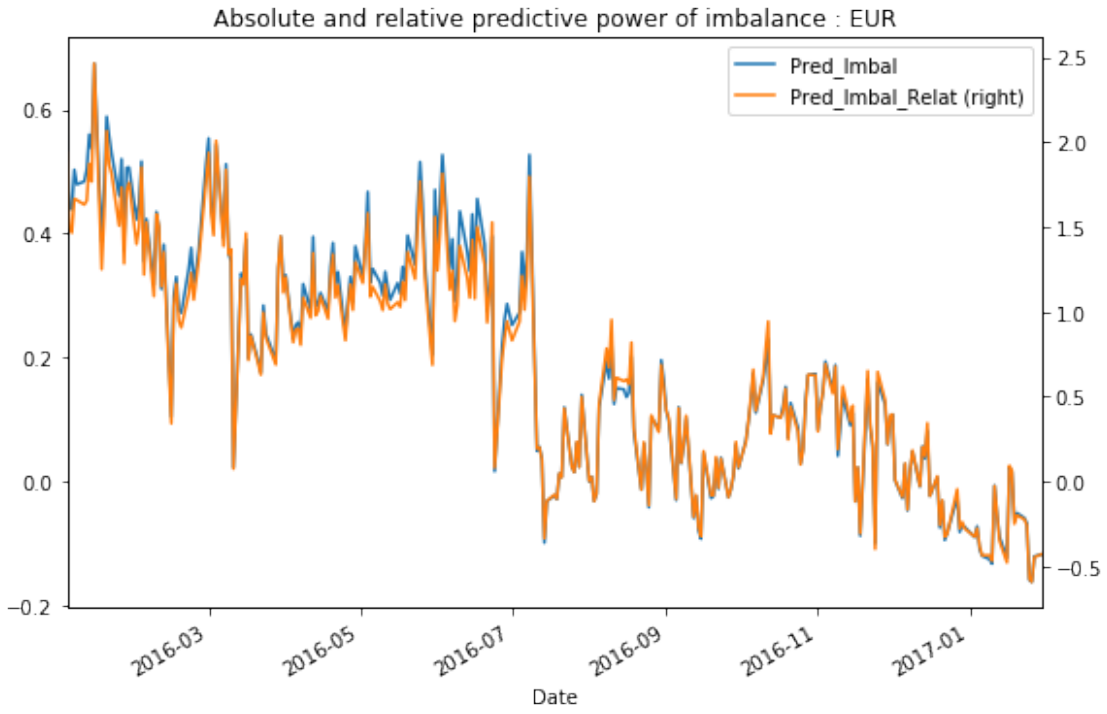
	coef	std err	t	P>|t|	[0.025	0.975]

```
const       -598.8128   1088.045     -0.550      0.583   -2751.073    1553.447
M              3.4639      0.075     46.213      0.000       3.316       3.612
==============================================================================
Omnibus:                        5.565   Durbin-Watson:                   1.202
Prob(Omnibus):                  0.062   Jarque-Bera (JB):                6.143
Skew:                          -0.281   Prob(JB):                       0.0463
Kurtosis:                       3.886   Cond. No.                     4.69e+04
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
[2] The condition number is large, 4.69e+04. This might indicate that there are
strong multicollinearity or other numerical problems.
```

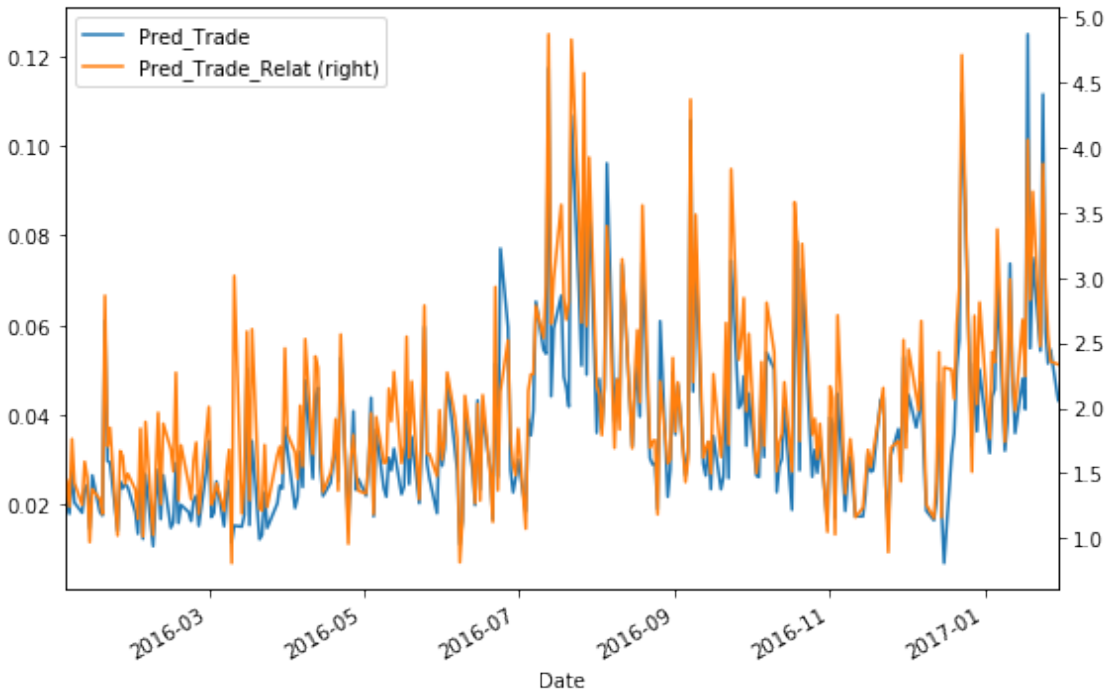
[552]:
```
cme.lin_reg_rob(PRIOR_OB_UZ_STATS, 'M', 'Volume')
```

```
                    Robust linear Model Regression Results
==============================================================================
Dep. Variable:                 Volume   No. Observations:                  134
Model:                            RLM   Df Residuals:                      132
Method:                          IRLS   Df Model:                            1
Norm:                          HuberT
Scale Est.:                       mad
Cov Type:                          H1
Date:                Wed, 09 Oct 2019
Time:                        15:07:06
No. Iterations:                     6
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
const       -706.6667   1017.503     -0.695      0.487   -2700.935    1287.602
M              3.4808      0.070     49.657      0.000       3.343       3.618
==============================================================================

If the model instance has been used for another fit with different fit
parameters, then the fit options might not be the correct ones anymore .
```

[553]:
```
IMBAL_STATS_TS.drop(columns=['eta1']).plot(secondary_y=['Pred_Imbal_Relat'],\
    figsize=(9,6), title='Absolute and relative predictive power of imbalance :␣
↪EUR');
```

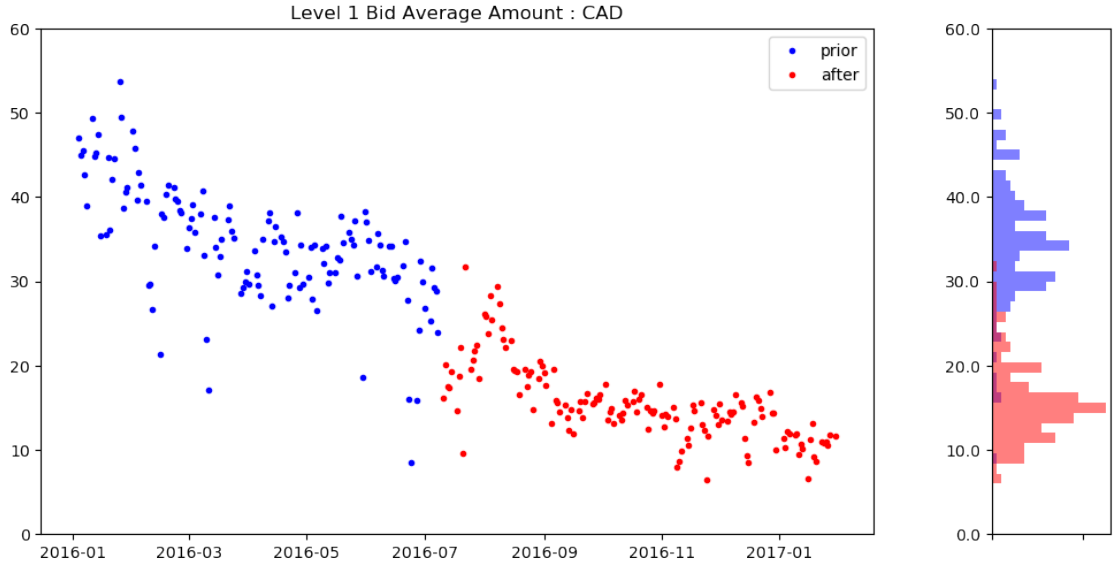


[554]:
```
TRADE_STATS_TS.plot(secondary_y=['Pred_Trade_Relat'], figsize=(9,6));
```

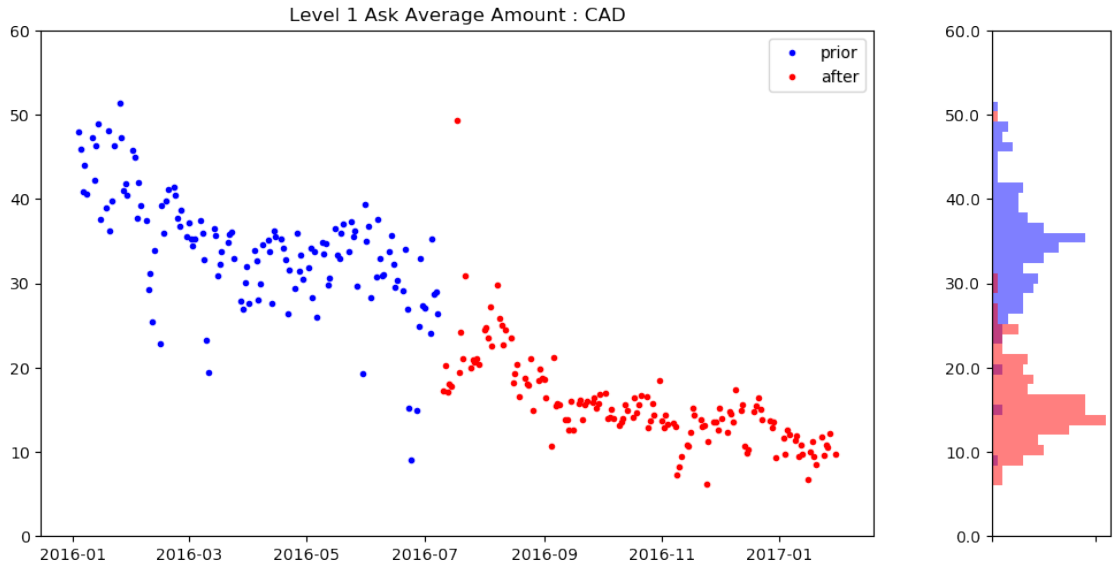


[555]:
```
OB_UZ_STATS_SPREADS = cme.spread_stats(OB_UZ_STATS)
```

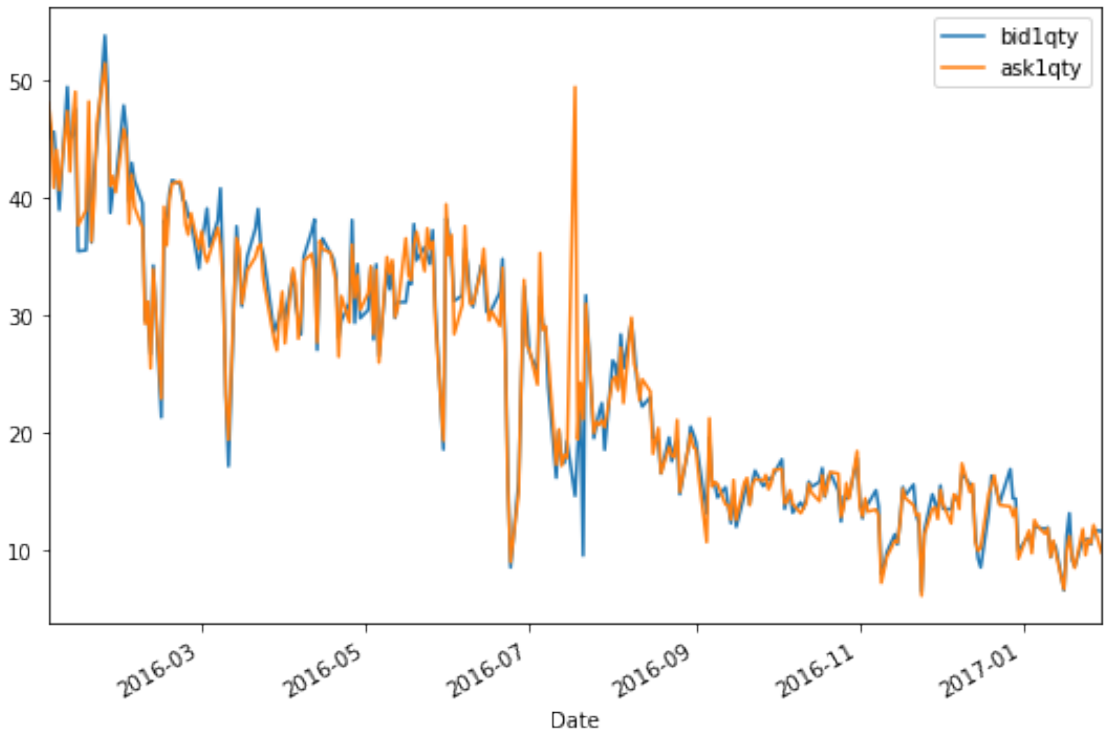
[605]:
```
cme.time_series_hist_plot(OB_UZ_STATS_SPREADS, 'bid1qty',\
    'Level 1 Bid Average Amount : '+CURR, 0, 60, 50)
```



[606]:
```
cme.time_series_hist_plot(OB_UZ_STATS_SPREADS, 'ask1qty',\
    'Level 1 Ask Average Amount : '+CURR, 0, 60, 50)
```



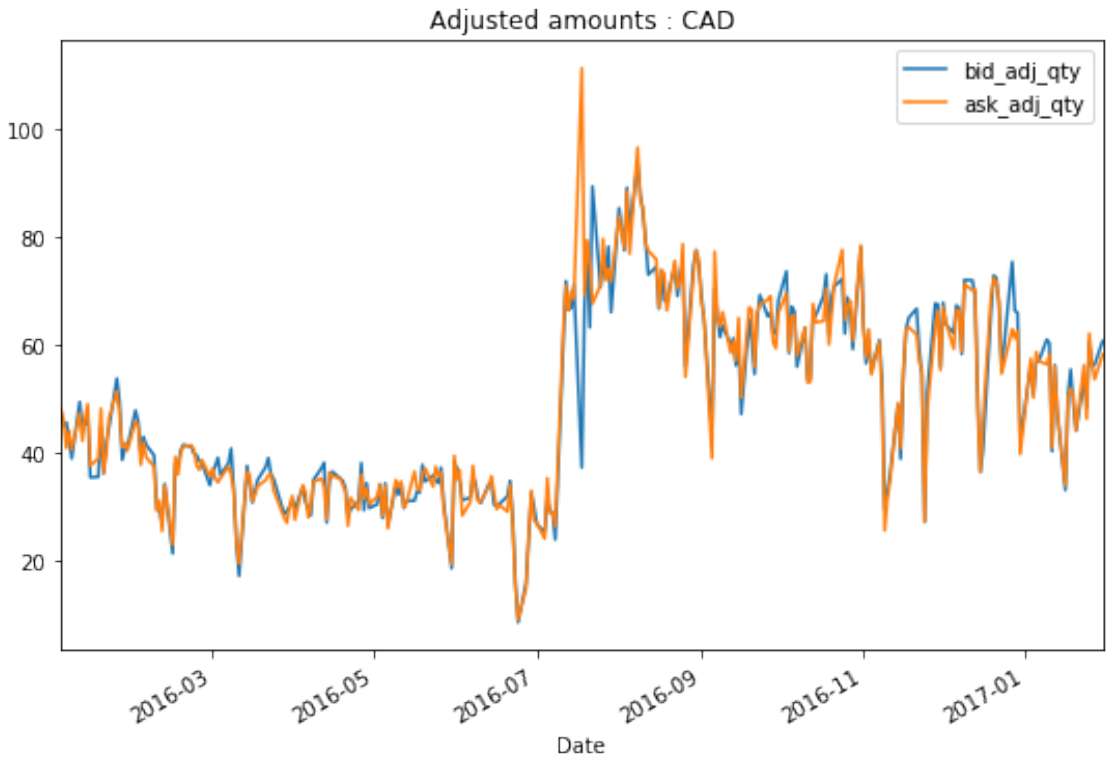
[558]:
```
OB_UZ_STATS_SPREADS[['bid1qty', 'ask1qty']].plot(figsize=(9,6));
```



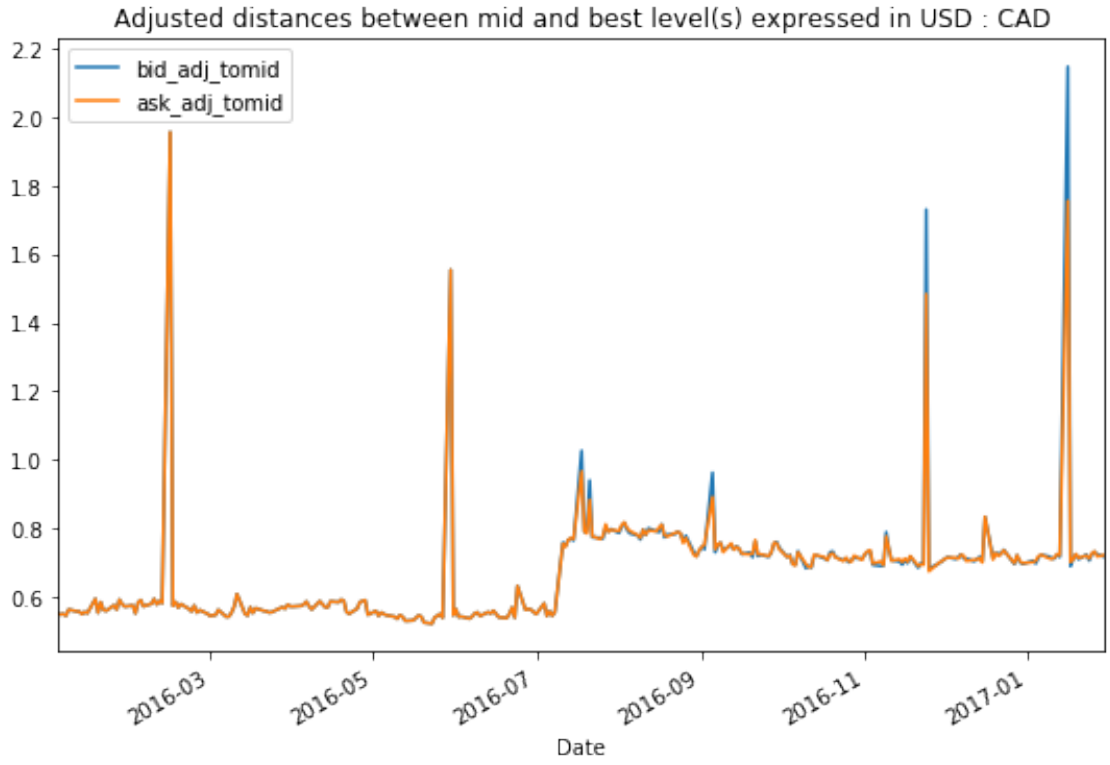
[559]:
```
OB_UZ_STATS_SPREADS[OB_UZ_STATS_SPREADS['Status'] == 'prior'][['bid1qty',␣
↪'ask1qty']].mean()/\
   OB_UZ_STATS_SPREADS[OB_UZ_STATS_SPREADS['Status'] == 'after'][['bid1qty',␣
↪'ask1qty']].mean()
```

[559]:
```
bid1qty    2.215393
ask1qty    2.182991
dtype: float64
```

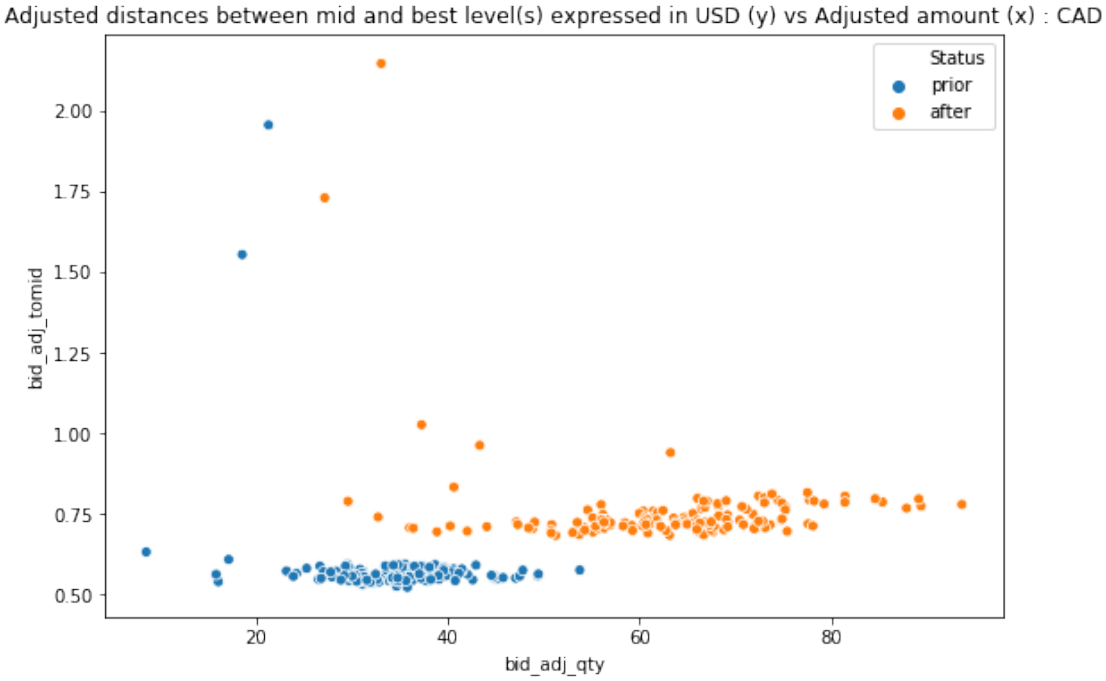
[560]:
```
OB_UZ_STATS_SPREADS[['bid_adj_qty', 'ask_adj_qty']].plot(figsize=(9,6),\
    title='Adjusted amounts : '+CURR);
```



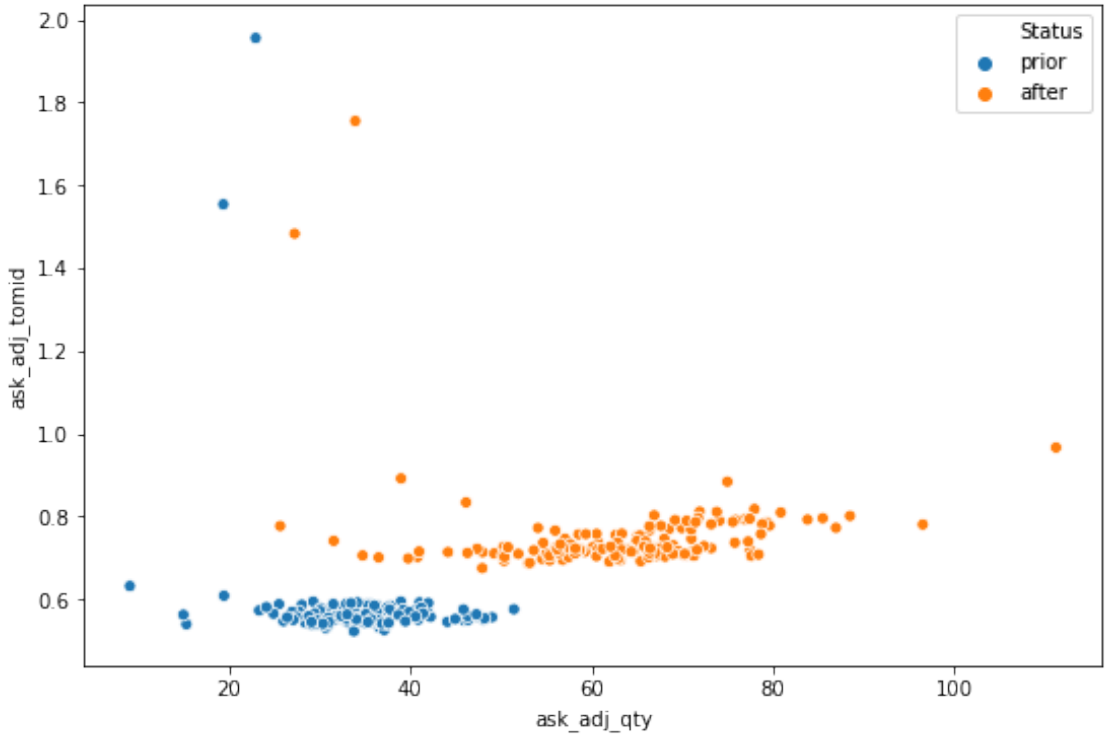
[561]:
```
OB_UZ_STATS_SPREADS[['bid_adj_tomid', 'ask_adj_tomid']].plot(figsize=(9,6),\
    title='Adjusted distances between mid and best level(s) expressed in USD :␣
↪'+CURR);
```



[562]:
```
plt.figure(figsize=(9, 6))
sns.scatterplot(x='bid_adj_qty', y='bid_adj_tomid',\
                hue='Status', data=OB_UZ_STATS_SPREADS);
plt.title('Adjusted distances between mid and best level(s) expressed in USD␣
 ↪(y) vs Adjusted amount (x) : '+CURR);
```



[563]:
```
plt.figure(figsize=(9, 6))
sns.scatterplot(x='ask_adj_qty', y='ask_adj_tomid',\
                hue='Status', data=OB_UZ_STATS_SPREADS);
```



2.8.1 Costs

[564]:
```
PRIOR_MEAN_COST = cme.cost_mean(PRIOR_COST_STATS, 100)
```

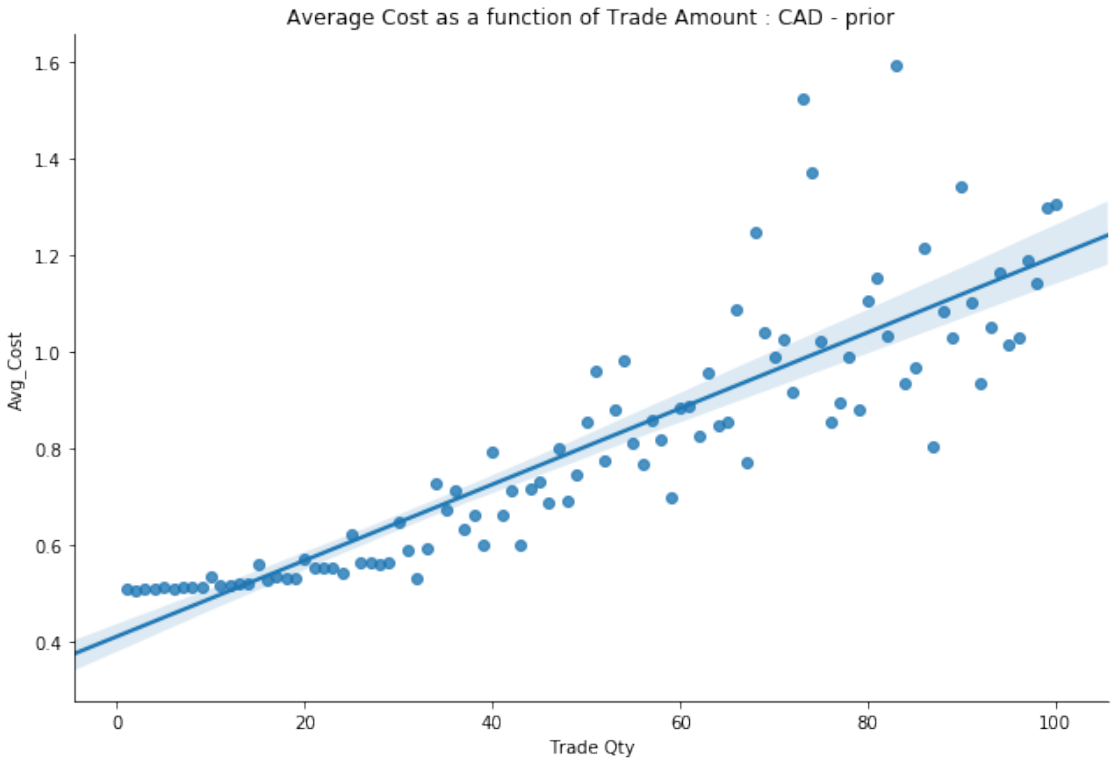
[565]:
```
PRIOR_MEAN_COST['Status'] = 'prior'
```

[566]:
```
AFTER_MEAN_COST = cme.cost_mean(AFTER_COST_STATS, 100)
```

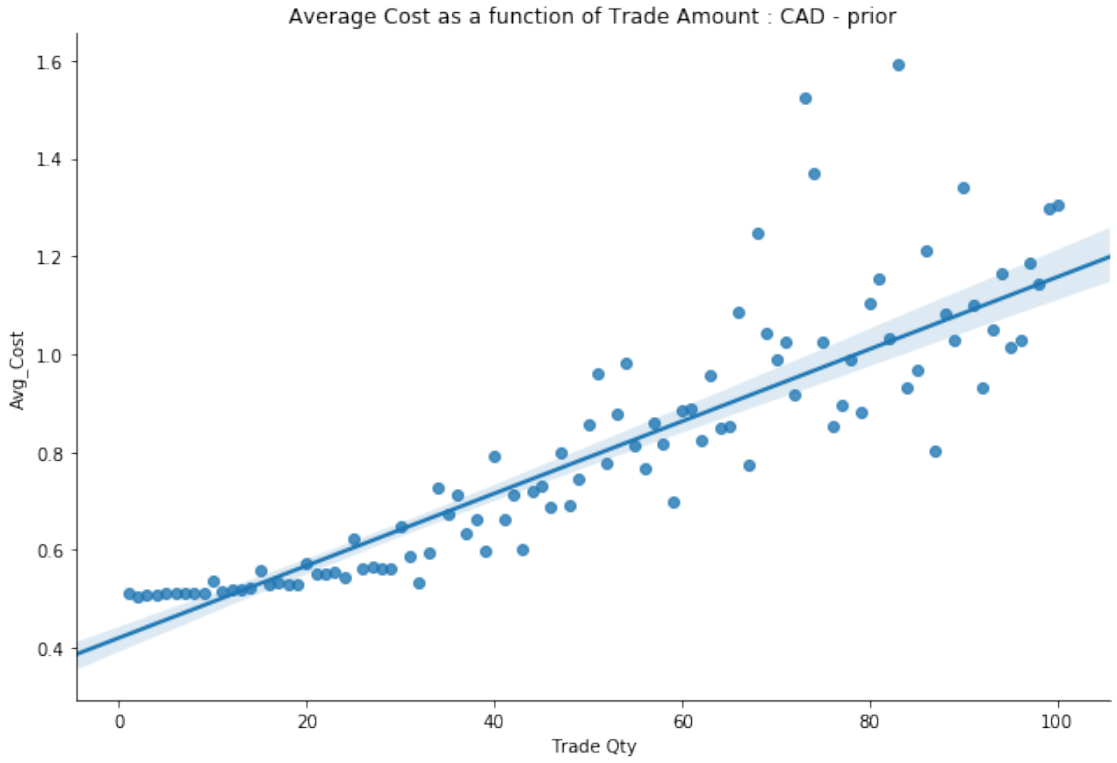
[567]:
```
AFTER_MEAN_COST['Status'] = 'after'
```

[568]:
```
MEAN_COST_STATS = pd.concat([PRIOR_MEAN_COST, AFTER_MEAN_COST], sort=False)
```

[569]:
```
sns.lmplot(x='Trade Qty', y='Avg_Cost', data=PRIOR_MEAN_COST.reset_index(),\
           height=6, aspect=1.5);
plt.title('Average Cost as a function of Trade Amount : '+CURR+' - prior');
```



[570]:
```
sns.lmplot(x='Trade Qty', y='Avg_Cost', data=PRIOR_MEAN_COST.reset_index(),\
           height=6, aspect=1.5, robust=True);
plt.title('Average Cost as a function of Trade Amount : '+CURR+' - prior');
```



[571]:
```
cme.lin_reg(cme.cost_mean(PRIOR_COST_STATS, 50).reset_index(), 'Trade Qty',␣
↪'Avg_Cost')
```

OLS Regression Results

Dep. Variable:	Avg_Cost	R-squared:	0.751
Model:	OLS	Adj. R-squared:	0.745
Method:	Least Squares	F-statistic:	144.5
Date:	Wed, 09 Oct 2019	Prob (F-statistic):	4.37e-16
Time:	15:07:16	Log-Likelihood:	83.666
No. Observations:	50	AIC:	-163.3
Df Residuals:	48	BIC:	-159.5
Df Model:	1		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	0.4591	0.013	34.507	0.000	0.432	0.486
Trade Qty	0.0055	0.000	12.022	0.000	0.005	0.006

Omnibus:	3.518	Durbin-Watson:	1.825
Prob(Omnibus):	0.172	Jarque-Bera (JB):	2.452
Skew:	0.434	Prob(JB):	0.293

```
Kurtosis:                       3.652   Cond. No.                         59.5
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
```

[572]:
```
cme.lin_reg_rob(cme.cost_mean(PRIOR_COST_STATS, 50).reset_index(), 'Trade Qty',␣
↪'Avg_Cost')
```

```
                    Robust linear Model Regression Results
==============================================================================
Dep. Variable:               Avg_Cost   No. Observations:                   50
Model:                            RLM   Df Residuals:                       48
Method:                          IRLS   Df Model:                            1
Norm:                          HuberT
Scale Est.:                       mad
Cov Type:                          H1
Date:                Wed, 09 Oct 2019
Time:                        15:07:16
No. Iterations:                    10
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
const          0.4641      0.012     40.135      0.000       0.441       0.487
Trade Qty      0.0052      0.000     13.053      0.000       0.004       0.006
==============================================================================

If the model instance has been used for another fit with different fit
parameters, then the fit options might not be the correct ones anymore .
```

[573]:
```
cme.lin_reg(cme.cost_mean(PRIOR_COST_STATS, 100).reset_index(), 'Trade Qty',␣
↪'Avg_Cost')
```

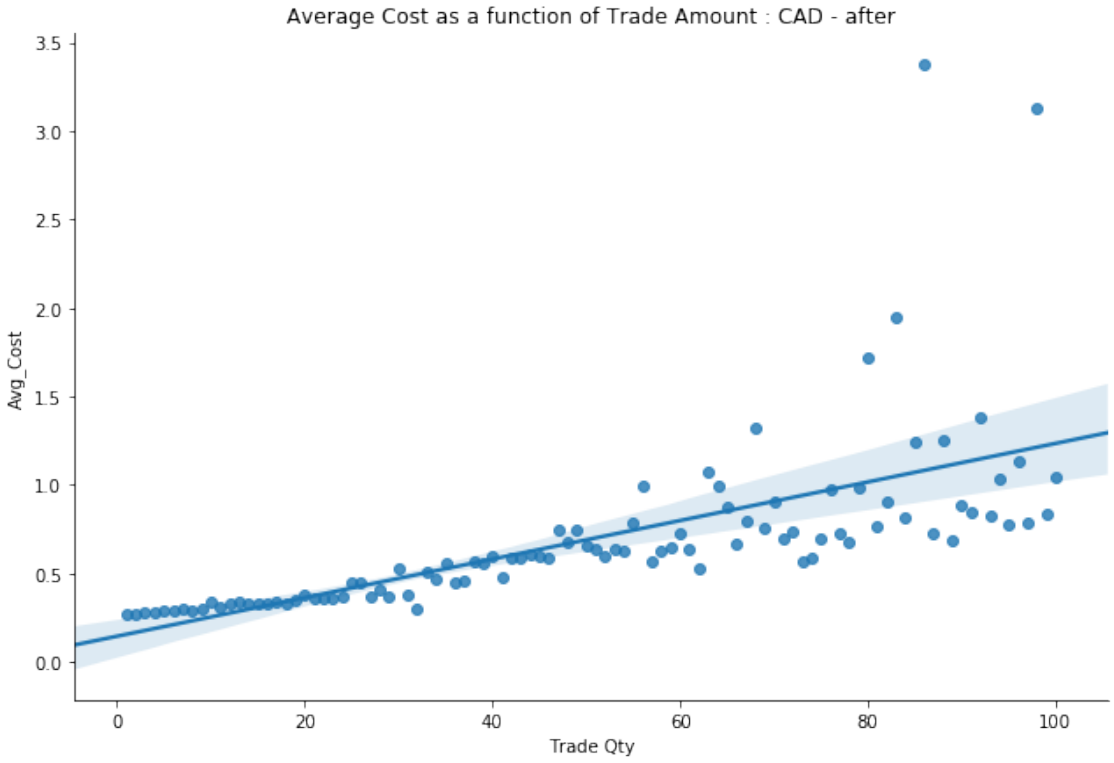
```
                            OLS Regression Results
==============================================================================
Dep. Variable:               Avg_Cost   R-squared:                       0.771
Model:                            OLS   Adj. R-squared:                  0.768
Method:                 Least Squares   F-statistic:                     329.1
Date:                Wed, 09 Oct 2019   Prob (F-statistic):           4.33e-33
Time:                        15:07:16   Log-Likelihood:                 67.028
No. Observations:                 100   AIC:                            -130.1
Df Residuals:                      98   BIC:                            -124.8
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
```

```
const          0.4114      0.025     16.327      0.000       0.361       0.461
Trade Qty      0.0079      0.000     18.140      0.000       0.007       0.009
==============================================================================
Omnibus:                       53.500   Durbin-Watson:                   1.816
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              203.950
Skew:                           1.796   Prob(JB):                     5.16e-45
Kurtosis:                       9.004   Cond. No.                         117.
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
```

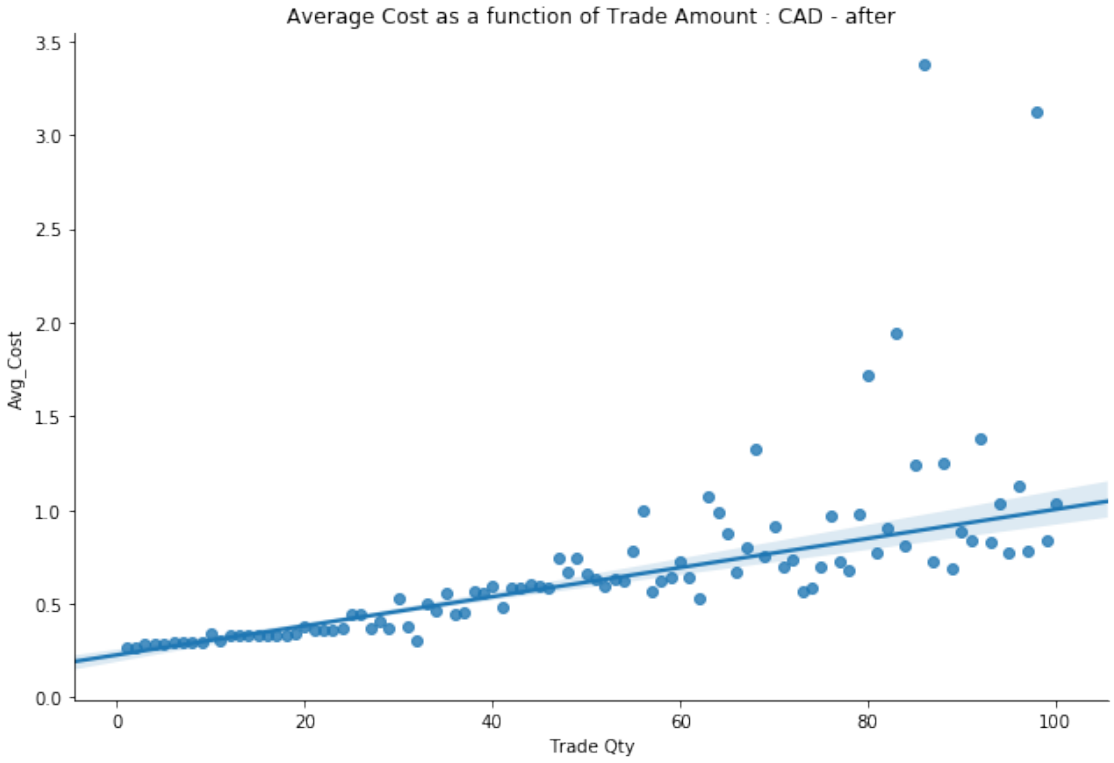
[574]:
```
cme.lin_reg_rob(cme.cost_mean(PRIOR_COST_STATS, 100).reset_index(), 'Trade␣
↪Qty', 'Avg_Cost')
```

```
                    Robust linear Model Regression Results
==============================================================================
Dep. Variable:                Avg_Cost   No. Observations:                  100
Model:                            RLM   Df Residuals:                       98
Method:                          IRLS   Df Model:                            1
Norm:                          HuberT
Scale Est.:                       mad
Cov Type:                          H1
Date:                Wed, 09 Oct 2019
Time:                        15:07:16
No. Iterations:                    26
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
const          0.4203      0.018     23.545      0.000       0.385       0.455
Trade Qty      0.0074      0.000     24.030      0.000       0.007       0.008
==============================================================================

If the model instance has been used for another fit with different fit
parameters, then the fit options might not be the correct ones anymore .
```

[575]:
```
sns.lmplot(x='Trade Qty', y='Avg_Cost', data=AFTER_MEAN_COST.reset_index(),\
           height=6, aspect=1.5);
plt.title('Average Cost as a function of Trade Amount : '+CURR+' - after');
```



[576]:
```
sns.lmplot(x='Trade Qty', y='Avg_Cost', data=AFTER_MEAN_COST.reset_index(),\
           height=6, aspect=1.5, robust=True);
plt.title('Average Cost as a function of Trade Amount : '+CURR+' - after');
```



[577]:
```
cme.lin_reg(cme.cost_mean(AFTER_COST_STATS, 50).reset_index(), 'Trade Qty',␣
↪'Avg_Cost')
```

OLS Regression Results

Dep. Variable:	Avg_Cost	R-squared:	0.835
Model:	OLS	Adj. R-squared:	0.832
Method:	Least Squares	F-statistic:	243.6
Date:	Wed, 09 Oct 2019	Prob (F-statistic):	1.96e-20
Time:	15:07:26	Log-Likelihood:	75.407
No. Observations:	50	AIC:	-146.8
Df Residuals:	48	BIC:	-143.0
Df Model:	1		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	0.2134	0.016	13.601	0.000	0.182	0.245
Trade Qty	0.0084	0.001	15.607	0.000	0.007	0.009

Omnibus:	6.653	Durbin-Watson:	1.490
Prob(Omnibus):	0.036	Jarque-Bera (JB):	7.265
Skew:	-0.453	Prob(JB):	0.0264

```
Kurtosis:                       4.633   Cond. No.                         59.5
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
```

[578]:
```
cme.lin_reg_rob(cme.cost_mean(AFTER_COST_STATS, 50).reset_index(), 'Trade Qty',␣
↪'Avg_Cost')
```

```
                    Robust linear Model Regression Results
==============================================================================
Dep. Variable:               Avg_Cost   No. Observations:                   50
Model:                            RLM   Df Residuals:                       48
Method:                          IRLS   Df Model:                            1
Norm:                          HuberT
Scale Est.:                       mad
Cov Type:                          H1
Date:                Wed, 09 Oct 2019
Time:                        15:07:26
No. Iterations:                    18
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
const          0.2193      0.014     15.233      0.000       0.191       0.248
Trade Qty      0.0082      0.000     16.665      0.000       0.007       0.009
==============================================================================

If the model instance has been used for another fit with different fit
parameters, then the fit options might not be the correct ones anymore .
```

[579]:
```
cme.lin_reg(cme.cost_mean(AFTER_COST_STATS, 100).reset_index(), 'Trade Qty',␣
↪'Avg_Cost')
```

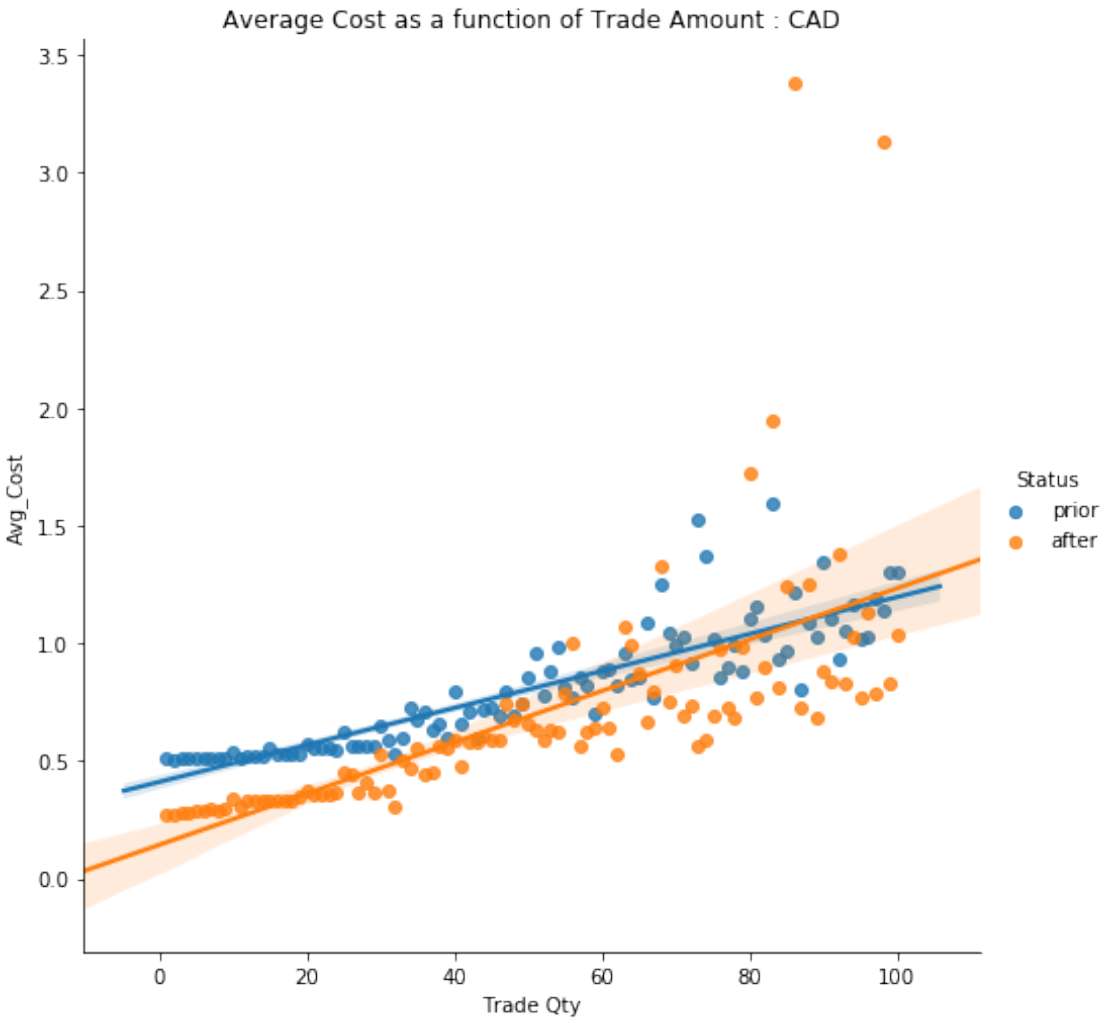
```
                            OLS Regression Results
==============================================================================
Dep. Variable:               Avg_Cost   R-squared:                       0.431
Model:                            OLS   Adj. R-squared:                  0.425
Method:                 Least Squares   F-statistic:                     74.20
Date:                Wed, 09 Oct 2019   Prob (F-statistic):           1.22e-13
Time:                        15:07:26   Log-Likelihood:                -40.198
No. Observations:                 100   AIC:                             84.40
Df Residuals:                      98   BIC:                             89.61
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
```

```
const          0.1439      0.074      1.955      0.053      -0.002       0.290
Trade Qty      0.0109      0.001      8.614      0.000       0.008       0.013
==============================================================================
Omnibus:                      121.193   Durbin-Watson:                   2.281
Prob(Omnibus):                  0.000   Jarque-Bera (JB):             2284.655
Skew:                           4.162   Prob(JB):                         0.00
Kurtosis:                      24.887   Cond. No.                         117.
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
```

[580]:
```
cme.lin_reg_rob(cme.cost_mean(AFTER_COST_STATS, 100).reset_index(), 'Trade␣
↪Qty', 'Avg_Cost')
```

```
                    Robust linear Model Regression Results
==============================================================================
Dep. Variable:                Avg_Cost   No. Observations:                  100
Model:                            RLM   Df Residuals:                       98
Method:                          IRLS   Df Model:                            1
Norm:                          HuberT
Scale Est.:                       mad
Cov Type:                          H1
Date:                Wed, 09 Oct 2019
Time:                        15:07:26
No. Iterations:                    26
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
const          0.2274      0.021     10.797      0.000       0.186       0.269
Trade Qty      0.0078      0.000     21.444      0.000       0.007       0.008
==============================================================================

If the model instance has been used for another fit with different fit
parameters, then the fit options might not be the correct ones anymore .
```

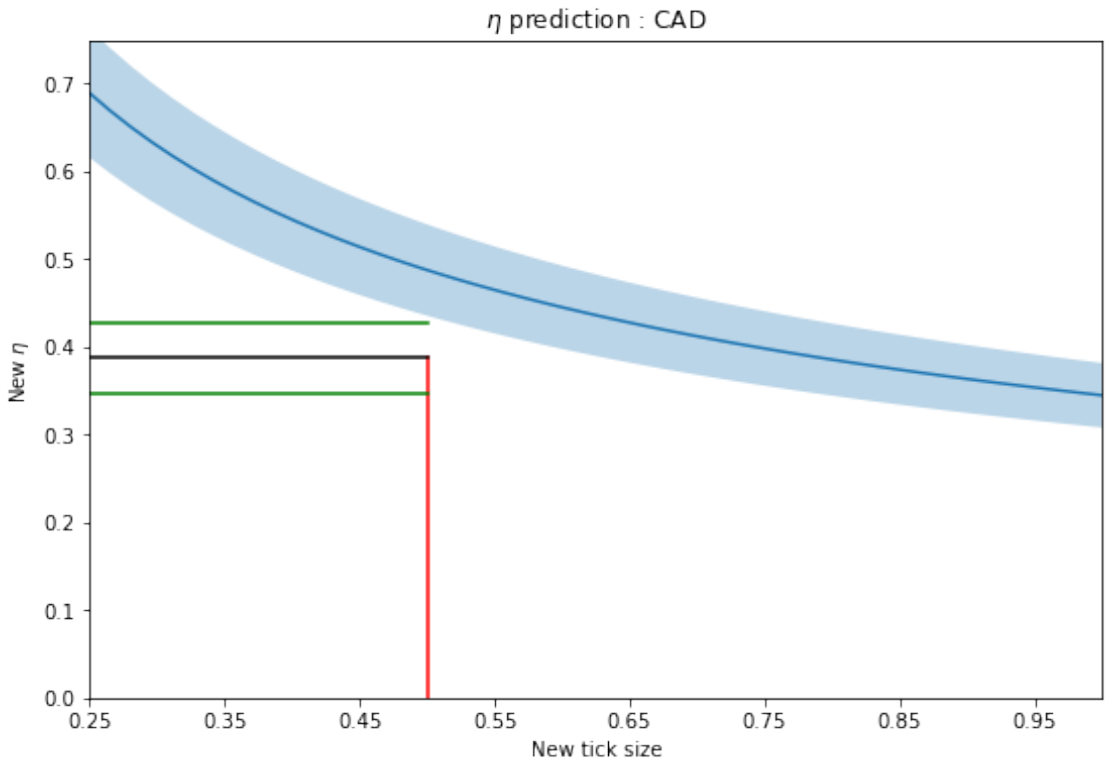
[581]:
```
cme.regr_plot(MEAN_COST_STATS.reset_index(), 'Trade Qty', 'Avg_Cost',\
    'Average Cost as a function of Trade Amount : '+CURR)
```



[582]:
```
cme.regr_plot(MEAN_COST_STATS.reset_index(), 'Trade Qty', 'Avg_Cost',\
    'Average Cost as a function of Trade Amount : '+CURR, True)
```

2.9 Eta prediction

[583]:
```
cme.plot_eta(TICK_PRIOR, TICK_AFTER,\
    TABLE_MATHIEU.loc['prior']['eta1'], TABLE_MATHIEU.loc['after']['eta1'],\
    TABLE_MATHIEU_ERR.loc['prior']['eta1'], TABLE_MATHIEU_ERR.
↪loc['after']['eta1'],\
    CURR)
```


η prediction : CAD
New η
New tick size
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.25
0.35
0.45
0.55
0.65
0.75
0.85
0.95

[ ]: