CME_Tick_Changes_EUR

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

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

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

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

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

2.7 File paths and initial values

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

```
[6]: CURR = 'EUR'
```

```
[7]: 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
```

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

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

```
[10]: PRIOR_CDATES_LIST = [['6EU5', '20150615'], ['6EU5', '20150616'], ['6EU5',
      ↪'20150617'],\
          ['6EU5', '20150618'], ['6EU5', '20150619'], ['6EU5', '20150622'], ['6EU5',
      ↪'20150623'],\
          ['6EU5', '20150624'], ['6EU5', '20150625'], ['6EU5', '20150626'], ['6EU5',
      ↪'20150629'],\
          ['6EU5', '20150630'], ['6EU5', '20150701'], ['6EU5', '20150702'], ['6EU5',
      ↪'20150703'],\
          ['6EU5', '20150706'], ['6EU5', '20150707'], ['6EU5', '20150708'], ['6EU5',
      ↪'20150709'],\
          ['6EU5', '20150710'], ['6EU5', '20150713'], ['6EU5', '20150714'], ['6EU5',
      ↪'20150715'],\
          ['6EU5', '20150716'], ['6EU5', '20150717'], ['6EU5', '20150720'], ['6EU5',
      ↪'20150721'],\
          ['6EU5', '20150722'], ['6EU5', '20150723'], ['6EU5', '20150724'], ['6EU5',
      ↪'20150727'],\
          ['6EU5', '20150728'], ['6EU5', '20150729'], ['6EU5', '20150730'], ['6EU5',
      ↪'20150731'],\
          ['6EU5', '20150803'], ['6EU5', '20150804'], ['6EU5', '20150805'], ['6EU5',
      ↪'20150806'],\
          ['6EU5', '20150807'], ['6EU5', '20150810'], ['6EU5', '20150811'], ['6EU5',
      ↪'20150812'],\
          ['6EU5', '20150813'], ['6EU5', '20150814'], ['6EU5', '20150817'], ['6EU5',
      ↪'20150818'],\
          ['6EU5', '20150819'], ['6EU5', '20150820'], ['6EU5', '20150821'], ['6EU5',
      ↪'20150824'],\
          ['6EU5', '20150825'], ['6EU5', '20150826'], ['6EU5', '20150827'], ['6EU5',
      ↪'20150828'],\
          ['6EU5', '20150831'], ['6EU5', '20150901'], ['6EU5', '20150902'], ['6EU5',
      ↪'20150903'],\
          ['6EU5', '20150904'], ['6EU5', '20150907'], ['6EU5', '20150908'], ['6EU5',
      ↪'20150909'],\
```

```
    ['6EU5', '20150910'], ['6EU5', '20150911'], ['6EZ5', '20150914'], ['6EZ5',␣
↪'20150915'],\
    ['6EZ5', '20150916'], ['6EZ5', '20150917'], ['6EZ5', '20150918'], ['6EZ5',␣
↪'20150921'],\
    ['6EZ5', '20150922'], ['6EZ5', '20150923'], ['6EZ5', '20150924'], ['6EZ5',␣
↪'20150925'],\
    ['6EZ5', '20150928'], ['6EZ5', '20150929'], ['6EZ5', '20150930'], ['6EZ5',␣
↪'20151001'],\
    ['6EZ5', '20151002'], ['6EZ5', '20151005'], ['6EZ5', '20151006'], ['6EZ5',␣
↪'20151007'],\
    ['6EZ5', '20151008'], ['6EZ5', '20151009'], ['6EZ5', '20151012'], ['6EZ5',␣
↪'20151013'],\
    ['6EZ5', '20151014'], ['6EZ5', '20151015'], ['6EZ5', '20151016'], ['6EZ5',␣
↪'20151019'],\
    ['6EZ5', '20151020'], ['6EZ5', '20151021'], ['6EZ5', '20151022'], ['6EZ5',␣
↪'20151023'],\
    ['6EZ5', '20151026'], ['6EZ5', '20151027'], ['6EZ5', '20151028'], ['6EZ5',␣
↪'20151029'],\
    ['6EZ5', '20151030'], ['6EZ5', '20151102'], ['6EZ5', '20151103'], ['6EZ5',␣
↪'20151104'],\
    ['6EZ5', '20151105'], ['6EZ5', '20151106'], ['6EZ5', '20151109'], ['6EZ5',␣
↪'20151110'],\
    ['6EZ5', '20151111'], ['6EZ5', '20151112'], ['6EZ5', '20151113'], ['6EZ5',␣
↪'20151116'],\
    ['6EZ5', '20151117'], ['6EZ5', '20151118'], ['6EZ5', '20151119'], ['6EZ5',␣
↪'20151120'],\
    ['6EZ5', '20151123'], ['6EZ5', '20151124'], ['6EZ5', '20151125'], ['6EZ5',␣
↪'20151126'],\
    ['6EZ5', '20151127'], ['6EZ5', '20151130'], ['6EZ5', '20151201'], ['6EZ5',␣
↪'20151202'],\
    ['6EZ5', '20151203'], ['6EZ5', '20151204'], ['6EZ5', '20151207'], ['6EZ5',␣
↪'20151208'],\
    ['6EZ5', '20151209'], ['6EZ5', '20151210'], ['6EZ5', '20151211'], ['x6EH6',␣
↪'20151214'],\
    ['x6EH6', '20151215'], ['x6EH6', '20151216'], ['x6EH6', '20151217'],␣
↪['x6EH6', '20151218'],\
    ['x6EH6', '20151221'], ['x6EH6', '20151222'], ['x6EH6', '20151223'],␣
↪['x6EH6', '20160104'],\
    ['x6EH6', '20160105'], ['x6EH6', '20160106'], ['x6EH6', '20160107'],␣
↪['x6EH6', '20160108']]
```

[11]:
```
AFTER_CDATES_LIST = [['x6EH6', '20160111'], ['x6EH6', '20160112'], ['x6EH6',␣
↪'20160113'],\
    ['x6EH6', '20160114'], ['x6EH6', '20160115'], ['x6EH6', '20160118'],␣
↪['x6EH6', '20160119'],\
```

```
    ['x6EH6', '20160120'], ['x6EH6', '20160121'], ['x6EH6', '20160122'],␣
↪['x6EH6', '20160125'],\
    ['x6EH6', '20160126'], ['x6EH6', '20160127'], ['x6EH6', '20160128'],␣
↪['x6EH6', '20160129'],\
    ['x6EH6', '20160201'], ['x6EH6', '20160202'], ['x6EH6', '20160203'],␣
↪['x6EH6', '20160204'],\
    ['x6EH6', '20160205'], ['x6EH6', '20160208'], ['x6EH6', '20160209'],␣
↪['x6EH6', '20160210'],\
    ['x6EH6', '20160211'], ['x6EH6', '20160212'], ['x6EH6', '20160215'],␣
↪['x6EH6', '20160216'],\
    ['x6EH6', '20160217'], ['x6EH6', '20160218'], ['x6EH6', '20160219'],␣
↪['x6EH6', '20160222'],\
    ['x6EH6', '20160223'], ['x6EH6', '20160224'], ['x6EH6', '20160225'],␣
↪['x6EH6', '20160226'],\
    ['x6EH6', '20160229'], ['x6EH6', '20160301'], ['x6EH6', '20160302'],␣
↪['x6EH6', '20160303'],\
    ['x6EH6', '20160304'], ['x6EH6', '20160307'], ['x6EH6', '20160308'],␣
↪['x6EH6', '20160309'],\
    ['x6EH6', '20160310'], ['x6EH6', '20160311'], ['x6EM6', '20160314'],␣
↪['x6EM6', '20160315'],\
    ['x6EM6', '20160316'], ['x6EM6', '20160317'], ['x6EM6', '20160318'],␣
↪['x6EM6', '20160321'],\
    ['x6EM6', '20160322'], ['x6EM6', '20160323'], ['x6EM6', '20160324'],␣
↪['x6EM6', '20160328'],\
    ['x6EM6', '20160329'], ['x6EM6', '20160330'], ['x6EM6', '20160331'],␣
↪['x6EM6', '20160401'],\
    ['x6EM6', '20160404'], ['x6EM6', '20160405'], ['x6EM6', '20160406'],␣
↪['x6EM6', '20160407'],\
    ['x6EM6', '20160408'], ['x6EM6', '20160411'], ['x6EM6', '20160412'],␣
↪['x6EM6', '20160413'],\
    ['x6EM6', '20160414'], ['x6EM6', '20160415'], ['x6EM6', '20160418'],␣
↪['x6EM6', '20160419'],\
    ['x6EM6', '20160420'], ['x6EM6', '20160421'], ['x6EM6', '20160422'],␣
↪['x6EM6', '20160425'],\
    ['x6EM6', '20160426'], ['x6EM6', '20160427'], ['x6EM6', '20160428'],␣
↪['x6EM6', '20160429'],\
    ['x6EM6', '20160502'], ['x6EM6', '20160503'], ['x6EM6', '20160504'],␣
↪['x6EM6', '20160505'],\
    ['x6EM6', '20160506'], ['x6EM6', '20160509'], ['x6EM6', '20160510'],␣
↪['x6EM6', '20160511'],\
    ['x6EM6', '20160512'], ['x6EM6', '20160513'], ['x6EM6', '20160516'],␣
↪['x6EM6', '20160517'],\
    ['x6EM6', '20160518'], ['x6EM6', '20160519'], ['x6EM6', '20160520'],␣
↪['x6EM6', '20160523'],\
```

```
      ['x6EM6', '20160524'], ['x6EM6', '20160525'], ['x6EM6', '20160526'],␣
→['x6EM6', '20160527'],\
      ['x6EM6', '20160530'], ['x6EM6', '20160531'], ['x6EM6', '20160601'],␣
→['x6EM6', '20160602'],\
      ['x6EM6', '20160603'], ['x6EM6', '20160606'], ['x6EM6', '20160607'],␣
→['x6EM6', '20160608'],\
      ['x6EM6', '20160609'], ['x6EM6', '20160610']]
```

2.7.1 Processing files

Prior

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

```
[13]: #PRIOR_CDATES_LIST
```

```
[14]: 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)
```

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

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

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

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

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

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

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

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

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

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

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

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

After

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

```
[28]: #AFTER_CDATES_LIST
```

```
[29]: 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)
```

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

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

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

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

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

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

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

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

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

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

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

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

Join prior and after

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

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

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

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

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

2.7.2 Tables

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

```
[48]: TABLE_MATHIEU
```

```
[48]:         Tick    chgavg    ndfpr_pred         ndfpr            M        Volume  \
      Status
      prior    1.0   1.02512    6353.77629    5305.30769   29594.02797   123379.33566
      after    0.5   0.53695   13933.73475   10053.65138   34444.03670   103885.55046

                 eta1        S1   lambda1   twspr1   duration    dt_avg      rvxe  \
      Status
      prior    0.27275   0.98247   0.98211   1.0795    6.75133   6.98122   0.00502
      after    0.36391   0.91773   0.93818   1.3534    3.16392   3.70119   0.00425

                spot_avg
      Status
      prior   11059.29584
      after   11188.67375
```

```
[49]: TABLE_MATHIEU_ERR
```

```
[49]:         Tick    chgavg    ndfpr_pred         ndfpr            M        Volume  \
      Status
      prior    0.0   0.03354    5368.22395    3607.53098   16068.80052   58201.90060
      after    0.0   0.02919   12261.33823    6571.33754   17112.52426   49303.78367

                 eta1        S1   lambda1   twspr1   duration    dt_avg      rvxe  \
      Status
      prior    0.03484   0.01488   0.02151   0.05261    5.04906   3.58378   0.00184
```

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```
after     0.02859  0.04243  0.04083  0.12583    2.37358  1.97312  0.00166


          spot_avg
Status
prior     225.70542
after     193.86091
```

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

[50]:
	Trade_Bid	Imbal_Bid	Neutral	Imbal_Ask	Trade_Ask	Total Cols
Trade_Bid	1.24	1.45	0.37	0.11	0.00	3.17
Imbal_Bid	0.90	26.59	1.37	0.10	0.33	29.28
Neutral	0.70	1.04	31.73	1.05	0.69	35.20
Imbal_Ask	0.33	0.10	1.37	26.49	0.90	29.19
Trade_Ask	0.00	0.11	0.36	1.45	1.23	3.15
Total Rows	3.17	29.28	35.20	29.19	3.15	100.00

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

[51]:
	Trade_Bid	Imbal_Bid	Neutral	Imbal_Ask	Trade_Ask	Total Cols
Trade_Bid	0.06	1.00	0.50	0.13	0.00	1.70
Imbal_Bid	0.56	23.61	1.97	0.41	0.42	26.97
Neutral	0.66	1.82	38.40	1.79	0.65	43.32
Imbal_Ask	0.42	0.40	1.95	22.99	0.55	26.32
Trade_Ask	0.00	0.14	0.51	0.99	0.06	1.69
Total Rows	1.70	26.97	43.32	26.32	1.69	100.00

[52]:
```python
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);
```

	Trade_Bid	Imbal_Bid	Neutral	Imbal_Ask	Trade_Ask
	1.2	1.4	0.4	0.1	0.0
	0.9	26.6	1.4	0.1	0.3
	0.7	1.0	31.7	1.1	0.7
	0.3	0.1	1.4	26.5	0.9
	0.0	0.1	0.4	1.4	1.2
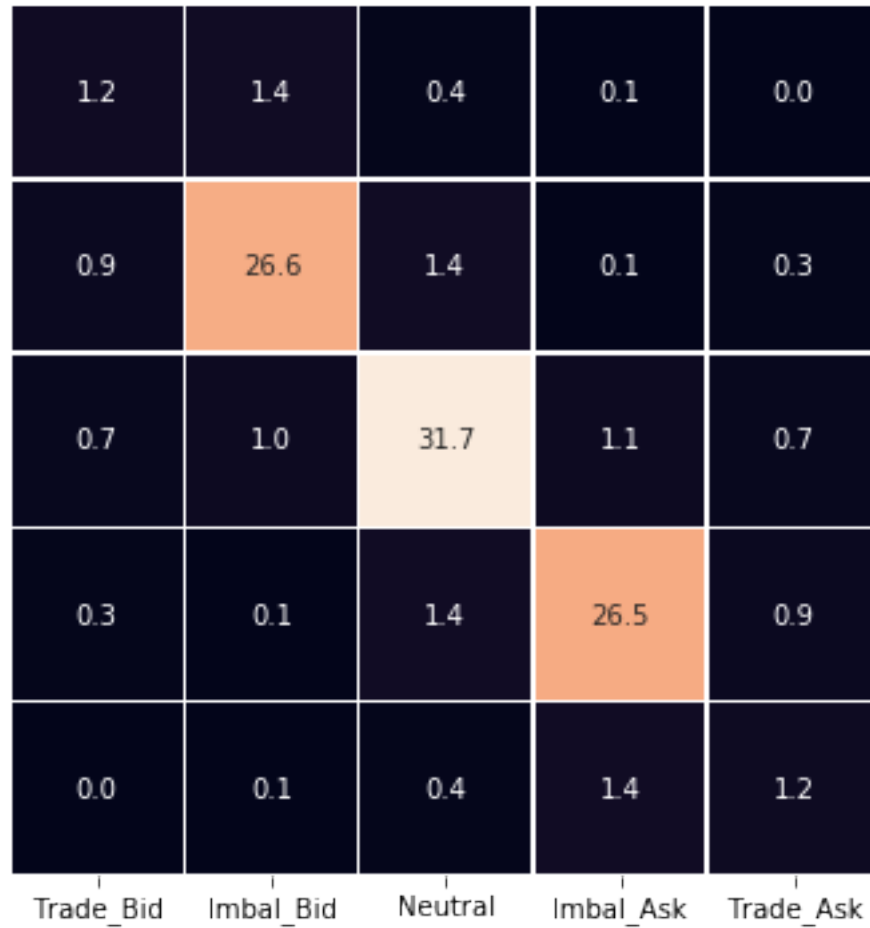
[53]: `cme.avg_perc_mat_2(PRIOR_DEPL_STATS, pd.to_datetime(PRIOR_CDATES['Date']))`

[53]:

	same				oppo				Total Cols
	D C	D T	D T+F	F	D C	D T	D T+F	F	
D C	0.02	0.02	0.09	21.20	0.01	0.01	1.96	0.59	23.90
D T	0.01	0.10	0.64	15.18	0.02	0.03	3.09	3.55	22.61
D T+F	0.01	0.02	0.22	4.85	0.01	0.01	1.06	0.89	7.07
F	14.06	6.60	0.00	0.08	9.76	15.83	0.00	0.09	46.42
Total Rows	14.10	6.74	0.95	41.30	9.80	15.87	6.12	5.12	100.00

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

[54]:

	same				oppo				Total Cols
	D C	D T	D T+F	F	D C	D T	D T+F	F	
D C	0.06	0.08	0.26	20.15	0.11	0.04	1.19	3.87	25.77
D T	0.07	0.30	0.58	12.18	0.17	0.11	2.29	6.16	21.87
D T+F	0.05	0.06	0.23	2.64	0.06	0.04	0.46	1.48	5.02
F	17.92	8.17	0.01	0.36	7.32	13.06	0.00	0.49	47.34

```
Total Rows   18.10   8.61   1.08   35.33   7.66   13.26   3.94   12.01        100.00
```

2.8 Charts and Regressions

```
[55]: 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);
```
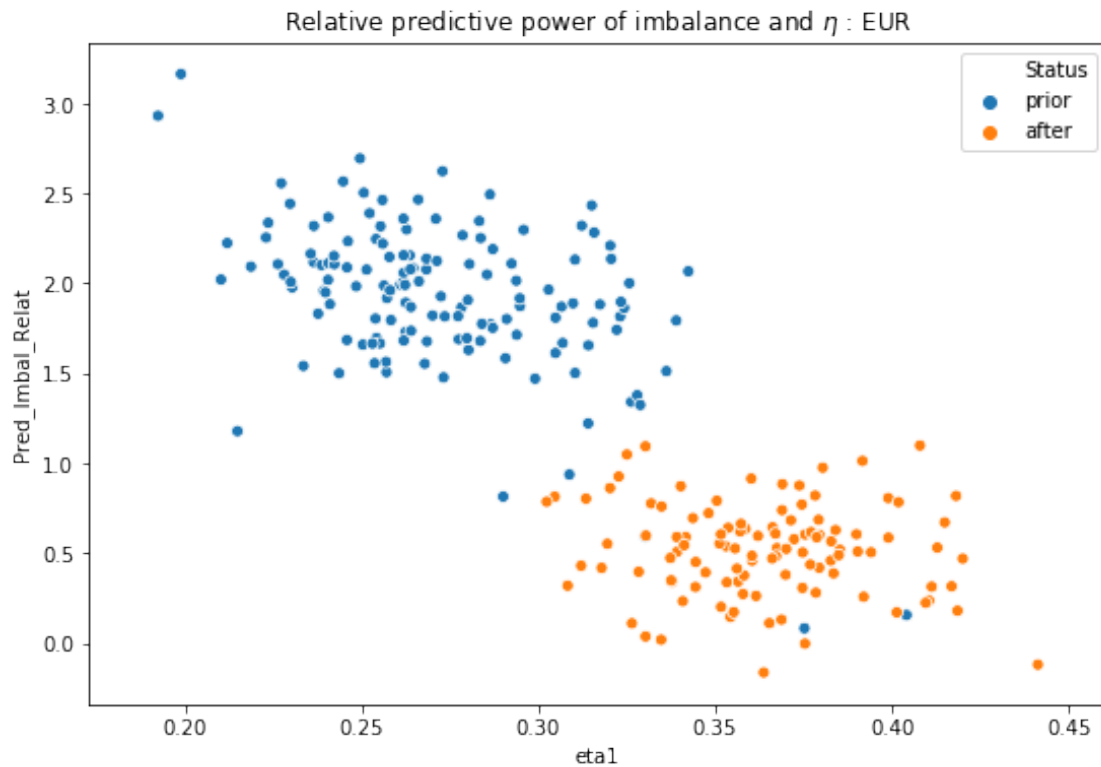


```
[56]: cme.time_series_hist_plot(IMBAL_STATS_TS, 'Pred_Imbal_Relat',\
          'Relative predictive power of imbalance : '+CURR, -1.0, 4.0, 50)
```

Relative predictive power of imbalance : EUR
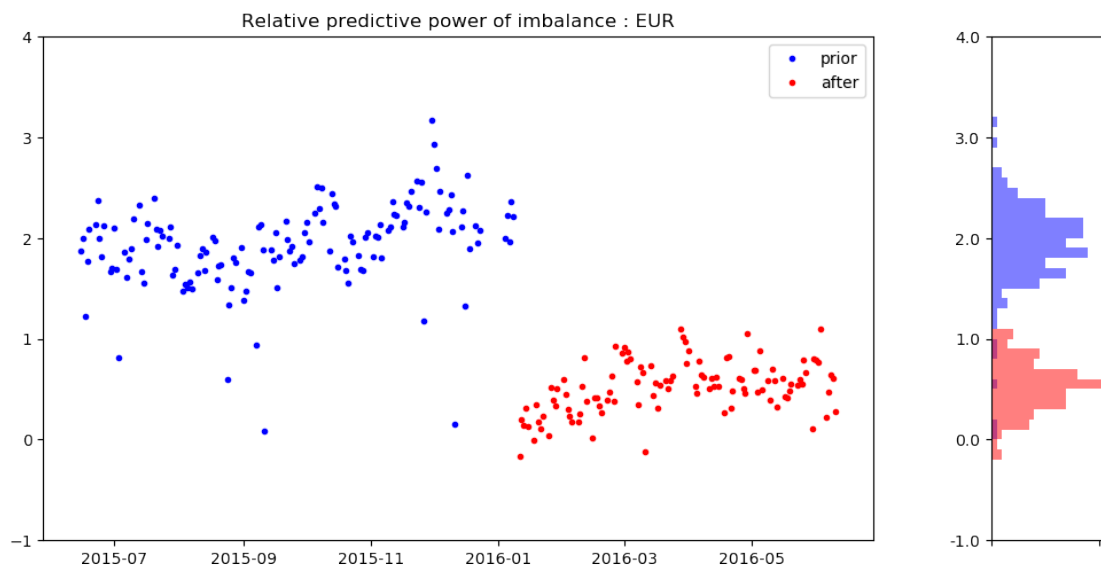
```
[57]: cme.time_series_hist_plot(ABSDEPL_STATS_TS, 'Depl_Cancel',\
      'Depl_Cancel : '+CURR, 0.0, 50000.0, 50)
```
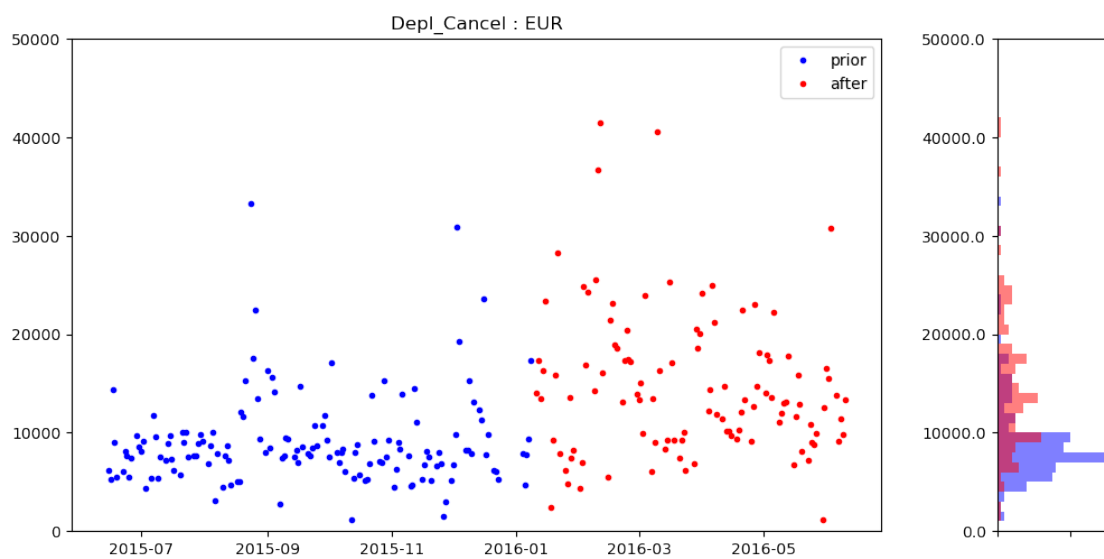

Depl_Cancel : EUR

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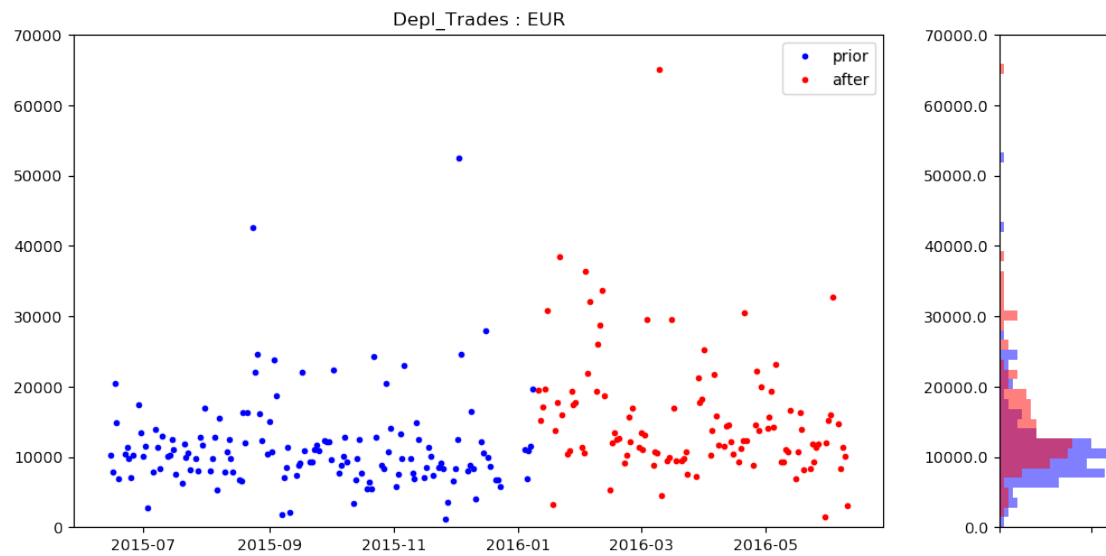
Depl_Trades : EUR

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

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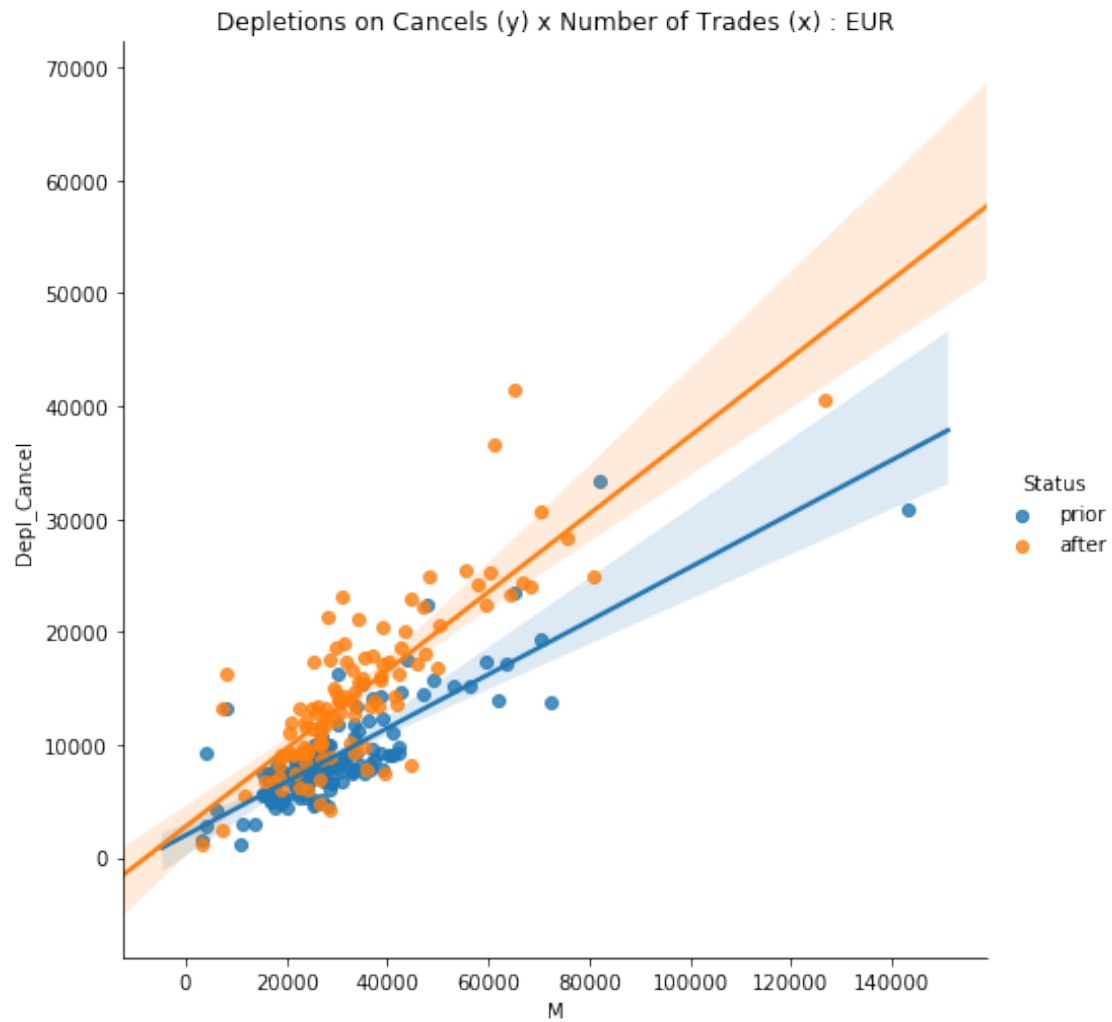
```
[60]: cme.regr_plot(ABSDEPL_STATS_TS, 'M', 'Depl_Trades',\
      'Depletions on Trades (y) x Number of Trades (x) : '+CURR)
```

Depletions on Trades (y) x Number of Trades (x) : EUR

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

                            OLS Regression Results
==
Dep. Variable: Depl_Cancel   R-squared: 0.615
Model: OLS   Adj. R-squared: 0.613
Method: Least Squares   F-statistic: 399.0
Date: Wed, 09 Oct 2019   Prob (F-statistic):   1.05e-53
Time: 14:35:38   Log-Likelihood: -2449.6
No. Observations: 252   AIC: 4903.
Df Residuals: 250   BIC: 4910.
Df Model: 1
Covariance Type: nonrobust
==
                 coef   std err   t   P>|t| [0.025   0.975]

14

```
const        1765.2868      548.510       3.218      0.001      684.997     2845.577
M               0.3061        0.015      19.975      0.000        0.276        0.336
==============================================================================
Omnibus:                       56.683   Durbin-Watson:                   0.743
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              157.310
Skew:                           0.986   Prob(JB):                     6.93e-35
Kurtosis:                       6.331   Cond. No.                     7.70e+04
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
[2] The condition number is large, 7.7e+04. This might indicate that there are
strong multicollinearity or other numerical problems.
```

/Users/marcoscscarreira/anaconda3/envs/CondaEnv36/lib/python3.6/site-packages/numpy/core/fromnumeric.py:2495: FutureWarning: Method .ptp is deprecated and will be removed in a future version. Use numpy.ptp instead.
  return ptp(axis=axis, out=out, **kwargs)

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

```
                            OLS Regression Results
==============================================================================
Dep. Variable:             Depl_Trades   R-squared:                       0.905
Model:                             OLS   Adj. R-squared:                  0.904
Method:                  Least Squares   F-statistic:                     2376.
Date:                 Wed, 09 Oct 2019   Prob (F-statistic):          1.13e-129
Time:                         14:35:38   Log-Likelihood:                -2317.1
No. Observations:                  252   AIC:                             4638.
Df Residuals:                      250   BIC:                             4645.
Df Model:                            1
Covariance Type:             nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const        -880.0296      324.188      -2.715      0.007    -1518.516     -241.543
M               0.4415        0.009      48.744      0.000        0.424        0.459
==============================================================================
Omnibus:                       20.443   Durbin-Watson:                   0.679
Prob(Omnibus):                  0.000   Jarque-Bera (JB):               51.189
Skew:                          -0.322   Prob(JB):                     7.67e-12
Kurtosis:                       5.112   Cond. No.                     7.70e+04
==============================================================================

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

[2] The condition number is large, 7.7e+04. This might indicate that there are strong multicollinearity or other numerical problems.

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

```
                            OLS Regression Results
==============================================================================
Dep. Variable:            Depl_Trades   R-squared:                       0.869
Model:                            OLS   Adj. R-squared:                  0.868
Method:                 Least Squares   F-statistic:                     932.0
Date:                Wed, 09 Oct 2019   Prob (F-statistic):           5.22e-64
Time:                        14:35:38   Log-Likelihood:                -1312.8
No. Observations:                 143   AIC:                             2630.
Df Residuals:                     141   BIC:                             2636.
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const        238.3896    415.711      0.573      0.567    -583.443    1060.222
M              0.3772      0.012     30.529      0.000       0.353       0.402
==============================================================================
Omnibus:                       34.380   Durbin-Watson:                   0.537
Prob(Omnibus):                  0.000   Jarque-Bera (JB):               72.748
Skew:                           1.028   Prob(JB):                     1.60e-16
Kurtosis:                       5.825   Cond. No.                     7.07e+04
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
[2] The condition number is large, 7.07e+04. This might indicate that there are
strong multicollinearity or other numerical problems.
```

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

```
                            OLS Regression Results
==============================================================================
Dep. Variable:            Depl_Trades   R-squared:                       0.977
Model:                            OLS   Adj. R-squared:                  0.977
Method:                 Least Squares   F-statistic:                     4626.
Date:                Wed, 09 Oct 2019   Prob (F-statistic):           7.00e-90
Time:                        14:35:38   Log-Likelihood:                -935.56
No. Observations:                 109   AIC:                             1875.
Df Residuals:                     107   BIC:                             1881.
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
```

```
                coef      std err          t       P>|t|       [0.025      0.975]
--------------------------------------------------------------------------------
const       -1825.6996     281.834     -6.478      0.000    -2384.403   -1266.996
M               0.4988       0.007     68.012      0.000        0.484       0.513
================================================================================
Omnibus:                       4.265   Durbin-Watson:                    1.220
Prob(Omnibus):                 0.119   Jarque-Bera (JB):                 4.347
Skew:                         -0.237   Prob(JB):                         0.114
Kurtosis:                      3.856   Cond. No.                      8.67e+04
================================================================================
```

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.
[2] The condition number is large, 8.67e+04. This might indicate that there are strong multicollinearity or other numerical problems.

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


Depl_Cancel : EUR
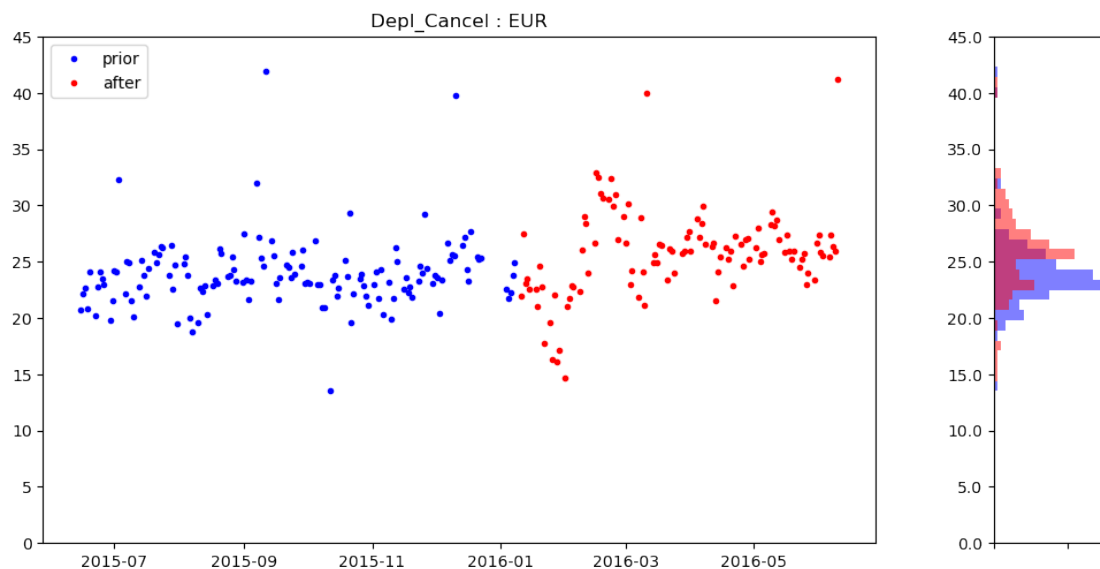
```
[66]:  cme.time_series_hist_plot(DEPL_STATS_TS, 'DC same-oppo',\
           'DC same-oppo : '+CURR, 0, 30, 50)
```

Figure title: DC same-oppo : EUR
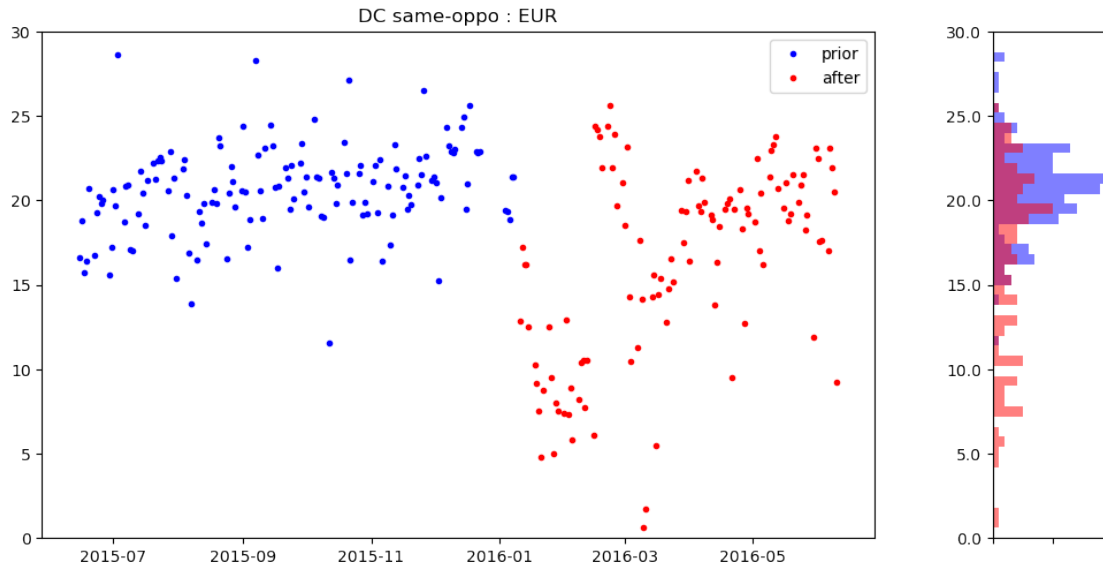
```
[67]: cme.time_series_hist_plot(DEPL_STATS_TS, 'Depl_Trade',\
          'Depl_Trade : '+CURR, 0, 40, 50)
```


Figure title: Depl_Trade : EUR
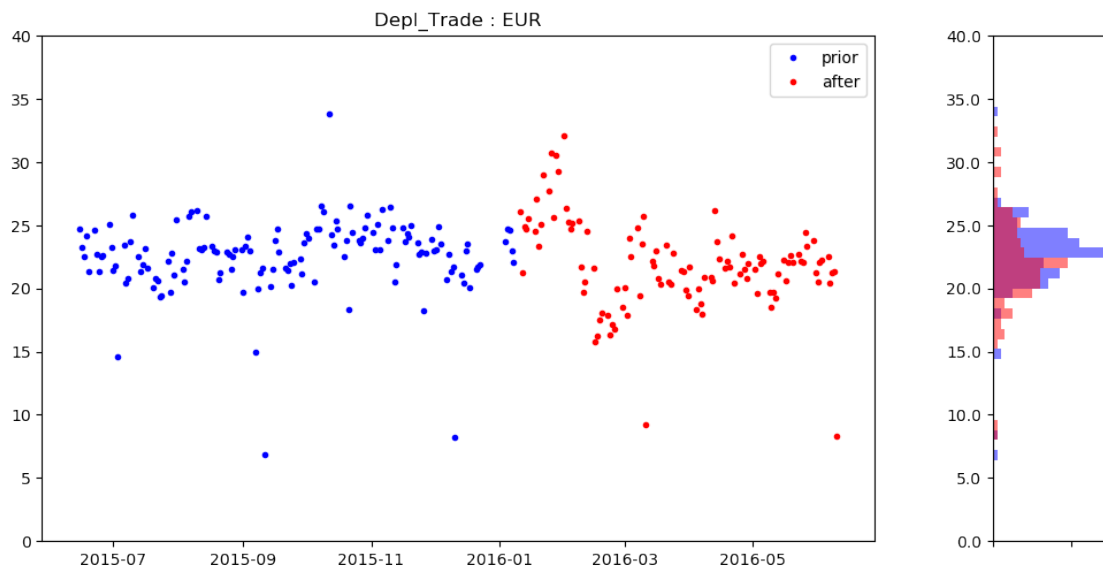
```
[68]: cme.time_series_hist_plot(DEPL_STATS_TS, 'DT same-oppo',\
          'DT same-oppo : '+CURR, -2, 20, 50)
```

DT same-oppo : EUR
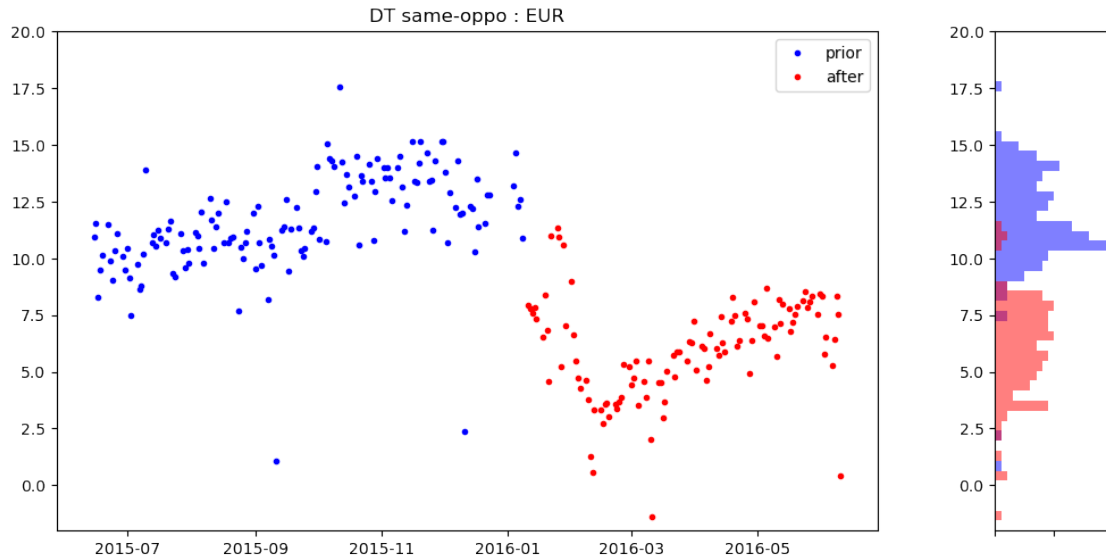
```
[69]: cme.time_series_hist_plot(DEPL_STATS_TS, 'DT+F same-oppo',\
      'DT+F same-oppo : '+CURR, -1, 6, 50)
```


DT+F same-oppo : EUR
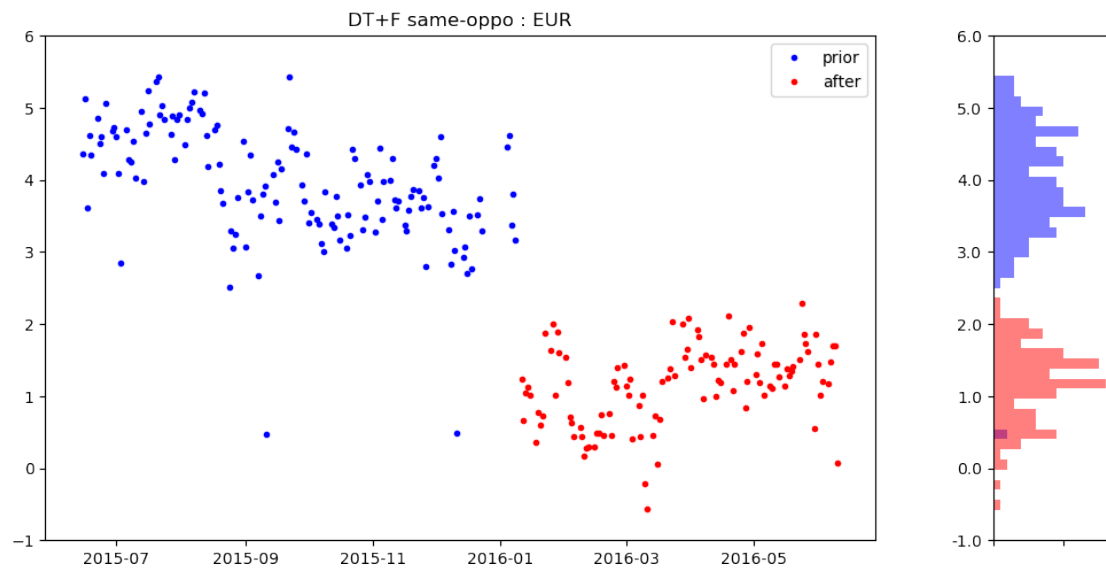
```
[70]: cme.time_series_hist_plot(DEPL_STATS_TS, 'Fill same-oppo',\
      'Filled : Same - Opposite : '+CURR, -15, 25, 50)
```

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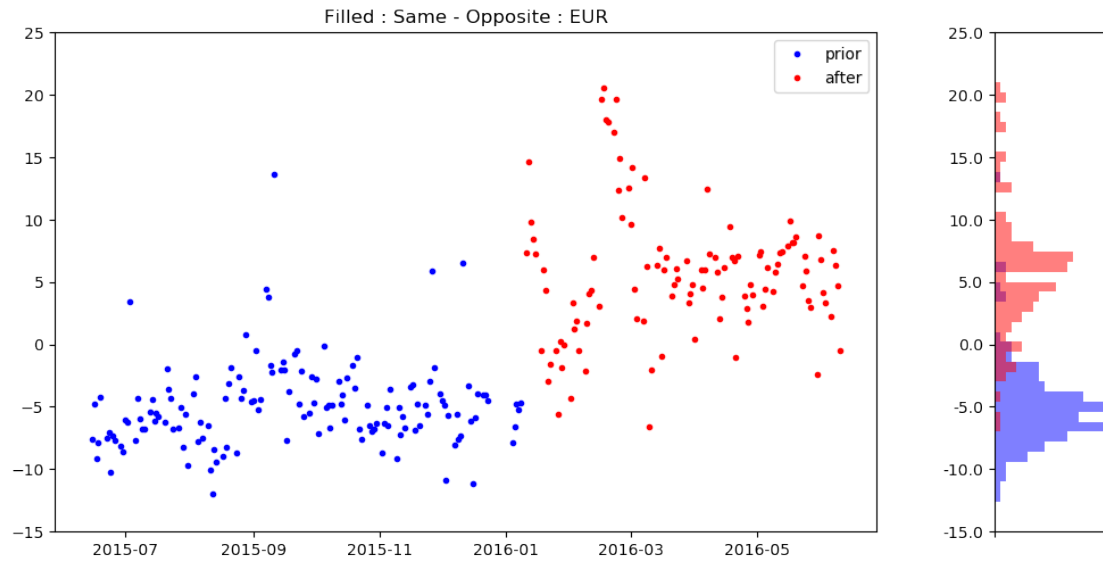
```
[71]: plt.figure(figsize=(9, 6))
      sns.scatterplot(x='eta1', y='DC same-oppo', hue='Status',\
              data=DEPL_STATS_TS);
      plt.title('DC same-oppo and $\eta$ : '+CURR);
```


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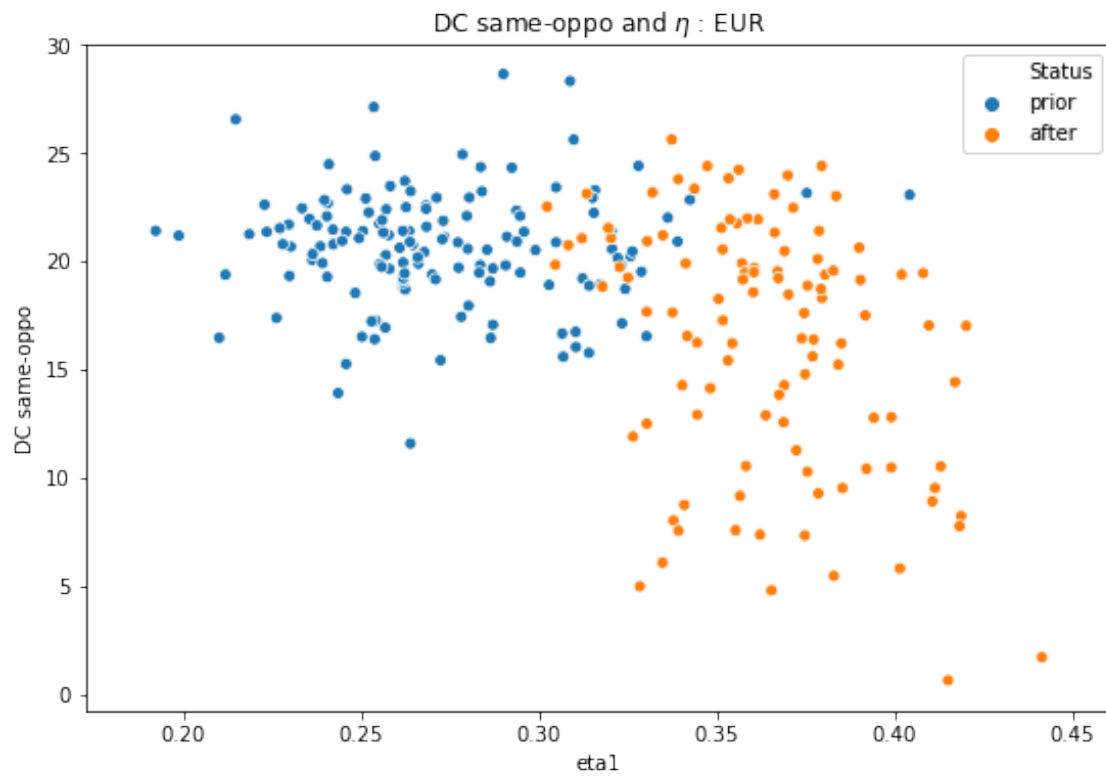
```
[72]: plt.figure(figsize=(9, 6))
      sns.scatterplot(x='eta1', y='DT same-oppo', hue='Status',\
              data=DEPL_STATS_TS);
      plt.title('DT same-oppo and $\eta$ : '+CURR);
```
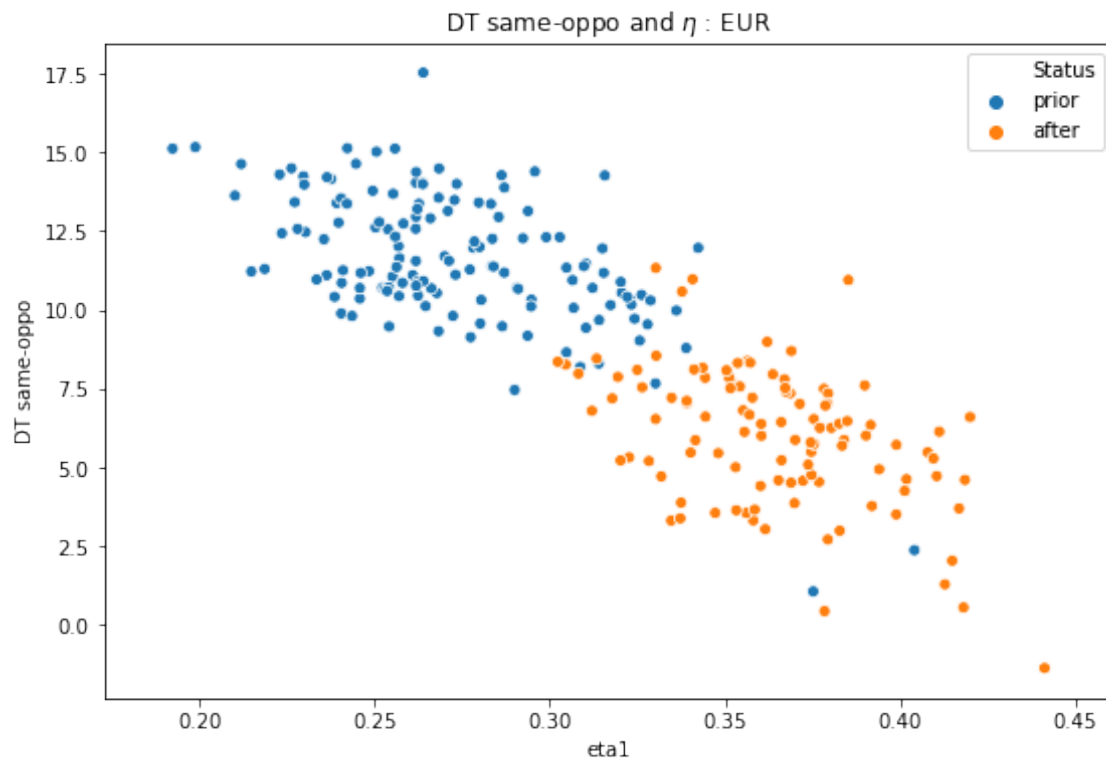


```
[73]: plt.figure(figsize=(9, 6))
      sns.scatterplot(x='eta1', y='DT+F same-oppo', hue='Status',\
              data=DEPL_STATS_TS);
      plt.title('DT+F same-oppo and $\eta$ : '+CURR);
```

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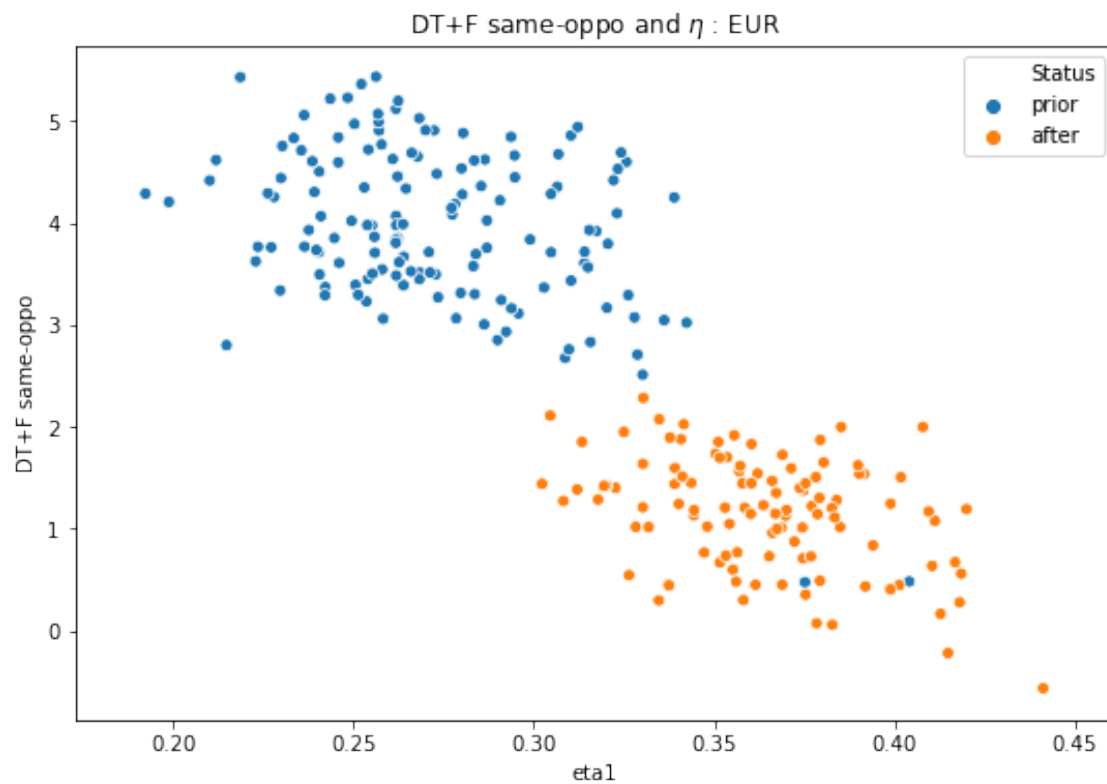
```
[74]: plt.figure(figsize=(9, 6))
      sns.scatterplot(x='eta1', y='Fill same-oppo', hue='Status',\
              data=DEPL_STATS_TS);
      plt.title('Fill and $\eta$ : '+CURR);
```

Fill and η : EUR
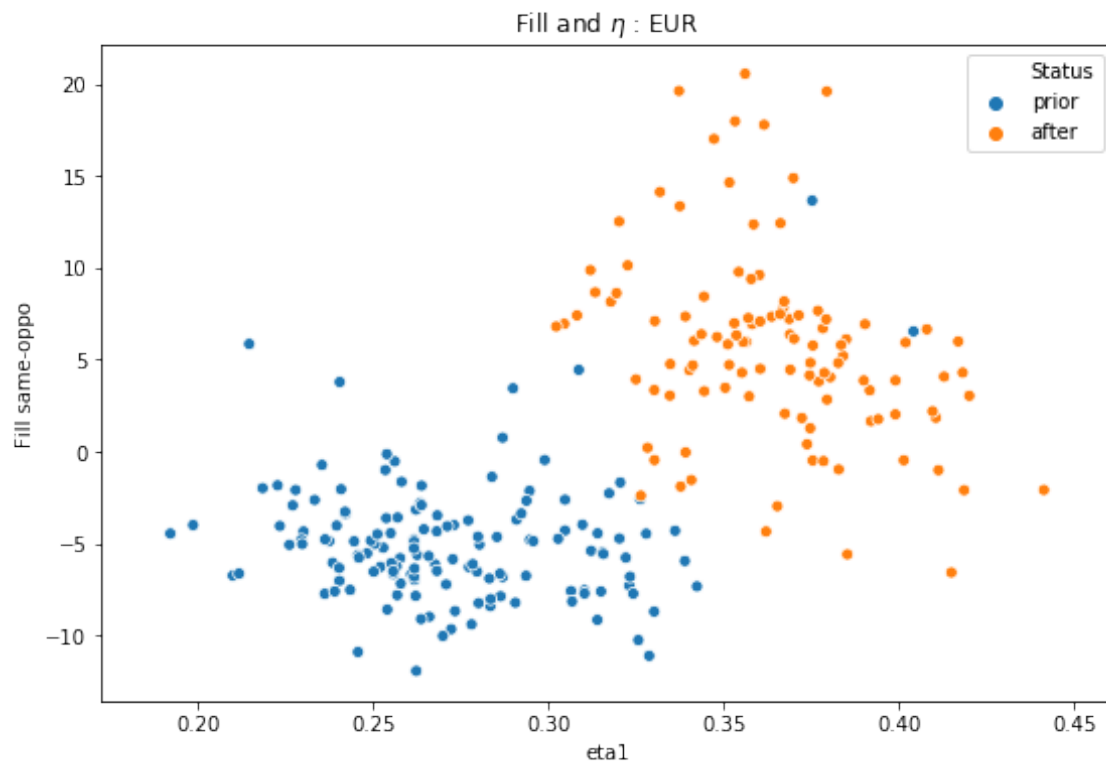
```
[75]: cme.time_series_hist_plot(OB_UZ_STATS, 'twspr1',\
         'Spread in Ticks : '+CURR, 1, 2, 50)
```


Spread in Ticks : EUR
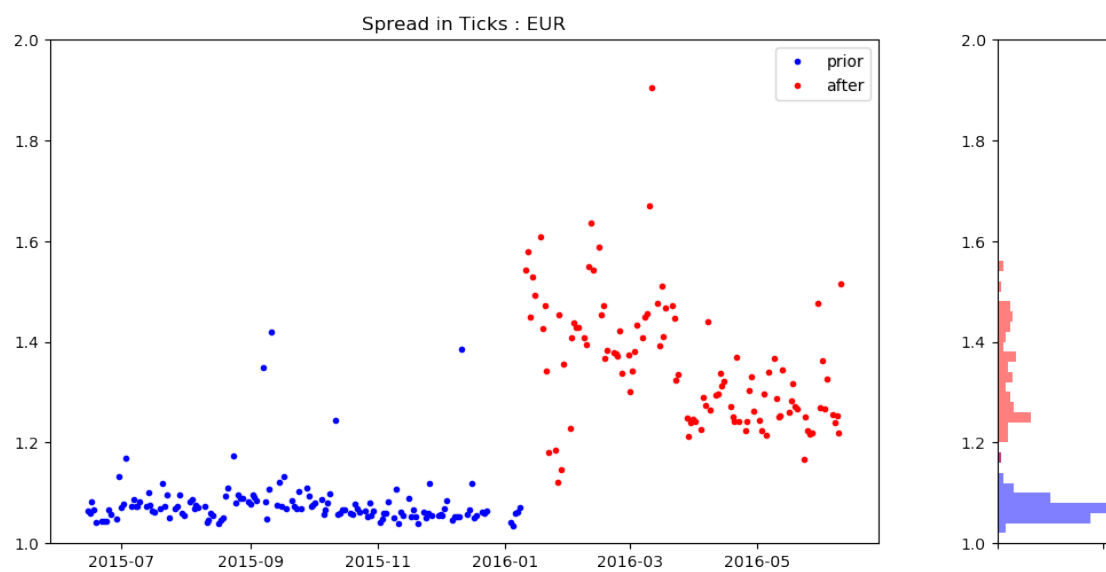
```
[76]: cme.twspr_plot_USD(OB_UZ_STATS, CURR)
```

Spread in USD : EUR
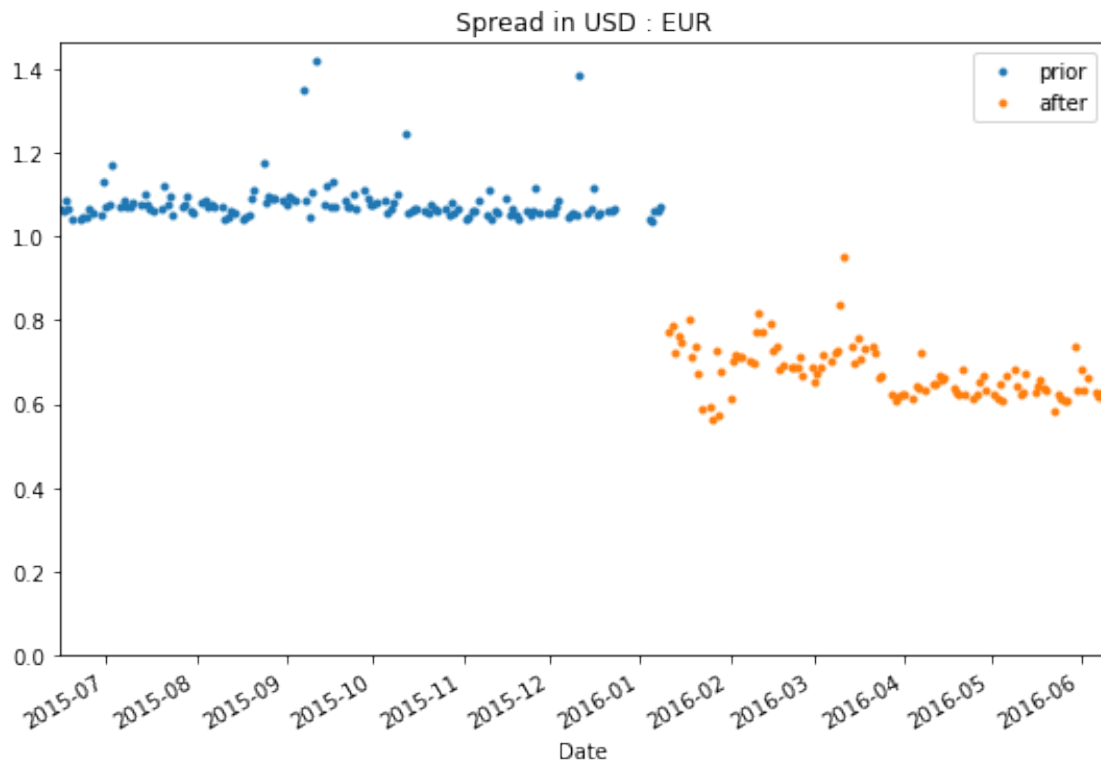

```
[77]: cme.time_series_hist_plot(OB_UZ_STATS, 'eta1',\
      '$\eta$ : '+CURR, 0, 0.5, 50)
```

η : EUR

24
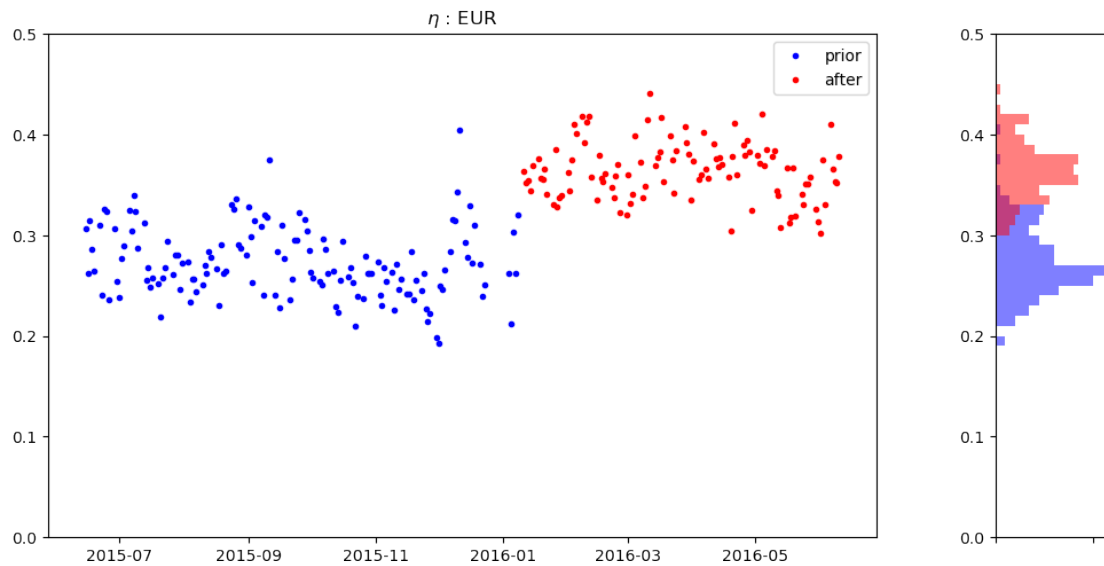
```
[78]:  cme.time_series_hist_plot(OB_UZ_STATS, 'chgavg',\
           'Average Price Change : '+CURR, 0.4, 1.4, 50)
```


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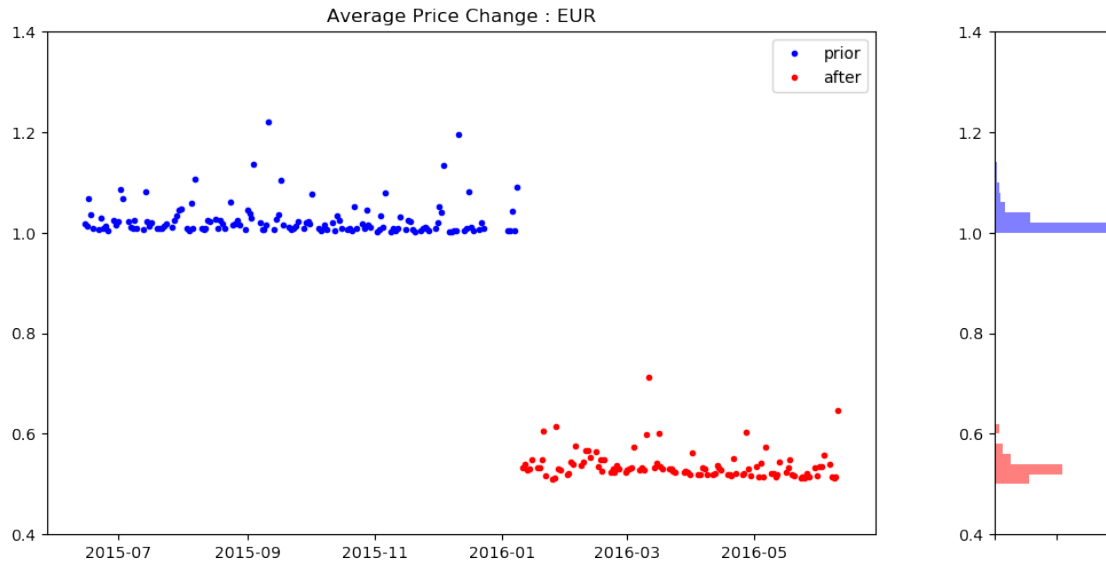
```
[79]:  cme.time_series_hist_plot(OB_UZ_STATS, 'rvxe',\
           'Estimated Volatility of Efficient Prices : '+CURR, 0, 0.015, 50)
```


Estimated Volatility of Efficient Prices : EUR
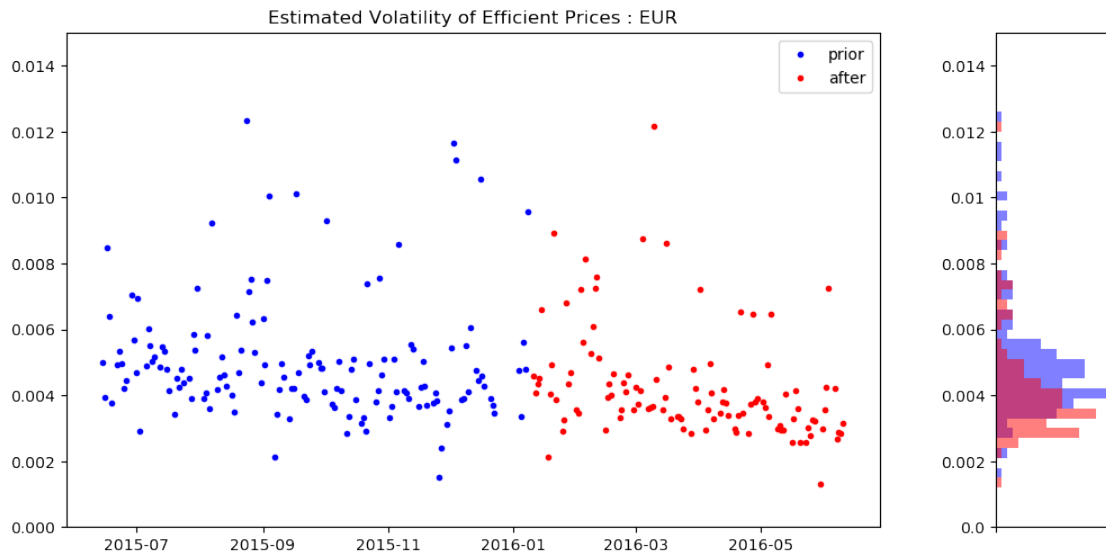
```
[80]:  cme.time_series_hist_plot(OB_UZ_STATS, 'ndfpr',\
           'Number of Price Changes : '+CURR, 0, 60000, 50)
```

Number of Price Changes : EUR
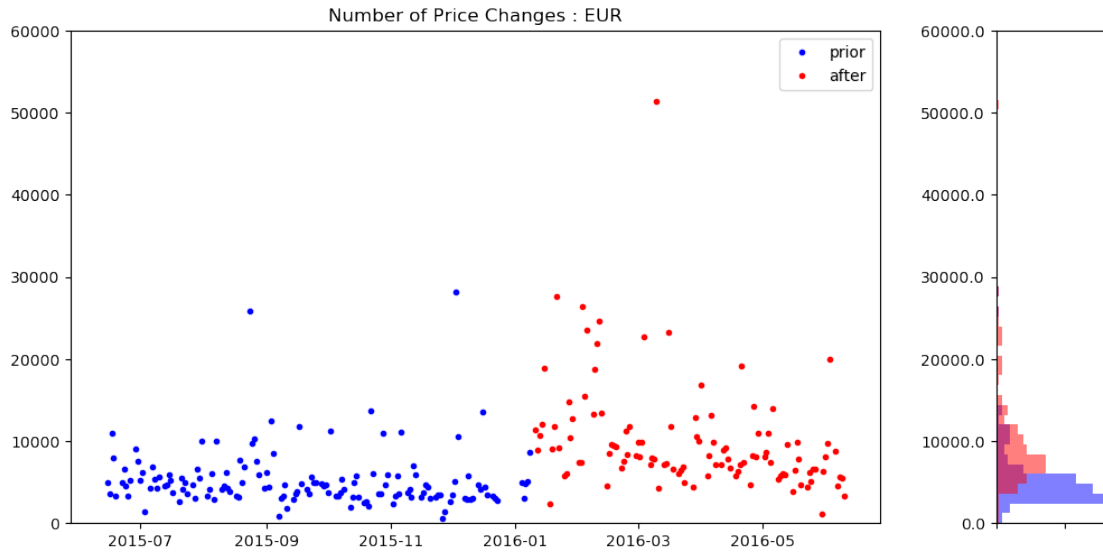

```
[81]: cme.time_series_hist_plot(OB_UZ_STATS, 'M',\
      'Number of Trades : '+CURR, 0, 150000, 50)
```

Number of Trades : EUR
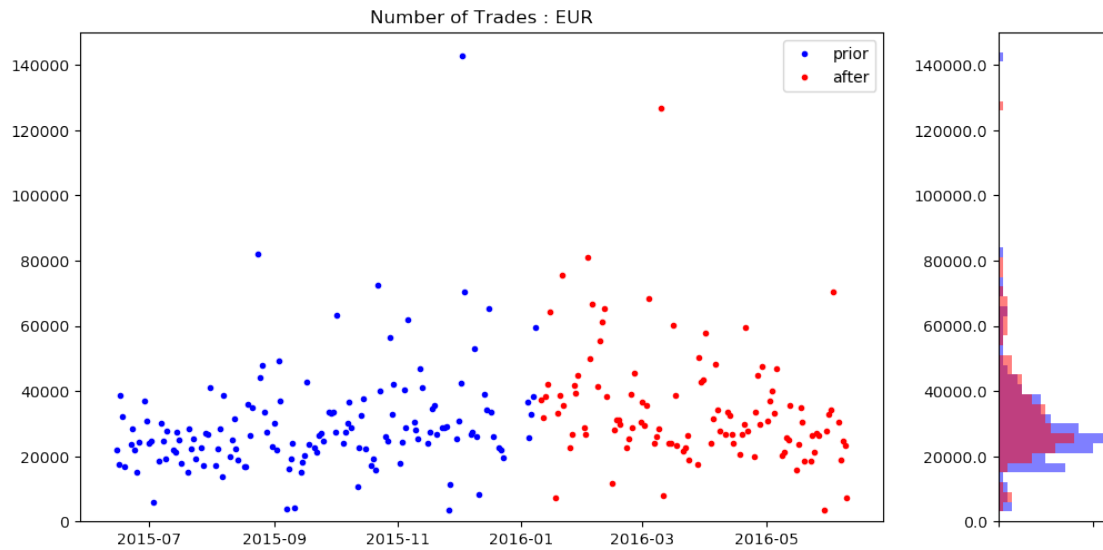

```
[82]: cme.time_series_hist_plot(OB_UZ_STATS, 'Volume',\
      'Volume : '+CURR, 0, 500000, 50)
```

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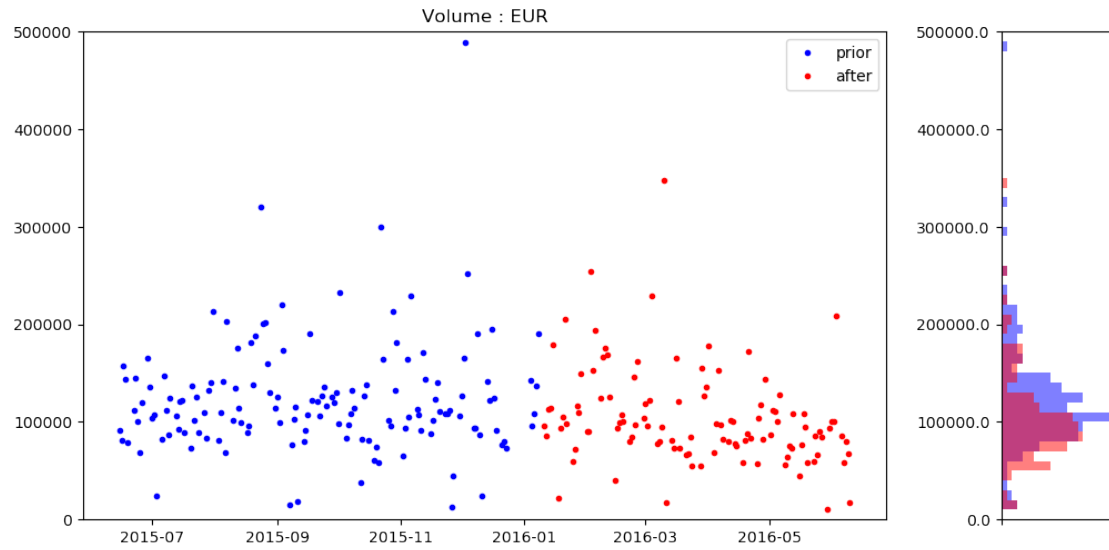
```
[83]: cme.scatter_plot(OB_UZ_STATS, 'chgavg', 'eta1',\
      'Eta (y) x Average Price Change (x) : '+CURR)
```


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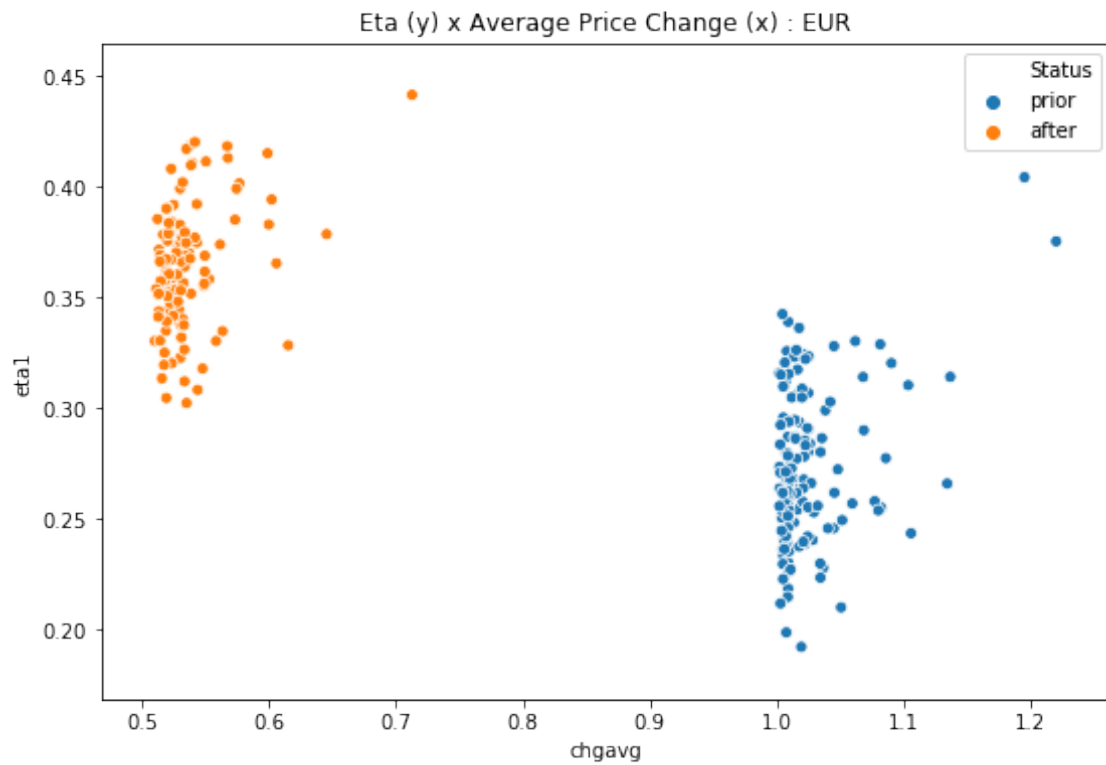
```
[84]: cme.scatter_plot(OB_UZ_STATS, 'rvxe', 'twspr1',\
          'Spread in Ticks (y) x Estimated Volatility of Efficient Prices (x) :␣
      ↪'+CURR)
```


Spread in Ticks (y) x Estimated Volatility of Efficient Prices (x) : EUR
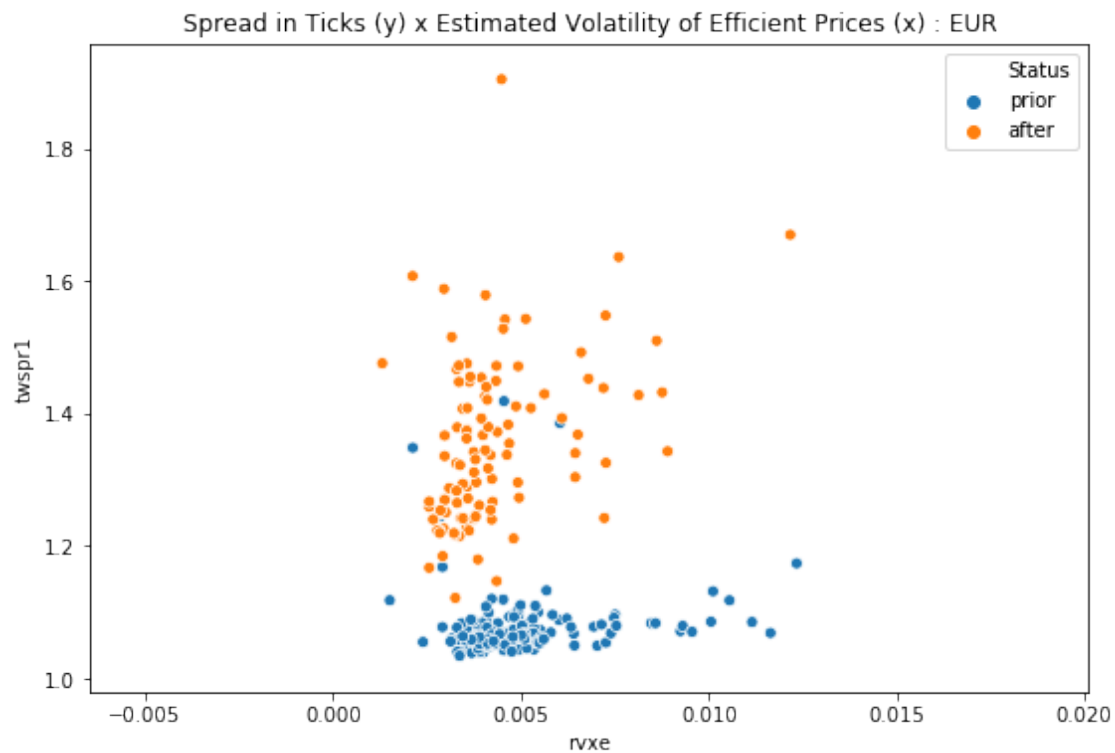
```
[85]: cme.scatter_plot(OB_UZ_STATS, 'eta1', 'twspr1',\
          'Spread in Ticks (y) x Eta (x) : '+CURR)
```

Spread in Ticks (y) x Eta (x) : EUR
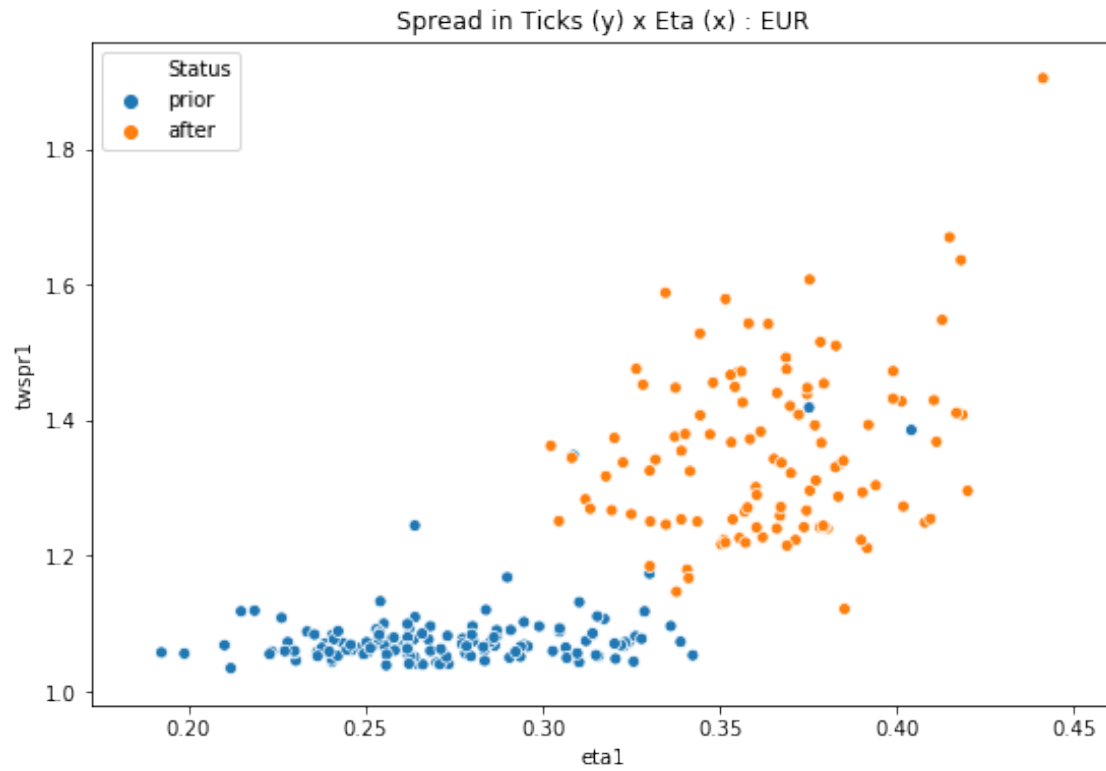
```
[86]: cme.time_series_hist(OB_UZ_STATS, 'eta1',\
      'Eta Histogram : '+CURR)
```

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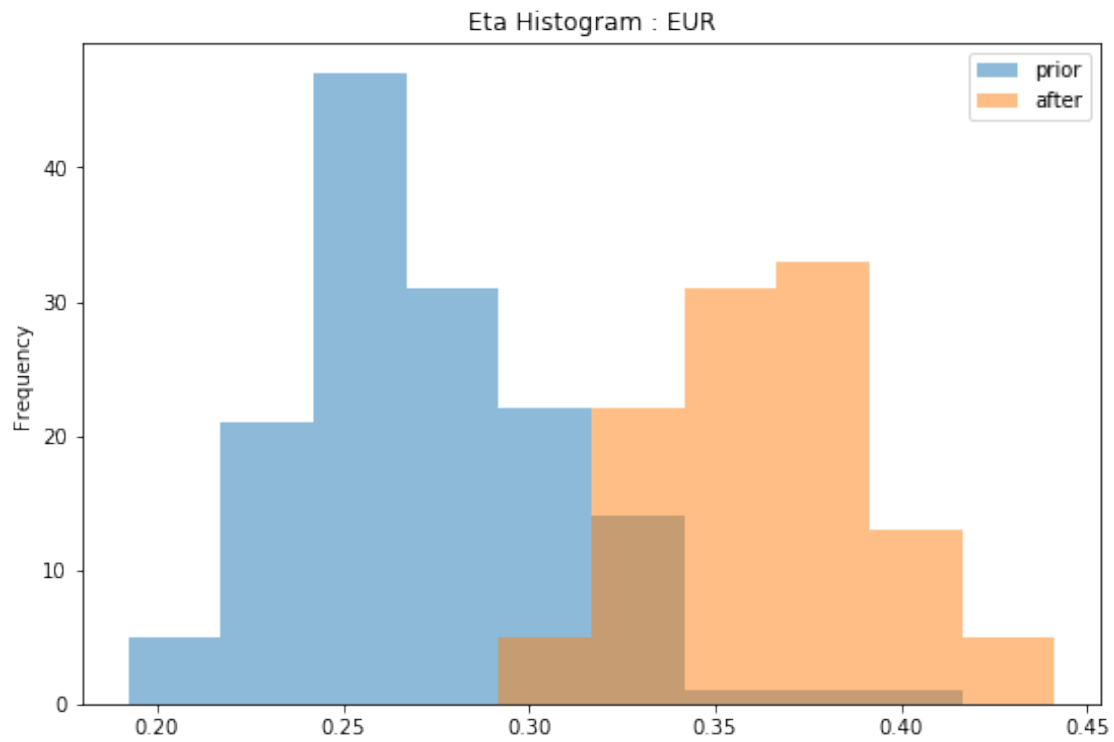
```
[87]: cme.scatter_plot(OB_UZ_STATS, 'duration', 'dt_avg',\
          'Realized Duration (y) x Predicted Duration (x) : '+CURR)
```

Realized Duration (y) x Predicted Duration (x) : EUR
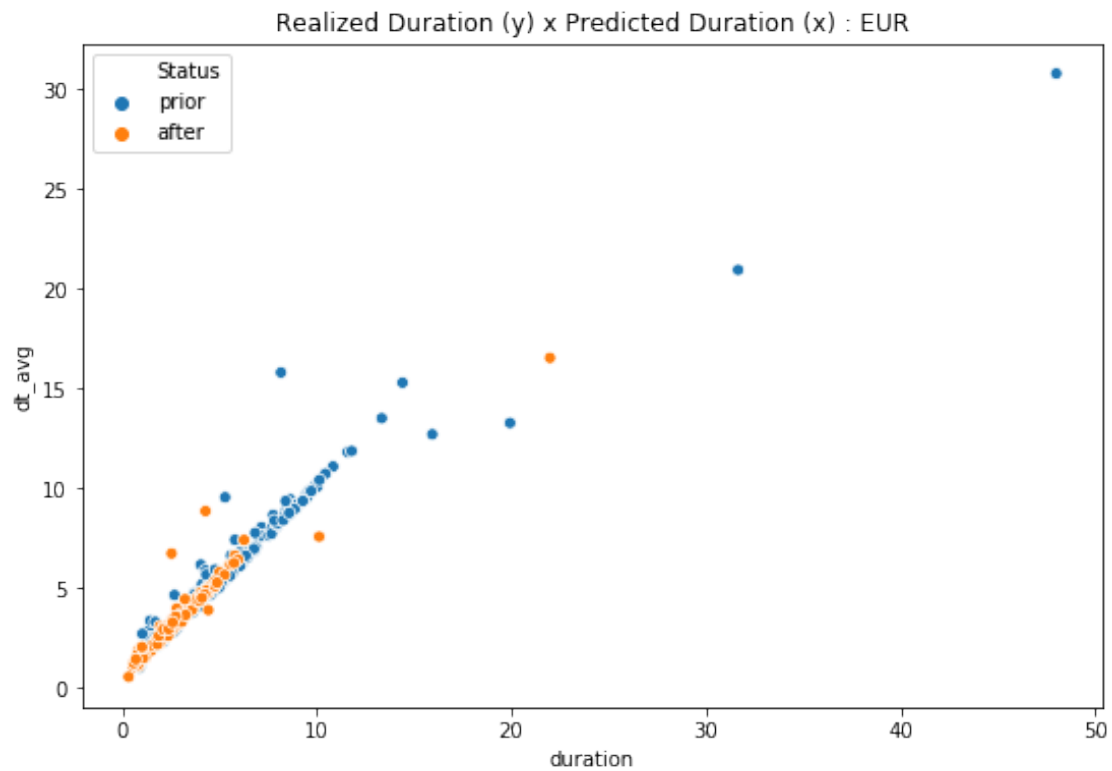
```
cme.scatter_plot(OB_UZ_STATS, 'twspr1', 'eta1',\
    'Eta (y) x Time-Weighted Average Spread (x) : '+CURR)
```

Eta (y) x Time-Weighted Average Spread (x) : EUR
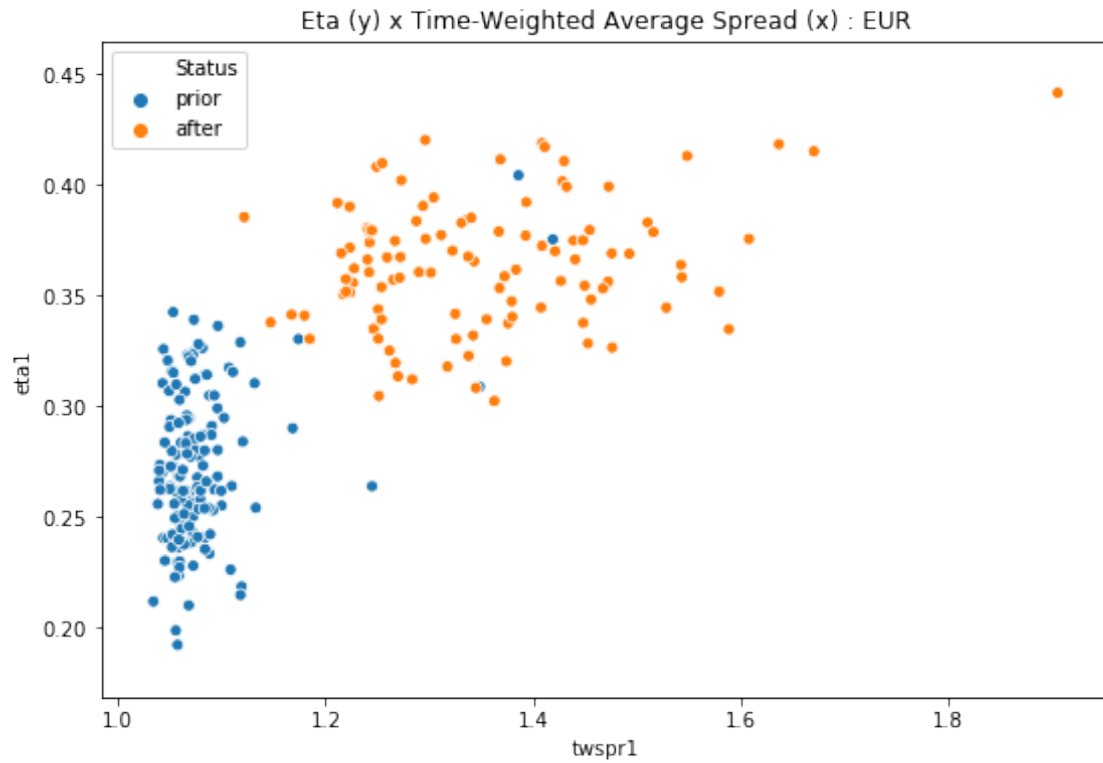
```
[89]:  cme.cloud1(OB_UZ_STATS, CURR)
```


Cloud ($\eta\alpha\sqrt{M}, \sigma$) : EUR
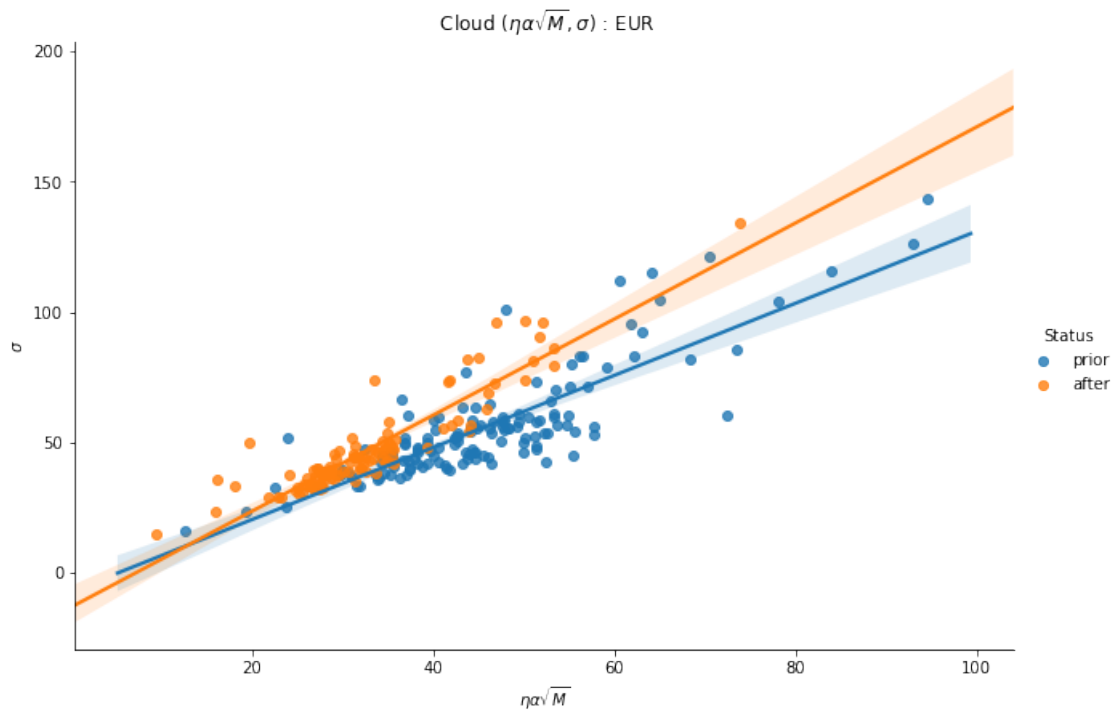
```
[90]: cme.cloud1(OB_UZ_STATS, CURR, True)
```


Cloud $(\eta\alpha\sqrt{M}, \sigma)$: EUR
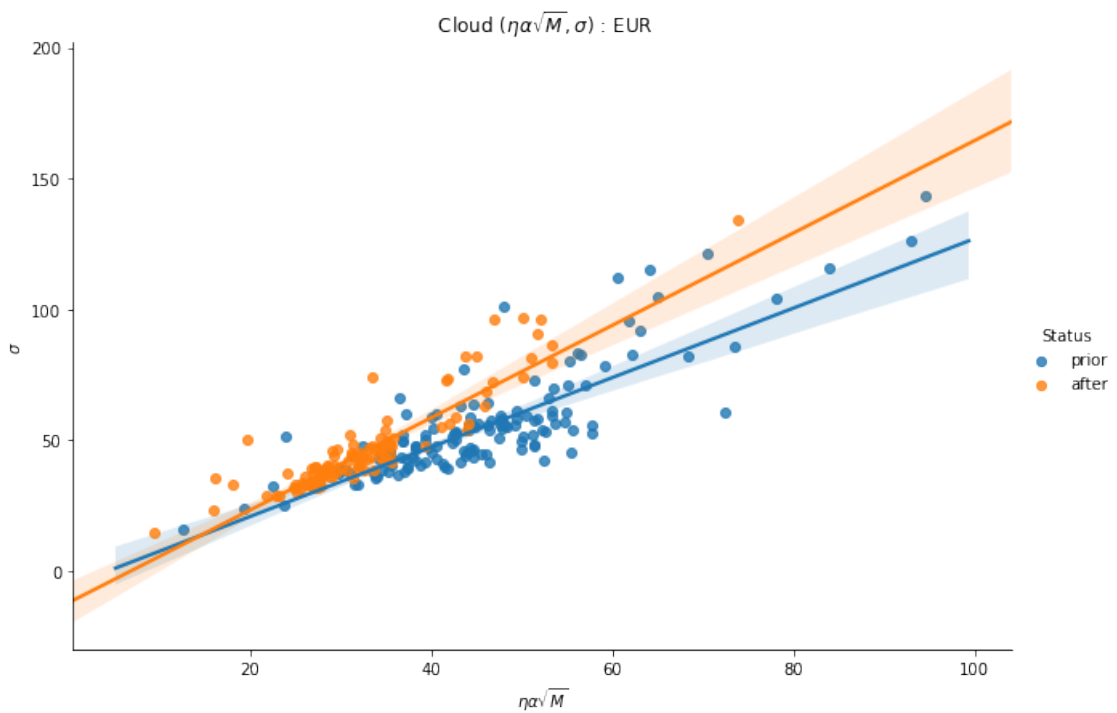
```
[91]: cme.lin_reg(PRIOR_OB_UZ_STATS, ['eta*alpha*sqrt(M)', 'S*sqrt(M)'], 'sigma')
```

                            OLS Regression Results
==
Dep. Variable: sigma   R-squared: 0.728
Model: OLS   Adj. R-squared: 0.724
Method: Least Squares   F-statistic: 187.0
Date: Wed, 09 Oct 2019   Prob (F-statistic):   2.93e-40
Time: 14:36:01   Log-Likelihood: -541.89
No. Observations: 143   AIC: 1090.
Df Residuals: 140   BIC: 1099.
Df Model: 2
Covariance Type: nonrobust
==
=====
                 coef   std err   t   P>|t| [0.025
0.975]

-----
const   -12.1276   3.825   -3.171   0.002   -19.690

```
                                    -4.565
eta*alpha*sqrt(M)        0.9745        0.166        5.876        0.000        0.647
1.302
S*sqrt(M)                0.1302        0.047        2.748        0.007        0.037
0.224
==============================================================================
Omnibus:                          30.999   Durbin-Watson:                   1.382
Prob(Omnibus):                     0.000   Jarque-Bera (JB):               57.052
Skew:                              0.990   Prob(JB):                     4.09e-13
Kurtosis:                          5.377   Cond. No.                         807.
==============================================================================
```

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

[92]: `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:                  143
Model:                              RLM   Df Residuals:                      140
Method:                            IRLS   Df Model:                            2
Norm:                            HuberT
Scale Est.:                         mad
Cov Type:                            H1
Date:                  Wed, 09 Oct 2019
Time:                          14:36:01
No. Iterations:                      21
==============================================================================
=====
                    coef    std err          z      P>|z|      [0.025
0.975]
------------------------------------------------------------------------------
-----
const            -10.0161      3.133     -3.197      0.001     -16.156
-3.876
eta*alpha*sqrt(M)   0.9886      0.136      7.279      0.000       0.722
1.255
S*sqrt(M)           0.1095      0.039      2.821      0.005       0.033
0.186
==============================================================================
=====
```

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 .

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

```
                          OLS Regression Results
==============================================================================
Dep. Variable:                  sigma   R-squared:                       0.879
Model:                            OLS   Adj. R-squared:                  0.876
Method:                 Least Squares   F-statistic:                     383.7
Date:                Wed, 09 Oct 2019   Prob (F-statistic):           2.86e-49
Time:                        14:36:01   Log-Likelihood:                -356.84
No. Observations:                 109   AIC:                             719.7
Df Residuals:                     106   BIC:                             727.8
Df Model:                           2
Covariance Type:            nonrobust
===================================================================================
                     coef    std err          t      P>|t|      [0.025
0.975]
-----------------------------------------------------------------------------------
const              -15.2391      2.356     -6.469      0.000     -19.909
-10.569
eta*alpha*sqrt(M)    0.7703      0.191      4.039      0.000       0.392
1.148
S*sqrt(M)            0.3045      0.050      6.036      0.000       0.204
0.405
==============================================================================
Omnibus:                       44.447   Durbin-Watson:                   1.931
Prob(Omnibus):                  0.000   Jarque-Bera (JB):               91.249
Skew:                           1.698   Prob(JB):                     1.53e-20
Kurtosis:                       5.926   Cond. No.                         500.
==============================================================================

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

```
[94]: 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:                  109
Model:                            RLM   Df Residuals:                      106
Method:                          IRLS   Df Model:                            2
Norm:                          HuberT
Scale Est.:                       mad
Cov Type:                          H1
Date:                Wed, 09 Oct 2019
Time:                        14:36:01
```

```
No. Iterations:                      35
================================================================================
=====
                    coef      std err         z       P>|z|        [0.025
   0.975]
--------------------------------------------------------------------------------
-----
const              -13.4553      1.388      -9.691      0.000      -16.176
-10.734
eta*alpha*sqrt(M)    0.7827      0.112       6.964      0.000        0.562
1.003
S*sqrt(M)            0.2750      0.030       9.247      0.000        0.217
0.333
================================================================================
=====
```

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 .

```python
[95]: 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)']
```

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

Cloud $(p_1\eta\alpha\sqrt{M}, \sigma - p_2S\sqrt{M})$: EUR
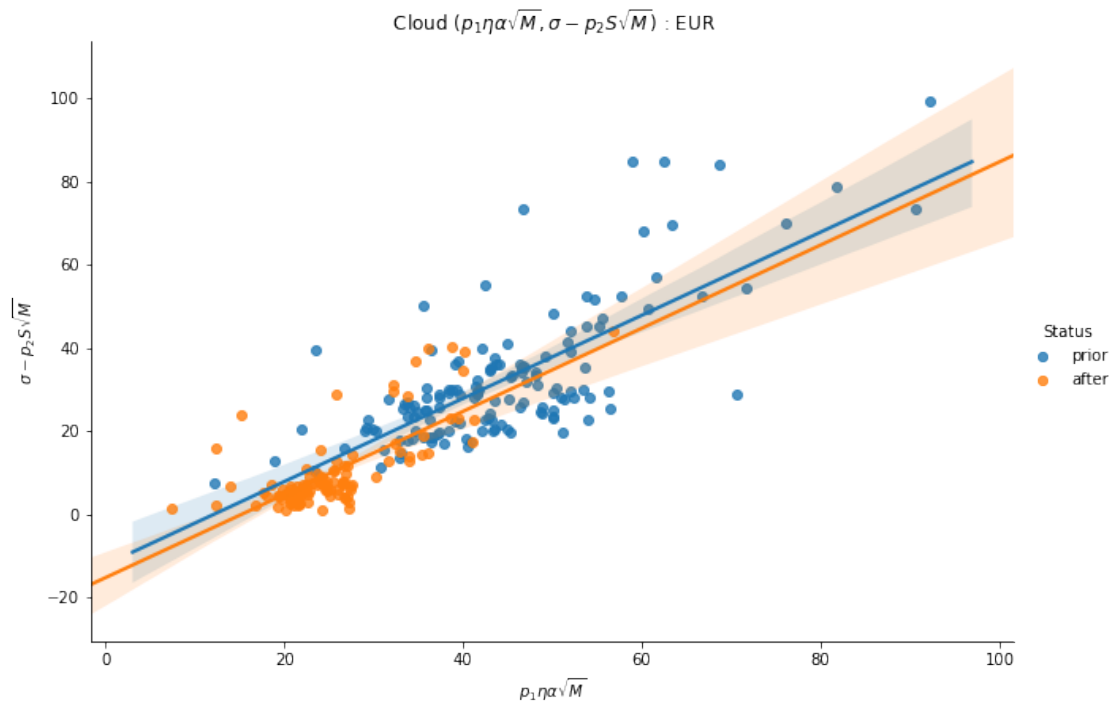
[97]:
```
cme.cloud2(OB_UZ_STATS, CURR, True)
```


Cloud $(p_1\eta\alpha\sqrt{M}, \sigma - p_2S\sqrt{M})$: EUR
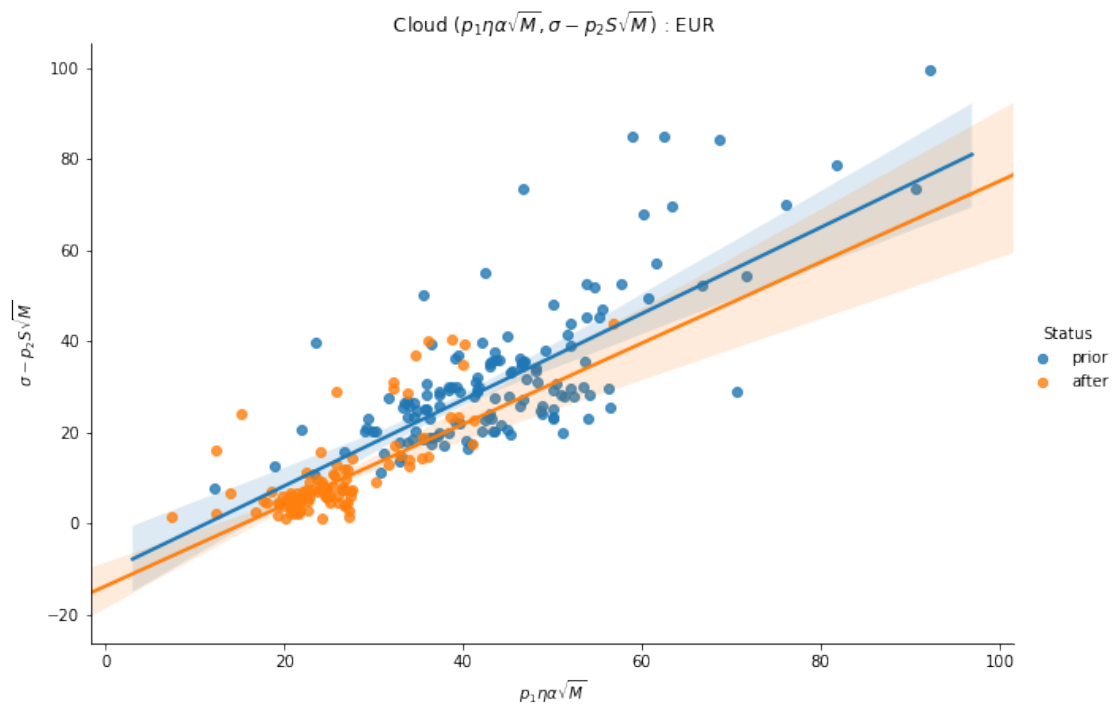
```
[98]: cme.lin_reg(OB_UZ_STATS[OB_UZ_STATS['Status']=='prior'],␣
      →['p1*eta*alpha*sqrt(M)'], 'sigma-p2*S*sqrt(M)')
```

```
                             OLS Regression Results
==============================================================================
Dep. Variable:       sigma-p2*S*sqrt(M)   R-squared:                    0.565
Model:                             OLS   Adj. R-squared:               0.561
Method:                  Least Squares   F-statistic:                  182.8
Date:                 Wed, 09 Oct 2019   Prob (F-statistic):        3.14e-27
Time:                         14:36:13   Log-Likelihood:             -541.89
No. Observations:                  143   AIC:                          1088.
Df Residuals:                      141   BIC:                          1094.
Df Model:                            1
Covariance Type:             nonrobust
==============================================================================
========
                        coef     std err          t      P>|t|      [0.025
0.975]
------------------------------------------------------------------------------
--------
const                -12.1276      3.403     -3.564      0.000     -18.855
-5.400
p1*eta*alpha*sqrt(M)   1.0000      0.074     13.519      0.000       0.854
1.146
==============================================================================
Omnibus:                        30.999   Durbin-Watson:                1.382
Prob(Omnibus):                   0.000   Jarque-Bera (JB):            57.052
Skew:                            0.990   Prob(JB):                  4.09e-13
Kurtosis:                        5.377   Cond. No.                      174.
==============================================================================

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

```
[99]: 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:               143
Model:                             RLM   Df Residuals:                   141
Method:                           IRLS   Df Model:                         1
Norm:                            HuberT
Scale Est.:                         mad
Cov Type:                            H1
Date:                 Wed, 09 Oct 2019
Time:                         14:36:13
```

```
No. Iterations:                    17
================================================================================
========
                       coef      std err          z      P>|z|      [0.025
0.975]
--------------------------------------------------------------------------------
--------
const                -10.7292      2.820     -3.805      0.000     -16.256
-5.202
p1*eta*alpha*sqrt(M)   0.9459      0.061     15.432      0.000       0.826
1.066
================================================================================
========
```

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 .

```
[100]: 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:                       0.546
Model:                          OLS   Adj. R-squared:                  0.542
Method:               Least Squares   F-statistic:                     128.6
Date:              Wed, 09 Oct 2019   Prob (F-statistic):           4.72e-20
Time:                      14:36:13   Log-Likelihood:                 -356.84
No. Observations:               109   AIC:                             717.7
Df Residuals:                   107   BIC:                             723.1
Df Model:                         1
Covariance Type:          nonrobust
================================================================================
========
                       coef      std err          t      P>|t|      [0.025
0.975]
--------------------------------------------------------------------------------
--------
const                -15.2391      2.325     -6.554      0.000     -19.848
-10.630
p1*eta*alpha*sqrt(M)   1.0000      0.088     11.341      0.000       0.825
1.175
================================================================================
Omnibus:                       44.447   Durbin-Watson:                   1.931
Prob(Omnibus):                  0.000   Jarque-Bera (JB):               91.249
Skew:                           1.698   Prob(JB):                     1.53e-20
Kurtosis:                       5.926   Cond. No.                        99.4
================================================================================
```

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

```
[101]: 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: 109
Model: RLM   Df Residuals: 107
Method: IRLS   Df Model: 1
Norm: HuberT
Scale Est.:   mad
Cov Type: H1
Date: Wed, 09 Oct 2019
Time: 14:36:13
No. Iterations: 24
==
========
                        coef   std err   z   P>|z| [0.025
0.975]

----
const   -13.7862   1.348   -10.227   0.000   -16.428
-11.144
p1*eta*alpha*sqrt(M)   0.8888   0.051   17.387   0.000   0.789
0.989
==
========

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 .

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

Volatility of Efficient Prices (y) x Estimated Volatility of Efficient Prices (x) : EUR
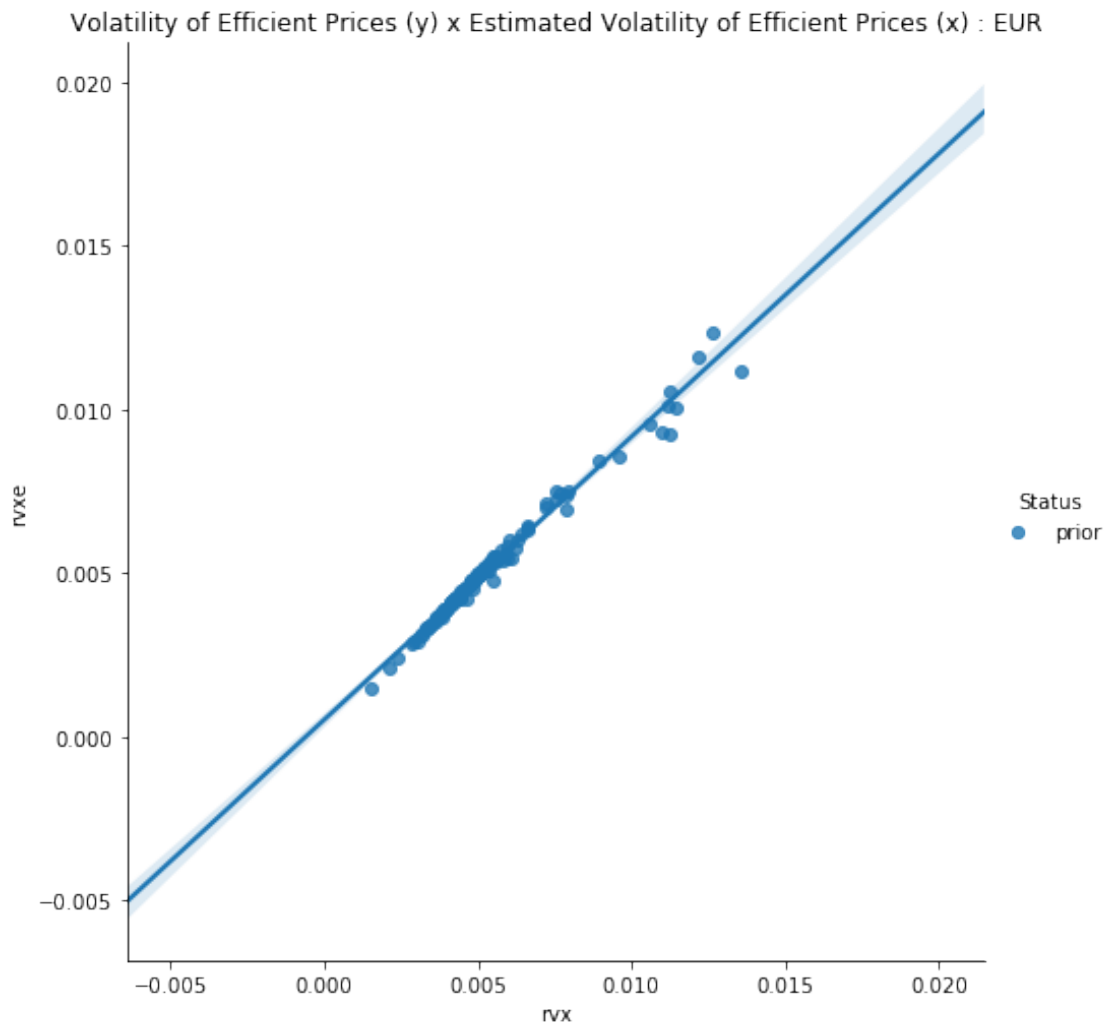

```
[103]: cme.lin_reg(PRIOR_OB_UZ_STATS, 'rvx', 'rvxe', True)
```

OLS Regression Results

Dep. Variable:	rvxe	R-squared:	0.992
Model:	OLS	Adj. R-squared:	0.992
Method:	Least Squares	F-statistic:	1.851e+04
Date:	Wed, 09 Oct 2019	Prob (F-statistic):	1.81e-151
Time:	14:36:13	Log-Likelihood:	308.95
No. Observations:	143	AIC:	-613.9
Df Residuals:	141	BIC:	-608.0
Df Model:	1		
Covariance Type:	nonrobust		

```
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
```

```
const           -0.3986      0.036     -10.934      0.000      -0.471      -0.327
rvx              0.9296      0.007     136.063      0.000       0.916       0.943
==============================================================================
Omnibus:                       55.160   Durbin-Watson:                   1.737
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              138.653
Skew:                          -1.593   Prob(JB):                     7.79e-31
Kurtosis:                       6.623   Cond. No.                         85.7
==============================================================================
```

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

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


Number of Price Changes (y) x Estimated Volatility of Efficient Prices (x) : EUR

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

Number of Price Changes (y) x Estimated Volatility of Efficient Prices (x) : EUR
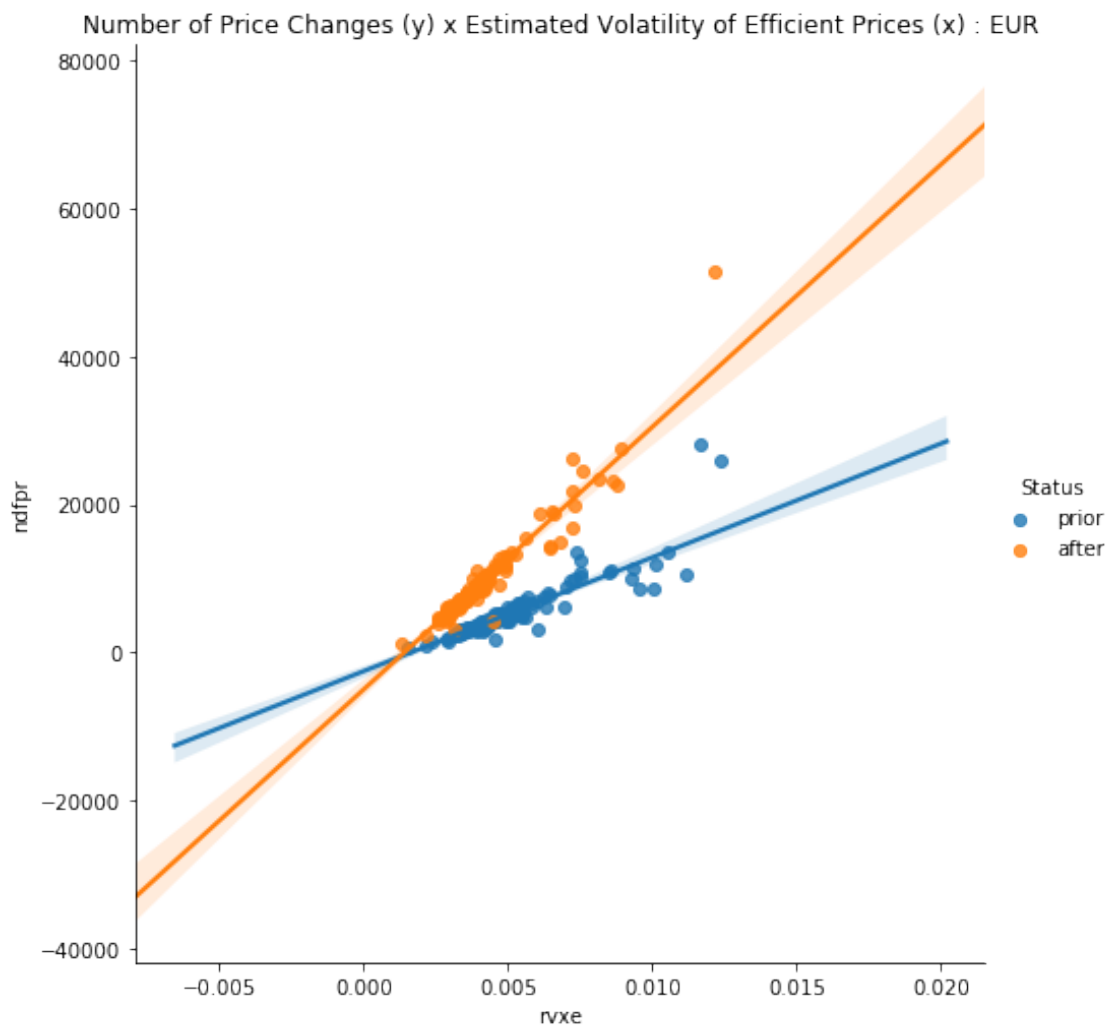

```
[106]: cme.lin_reg(PRIOR_OB_UZ_STATS, 'rvxe', 'ndfpr', True)
```

OLS Regression Results
==
Dep. Variable: ndfpr   R-squared: 0.887
Model: OLS   Adj. R-squared: 0.886
Method: Least Squares   F-statistic: 1103.
Date: Wed, 09 Oct 2019   Prob (F-statistic):   1.52e-68
Time: 14:36:22   Log-Likelihood: 43.928
No. Observations: 143   AIC: -83.86

```
Df Residuals:                    141   BIC:                         -77.93
Df Model:                          1
Covariance Type:            nonrobust
=================================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
---------------------------------------------------------------------------------
const          16.7255      0.250     66.825      0.000      16.231      17.220
rvxe            1.5517      0.047     33.214      0.000       1.459       1.644
=================================================================================
Omnibus:                        67.147   Durbin-Watson:                   1.869
Prob(Omnibus):                   0.000   Jarque-Bera (JB):              271.853
Skew:                           -1.714   Prob(JB):                     9.29e-60
Kurtosis:                        8.820   Cond. No.                         92.6
=================================================================================

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

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

```
                    Robust linear Model Regression Results
==================================================================================
Dep. Variable:                   ndfpr   No. Observations:                  143
Model:                             RLM   Df Residuals:                      141
Method:                           IRLS   Df Model:                            1
Norm:                           HuberT
Scale Est.:                        mad
Cov Type:                           H1
Date:                 Wed, 09 Oct 2019
Time:                         14:36:22
No. Iterations:                     32
==================================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
----------------------------------------------------------------------------------
const          16.8768      0.181     93.414      0.000      16.523      17.231
rvxe            1.5761      0.034     46.738      0.000       1.510       1.642
==================================================================================

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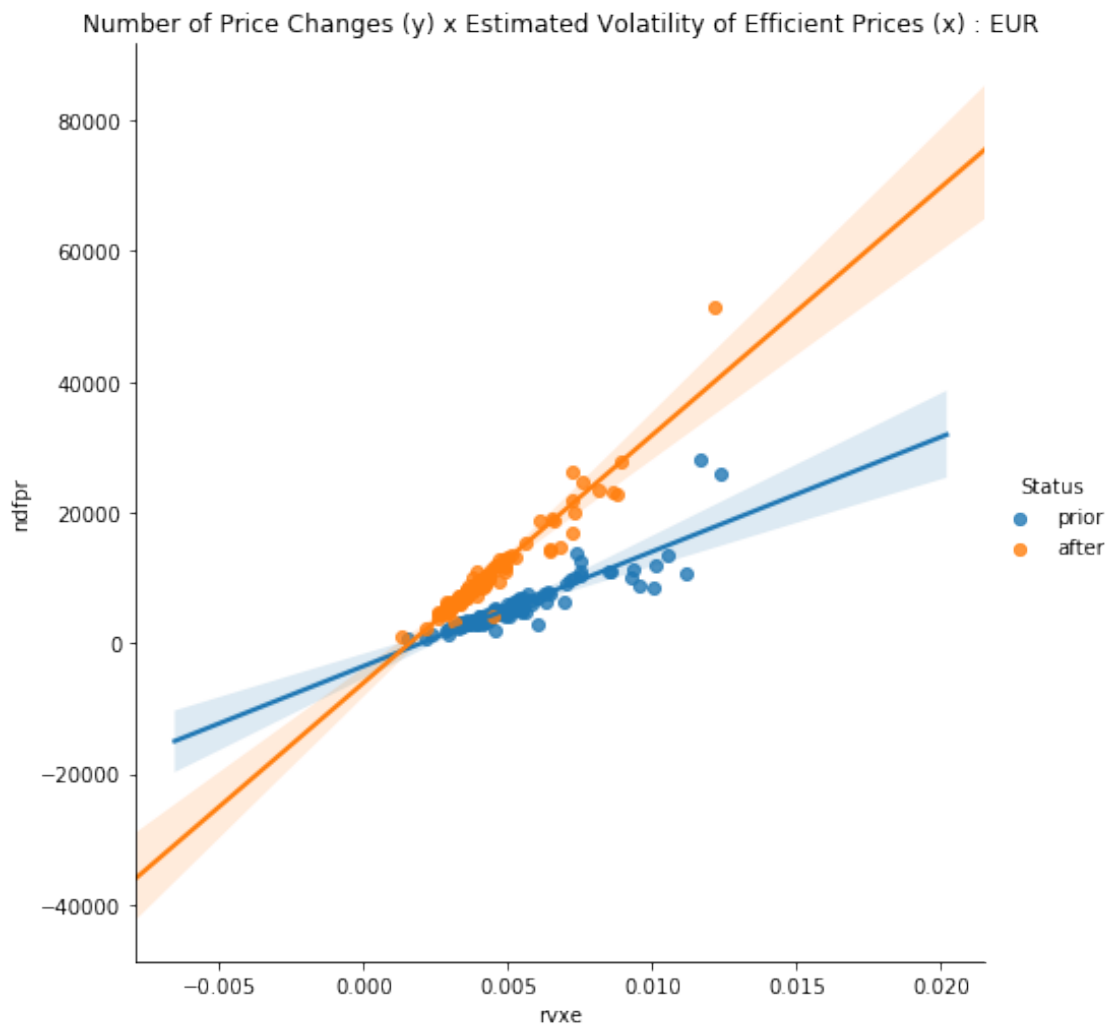
[108]: `cme.lin_reg(AFTER_OB_UZ_STATS, 'rvxe', 'ndfpr', True)`

```
                            OLS Regression Results
==================================================================================
Dep. Variable:                   ndfpr   R-squared:                       0.917
Model:                             OLS   Adj. R-squared:                  0.917
```

```
Method:                 Least Squares   F-statistic:                      1187.
Date:               Wed, 09 Oct 2019   Prob (F-statistic):            9.53e-60
Time:                       14:36:22   Log-Likelihood:                  50.105
No. Observations:                 109   AIC:                             -96.21
Df Residuals:                     107   BIC:                             -90.83
Df Model:                           1
Covariance Type:            nonrobust
===============================================================================
                 coef     std err          t      P>|t|      [0.025      0.975]
-------------------------------------------------------------------------------
const         17.4501       0.244     71.601      0.000      16.967      17.933
rvxe           1.5180       0.044     34.460      0.000       1.431       1.605
===============================================================================
Omnibus:                       87.104   Durbin-Watson:                    1.931
Prob(Omnibus):                  0.000   Jarque-Bera (JB):               675.314
Skew:                          -2.663   Prob(JB):                     2.28e-147
Kurtosis:                      13.969   Cond. No.                          94.2
===============================================================================
```

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

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

```
                    Robust linear Model Regression Results
===============================================================================
Dep. Variable:                  ndfpr   No. Observations:                  109
Model:                            RLM   Df Residuals:                      107
Method:                          IRLS   Df Model:                            1
Norm:                          HuberT
Scale Est.:                       mad
Cov Type:                          H1
Date:               Wed, 09 Oct 2019
Time:                       14:36:22
No. Iterations:                    19
===============================================================================
                 coef     std err          z      P>|z|      [0.025      0.975]
-------------------------------------------------------------------------------
const         17.3846       0.151    114.780      0.000      17.088      17.681
rvxe           1.5016       0.027     54.849      0.000       1.448       1.555
===============================================================================
```

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 .

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


Number of Trades (y) x Estimated Volatility of Efficient Prices (x) : EUR

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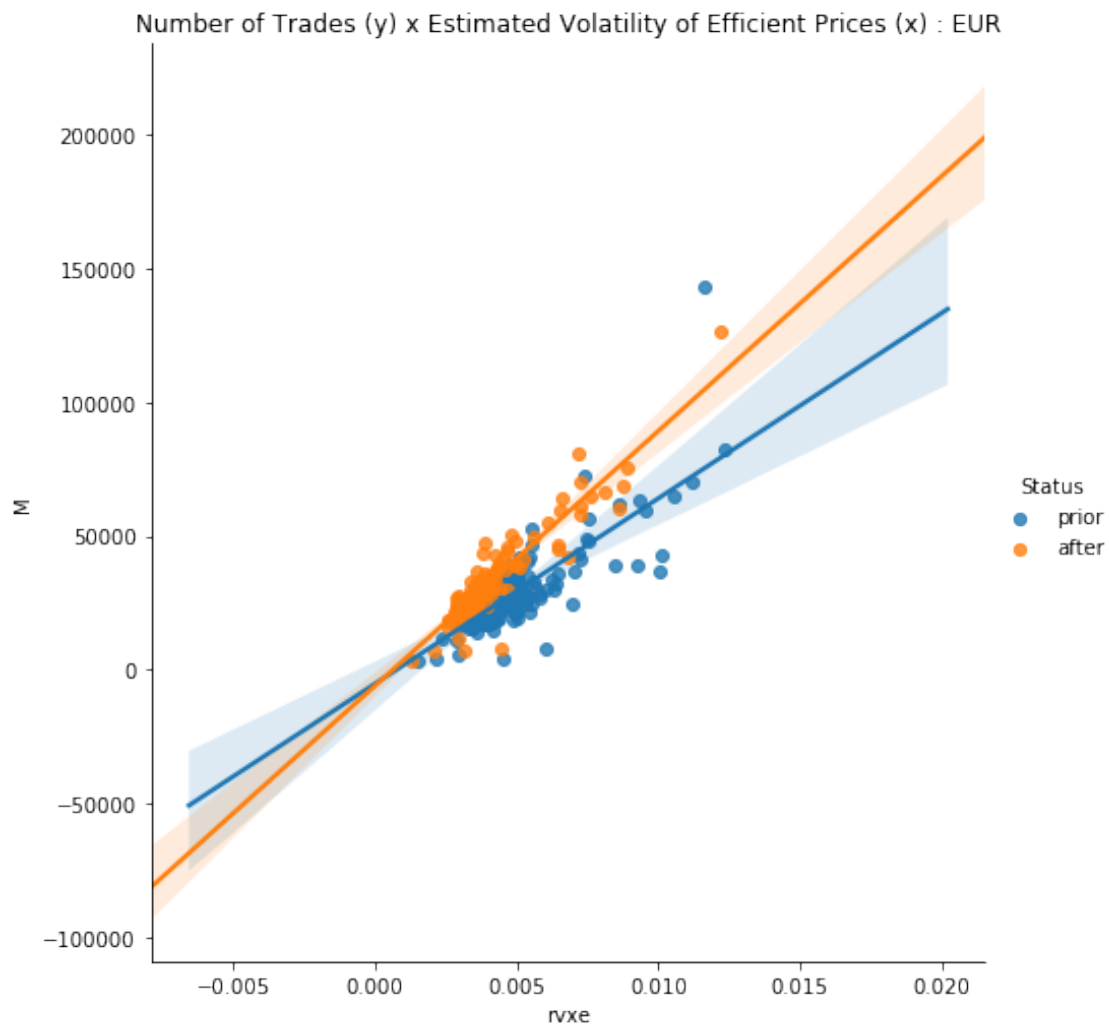
Number of Trades (y) x Estimated Volatility of Efficient Prices (x) : EUR
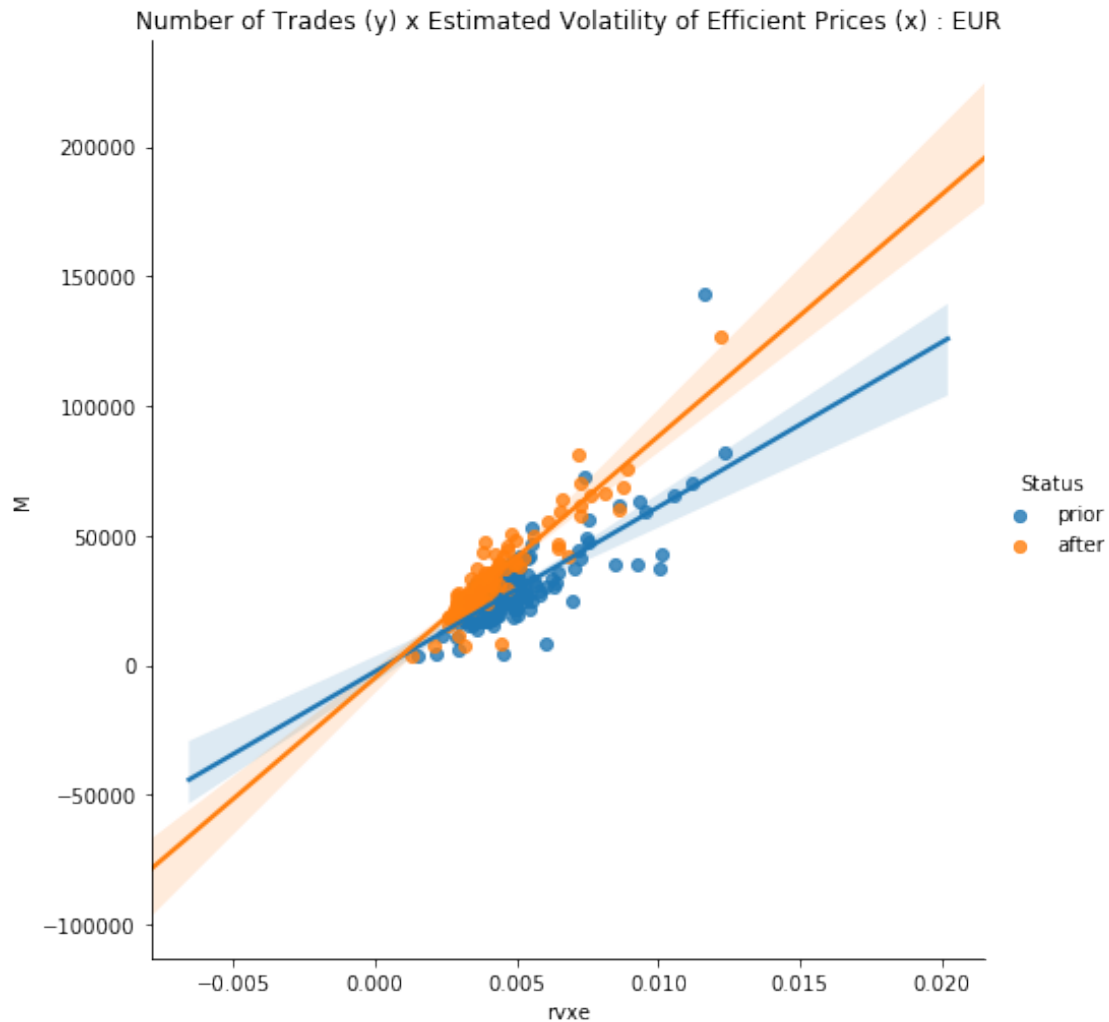
```
[112]: cme.lin_reg(PRIOR_OB_UZ_STATS, 'rvxe', 'M', True)
```

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                      M   R-squared:                       0.573
Model:                            OLS   Adj. R-squared:                  0.570
Method:                 Least Squares   F-statistic:                     188.9
Date:                Wed, 09 Oct 2019   Prob (F-statistic):           8.26e-28
Time:                        14:36:27   Log-Likelihood:                -44.632
No. Observations:                 143   AIC:                             93.26
Df Residuals:                     141   BIC:                             99.19
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
```

47

```
const          16.5558      0.465       35.608        0.000       15.637      17.475
rvxe            1.1928      0.087       13.745        0.000        1.021       1.364
==============================================================================
Omnibus:                         77.329   Durbin-Watson:                   1.282
Prob(Omnibus):                    0.000   Jarque-Bera (JB):              414.983
Skew:                            -1.893   Prob(JB):                     7.72e-91
Kurtosis:                        10.437   Cond. No.                         92.6
==============================================================================
```

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

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

```
                    Robust linear Model Regression Results
==============================================================================
Dep. Variable:                        M   No. Observations:                 143
Model:                              RLM   Df Residuals:                     141
Method:                            IRLS   Df Model:                           1
Norm:                            HuberT
Scale Est.:                         mad
Cov Type:                            H1
Date:                    Wed, 09 Oct 2019
Time:                            14:36:27
No. Iterations:                      14
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
const          16.1332      0.363       44.419        0.000       15.421      16.845
rvxe            1.1088      0.068       16.355        0.000        0.976       1.242
==============================================================================
```

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 .

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

```
                          OLS Regression Results
==============================================================================
Dep. Variable:                        M   R-squared:                       0.732
Model:                              OLS   Adj. R-squared:                  0.729
Method:                   Least Squares   F-statistic:                     291.8
Date:                    Wed, 09 Oct 2019   Prob (F-statistic):           2.43e-32
Time:                            14:36:27   Log-Likelihood:               -7.2746
No. Observations:                   109   AIC:                             18.55
Df Residuals:                       107   BIC:                             23.93
Df Model:                             1
```

```
Covariance Type:                nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const         17.3683      0.413     42.097      0.000      16.550      18.186
rvxe           1.2738      0.075     17.081      0.000       1.126       1.422
==============================================================================
Omnibus:                       94.174   Durbin-Watson:                   1.754
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              847.799
Skew:                          -2.894   Prob(JB):                     7.99e-185
Kurtosis:                      15.376   Cond. No.                         94.2
==============================================================================
```

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

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

```
                 Robust linear Model Regression Results
==============================================================================
Dep. Variable:                      M   No. Observations:                 109
Model:                            RLM   Df Residuals:                     107
Method:                          IRLS   Df Model:                           1
Norm:                          HuberT
Scale Est.:                       mad
Cov Type:                          H1
Date:                Wed, 09 Oct 2019
Time:                        14:36:27
No. Iterations:                    16
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
const         16.8512      0.239     70.596      0.000      16.383      17.319
rvxe           1.1740      0.043     27.210      0.000       1.089       1.259
==============================================================================
```

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 .

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

Realized Number of Price Changes (y) x Predicted Number of Price Changes (x) : EUR


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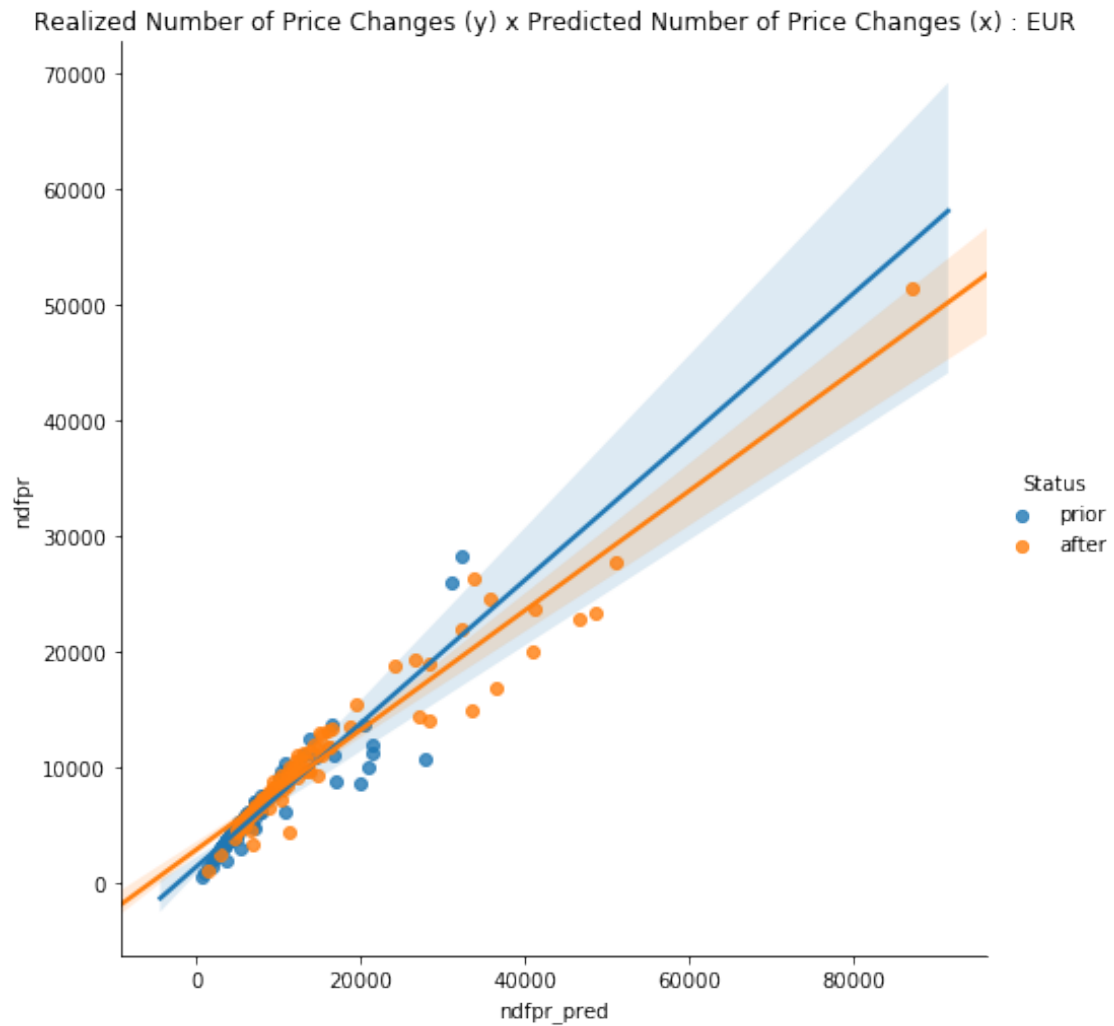
Realized Number of Price Changes (y) x Predicted Number of Price Changes (x) : EUR
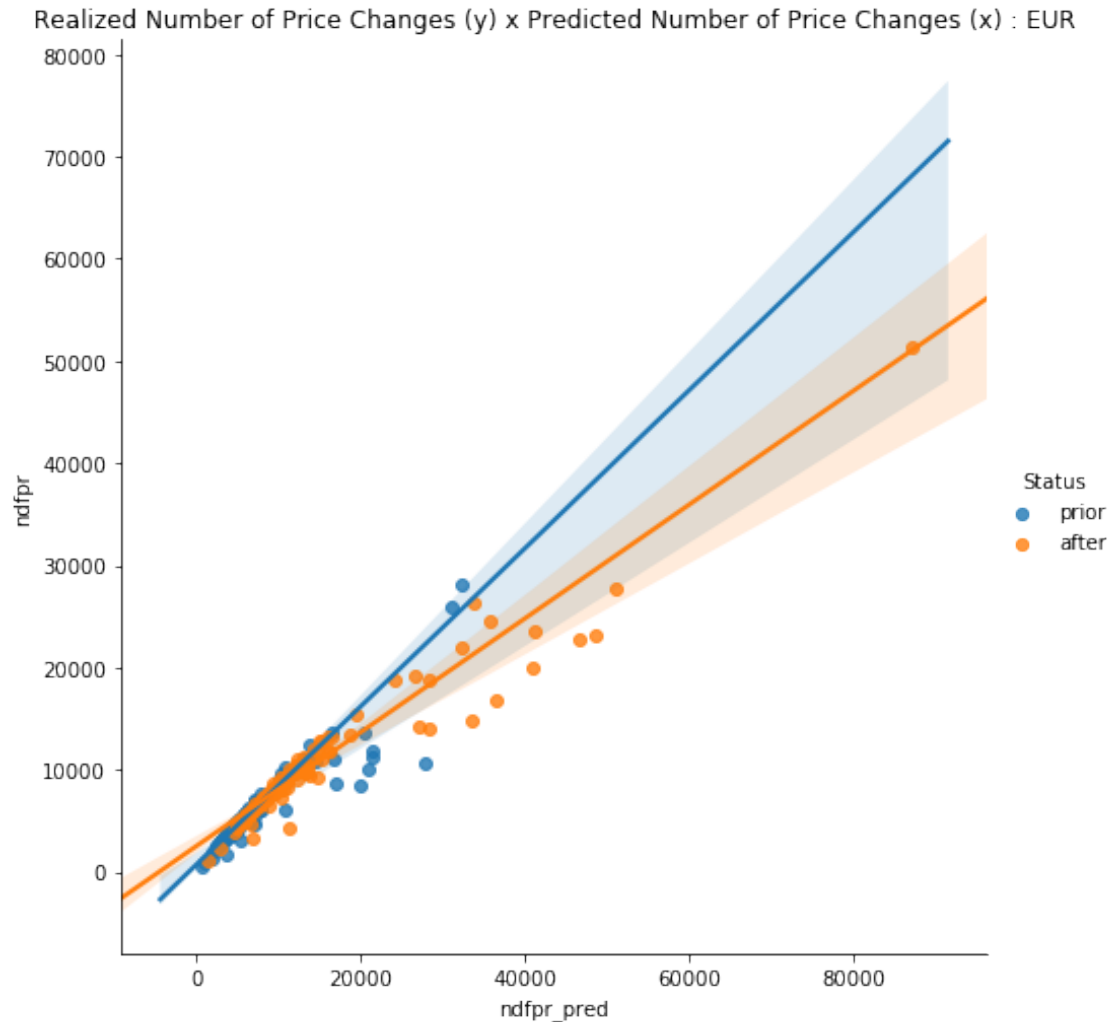

```
[118]: cme.lin_reg(PRIOR_OB_UZ_STATS, 'ndfpr_pred', 'ndfpr')
```

OLS Regression Results
```
==============================================================================
Dep. Variable:                  ndfpr   R-squared:                       0.851
Model:                            OLS   Adj. R-squared:                  0.850
Method:                 Least Squares   F-statistic:                     805.5
Date:                Wed, 09 Oct 2019   Prob (F-statistic):           3.67e-60
Time:                        14:36:39   Log-Likelihood:                -1237.6
No. Observations:                 143   AIC:                             2479.
Df Residuals:                     141   BIC:                             2485.
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
```

```
const         1366.3251    181.427       7.531        0.000      1007.657     1724.993
ndfpr_pred       0.6199      0.022      28.381        0.000         0.577        0.663
==============================================================================
Omnibus:                       58.123   Durbin-Watson:                   2.191
Prob(Omnibus):                  0.000   Jarque-Bera (JB):             1003.445
Skew:                          -0.859   Prob(JB):                    1.27e-218
Kurtosis:                      15.863   Cond. No.                     1.29e+04
==============================================================================
```

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
[2] The condition number is large, 1.29e+04. This might indicate that there are
strong multicollinearity or other numerical problems.

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

```
                    Robust linear Model Regression Results
==============================================================================
Dep. Variable:                  ndfpr   No. Observations:                  143
Model:                            RLM   Df Residuals:                      141
Method:                          IRLS   Df Model:                            1
Norm:                          HuberT
Scale Est.:                       mad
Cov Type:                          H1
Date:                Wed, 09 Oct 2019
Time:                        14:36:39
No. Iterations:                    45
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
const         727.8902     47.904     15.195      0.000     634.001     821.779
ndfpr_pred      0.7741      0.006    134.223      0.000       0.763       0.785
==============================================================================
```

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 .

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

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                  ndfpr   R-squared:                       0.931
Model:                            OLS   Adj. R-squared:                  0.931
Method:                 Least Squares   F-statistic:                     1448.
Date:                Wed, 09 Oct 2019   Prob (F-statistic):           5.13e-64
Time:                        14:36:39   Log-Likelihood:                -966.45
No. Observations:                 109   AIC:                             1937.
```

```
Df Residuals:                        107    BIC:                              1942.
Df Model:                              1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const        2847.4496    251.718     11.312      0.000    2348.447    3346.452
ndfpr_pred      0.5172      0.014     38.058      0.000       0.490       0.544
==============================================================================
Omnibus:                       13.638   Durbin-Watson:                   1.819
Prob(Omnibus):                  0.001   Jarque-Bera (JB):               27.953
Skew:                          -0.445   Prob(JB):                     8.51e-07
Kurtosis:                       5.316   Cond. No.                     2.81e+04
==============================================================================
```

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.
[2] The condition number is large, 2.81e+04. This might indicate that there are strong multicollinearity or other numerical problems.

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

```
                    Robust linear Model Regression Results
==============================================================================
Dep. Variable:                  ndfpr   No. Observations:                  109
Model:                            RLM   Df Residuals:                      107
Method:                          IRLS   Df Model:                            1
Norm:                          HuberT
Scale Est.:                       mad
Cov Type:                          H1
Date:                Wed, 09 Oct 2019
Time:                        14:36:39
No. Iterations:                    12
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
const        2540.7052    151.027     16.823      0.000    2244.698    2836.712
ndfpr_pred      0.5572      0.008     68.335      0.000       0.541       0.573
==============================================================================
```

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 .

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

Number of Trades (y) x Number of Price Changes (x) : EUR

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

Number of Trades (y) x Number of Price Changes (x) : EUR


```
[124]:  cme.regr_plot(OB_UZ_STATS.loc[:'2015-09-26'], 'ndfpr', 'M',\
            'Number of Trades (y) x Number of Price Changes (x) : '+CURR, True)
```

Number of Trades (y) x Number of Price Changes (x) : EUR


```
[125]: cme.regr_plot(OB_UZ_STATS.loc['2015-09-26':], 'ndfpr', 'M',\
       'Number of Trades (y) x Number of Price Changes (x) : '+CURR, True)
```
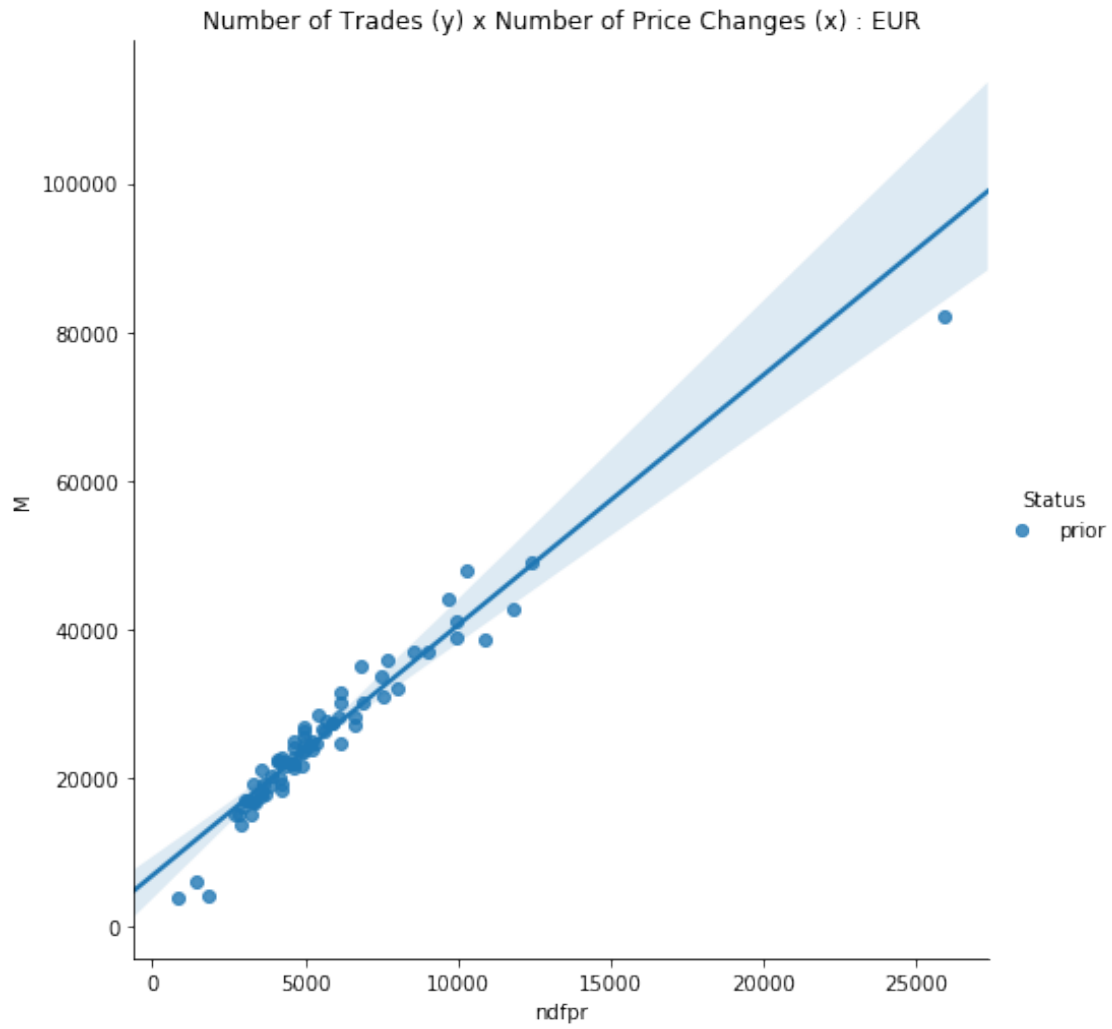
Number of Trades (y) x Number of Price Changes (x) : EUR
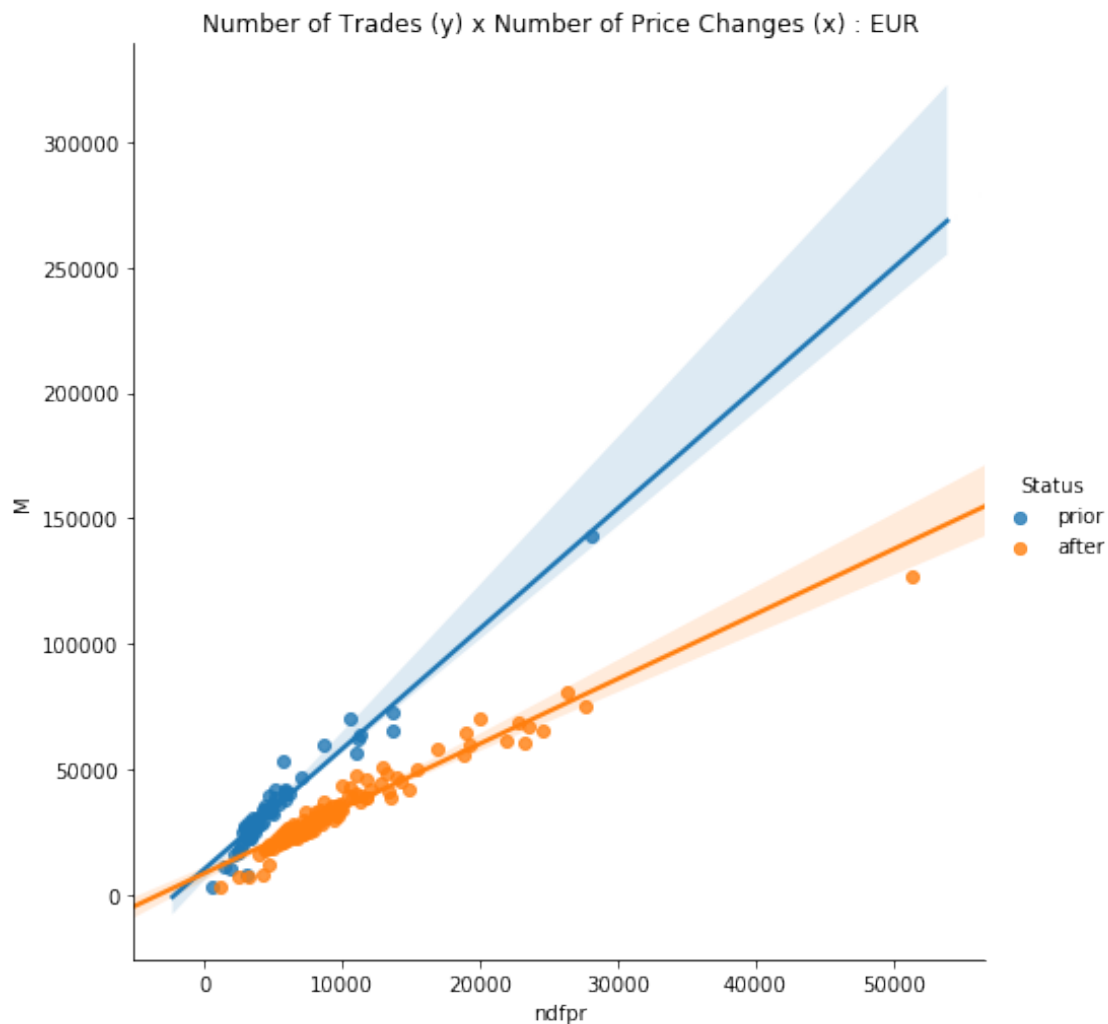
```
[126]: cme.lin_reg(PRIOR_OB_UZ_STATS.loc[:'2015-09-26'], 'ndfpr', 'M')
```

```
                          OLS Regression Results
==============================================================================
Dep. Variable:                      M   R-squared:                       0.938
Model:                            OLS   Adj. R-squared:                  0.937
Method:                 Least Squares   F-statistic:                     1095.
Date:                Wed, 09 Oct 2019   Prob (F-statistic):           1.07e-45
Time:                        14:36:51   Log-Likelihood:                -700.22
No. Observations:                  75   AIC:                             1404.
Df Residuals:                      73   BIC:                             1409.
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
```

```
const      7590.6126    631.093     12.028       0.000     6332.846    8848.379
ndfpr         3.2082      0.097     33.094       0.000        3.015       3.401
==============================================================================
Omnibus:                      14.546   Durbin-Watson:                   1.783
Prob(Omnibus):                 0.001   Jarque-Bera (JB):               23.268
Skew:                         -0.726   Prob(JB):                     8.86e-06
Kurtosis:                      5.310   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.
```

[127]: `cme.lin_reg(PRIOR_OB_UZ_STATS.loc['2015-09-26':], 'ndfpr', 'M')`

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                      M   R-squared:                       0.943
Model:                            OLS   Adj. R-squared:                  0.942
Method:                 Least Squares   F-statistic:                     1088.
Date:                Wed, 09 Oct 2019   Prob (F-statistic):           9.91e-43
Time:                        14:36:51   Log-Likelihood:                -669.87
No. Observations:                  68   AIC:                             1344.
Df Residuals:                      66   BIC:                             1348.
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const       9968.5480    922.956     10.801       0.000     8125.806    1.18e+04
ndfpr          4.8361      0.147     32.984       0.000        4.543       5.129
==============================================================================
Omnibus:                      10.106   Durbin-Watson:                   1.799
Prob(Omnibus):                 0.006   Jarque-Bera (JB):               22.087
Skew:                         -0.291   Prob(JB):                     1.60e-05
Kurtosis:                      5.731   Cond. No.                     1.03e+04
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
[2] The condition number is large, 1.03e+04. This might indicate that there are
strong multicollinearity or other numerical problems.
```

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

```
                          OLS Regression Results
==============================================================================
Dep. Variable:                      M   R-squared:                       0.795
Model:                            OLS   Adj. R-squared:                  0.794
Method:                 Least Squares   F-statistic:                     546.9
Date:                Wed, 09 Oct 2019   Prob (F-statistic):           2.25e-50
Time:                        14:36:51   Log-Likelihood:                 -1474.0
No. Observations:                 143   AIC:                             2952.
Df Residuals:                     141   BIC:                             2958.
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const       8523.6772   1088.390      7.831      0.000    6372.006    1.07e+04
ndfpr          3.9716      0.170     23.385      0.000       3.636       4.307
==============================================================================
Omnibus:                        8.977   Durbin-Watson:                   0.700
Prob(Omnibus):                  0.011   Jarque-Bera (JB):               16.418
Skew:                           0.203   Prob(JB):                     0.000272
Kurtosis:                       4.609   Cond. No.                     1.14e+04
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
[2] The condition number is large, 1.14e+04. This might indicate that there are
strong multicollinearity or other numerical problems.
```

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

```
                    Robust linear Model Regression Results
==============================================================================
Dep. Variable:                      M   No. Observations:                  143
Model:                            RLM   Df Residuals:                      141
Method:                          IRLS   Df Model:                            1
Norm:                          HuberT
Scale Est.:                       mad
Cov Type:                          H1
Date:                Wed, 09 Oct 2019
Time:                        14:36:51
No. Iterations:                     4
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
const       8107.7176    992.405      8.170      0.000    6162.640    1.01e+04
ndfpr          4.0277      0.155     26.009      0.000       3.724       4.331
==============================================================================
```

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 .

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

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                      M   R-squared:                       0.943
Model:                            OLS   Adj. R-squared:                  0.942
Method:                 Least Squares   F-statistic:                     1755.
Date:                Wed, 09 Oct 2019   Prob (F-statistic):           3.41e-68
Time:                        14:36:51   Log-Likelihood:                -1061.0
No. Observations:                 109   AIC:                             2126.
Df Residuals:                     107   BIC:                             2131.
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const       9026.7195    723.928     12.469      0.000    7591.617    1.05e+04
ndfpr          2.5282      0.060     41.887      0.000       2.409       2.648
==============================================================================
Omnibus:                        5.468   Durbin-Watson:                   1.346
Prob(Omnibus):                  0.065   Jarque-Bera (JB):                7.320
Skew:                          -0.174   Prob(JB):                       0.0257
Kurtosis:                       4.221   Cond. No.                     2.20e+04
==============================================================================
```

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.
[2] The condition number is large, 2.2e+04. This might indicate that there are strong multicollinearity or other numerical problems.

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

```
                    Robust linear Model Regression Results
==============================================================================
Dep. Variable:                      M   No. Observations:                 109
Model:                            RLM   Df Residuals:                     107
Method:                          IRLS   Df Model:                           1
Norm:                           HuberT
Scale Est.:                        mad
Cov Type:                           H1
Date:                Wed, 09 Oct 2019
Time:                        14:36:51
No. Iterations:                     6
```

```
================================================================================
                 coef      std err          z       P>|z|      [0.025      0.975]
--------------------------------------------------------------------------------
const        8567.0067      600.851     14.258      0.000     7389.361    9744.652
ndfpr           2.5810        0.050     51.523      0.000        2.483       2.679
================================================================================
```

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 .

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

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

Volume (y) x Number of Trades (x) : EUR

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

                          OLS Regression Results
==
Dep. Variable: Volume   R-squared: 0.907
Model: OLS   Adj. R-squared: 0.907
Method: Least Squares   F-statistic: 1383.
Date: Wed, 09 Oct 2019   Prob (F-statistic):   9.33e-75
Time: 14:36:53   Log-Likelihood: -1601.2
No. Observations: 143   AIC: 3206.
Df Residuals: 141   BIC: 3212.
Df Model: 1
Covariance Type: nonrobust
==
                 coef   std err   t   P>|t| [0.025   0.975]

```
const        2.127e+04    3122.099        6.812      0.000    1.51e+04    2.74e+04
M               3.4504       0.093       37.187      0.000       3.267       3.634
===============================================================================
Omnibus:                        4.050   Durbin-Watson:                   0.743
Prob(Omnibus):                  0.132   Jarque-Bera (JB):                3.707
Skew:                           0.390   Prob(JB):                        0.157
Kurtosis:                       3.111   Cond. No.                     7.07e+04
===============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
[2] The condition number is large, 7.07e+04. This might indicate that there are
strong multicollinearity or other numerical problems.
```

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

```
                  Robust linear Model Regression Results
===============================================================================
Dep. Variable:                 Volume   No. Observations:                  143
Model:                            RLM   Df Residuals:                      141
Method:                          IRLS   Df Model:                            1
Norm:                          HuberT
Scale Est.:                       mad
Cov Type:                          H1
Date:                Wed, 09 Oct 2019
Time:                        14:36:53
No. Iterations:                     3
===============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
-------------------------------------------------------------------------------
const        2.056e+04    2976.103        6.908      0.000    1.47e+04    2.64e+04
M               3.4618       0.088       39.140      0.000       3.288       3.635
===============================================================================
```
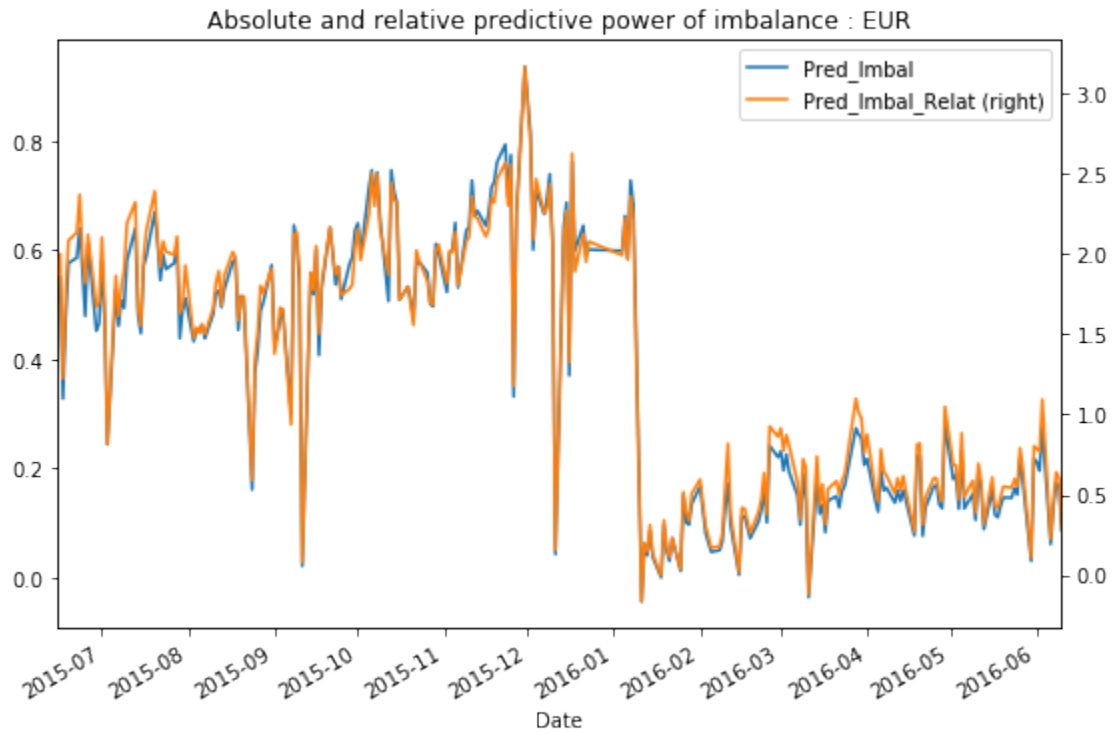
If the model instance has been used for another fit with different fit
parameters, then the fit options might not be the correct ones anymore .

[136]:
```
IMBAL_STATS_TS.drop(columns=['eta1']).plot(secondary_y=['Pred_Imbal_Relat'],\
    figsize=(9,6), title='Absolute and relative predictive power of imbalance :␣
↪EUR');
```

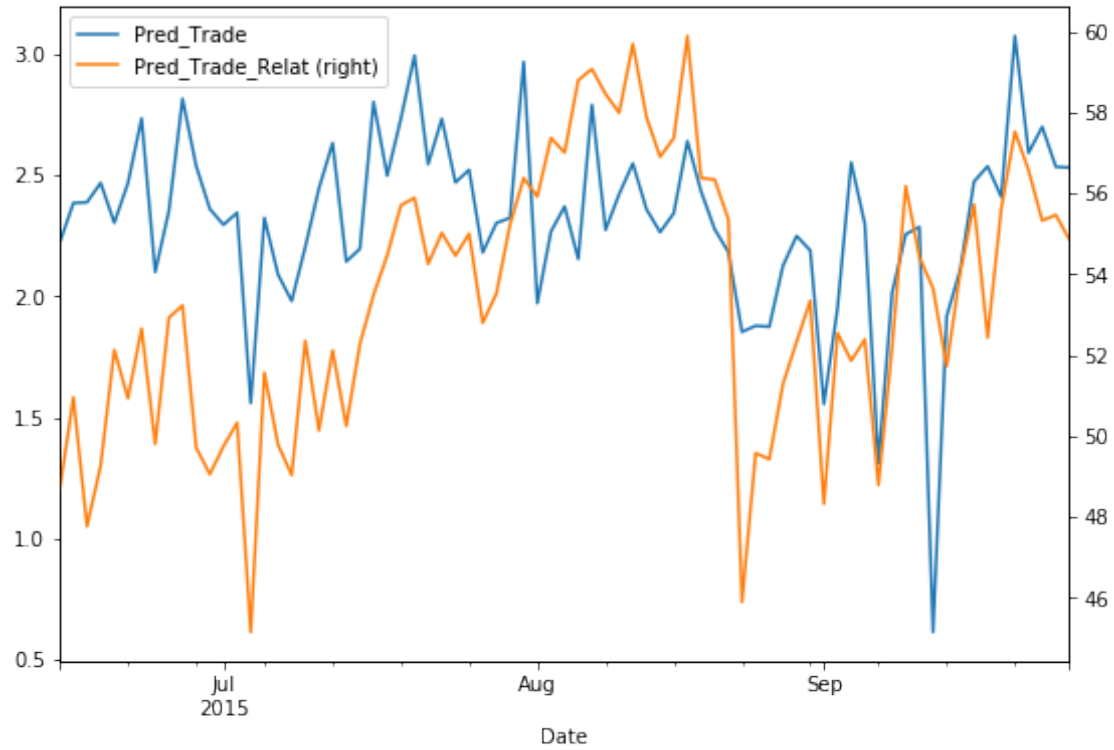Absolute and relative predictive power of imbalance : EUR

```
[137]: TRADE_STATS_TS.plot(secondary_y=['Pred_Trade_Relat'], figsize=(9,6));
```
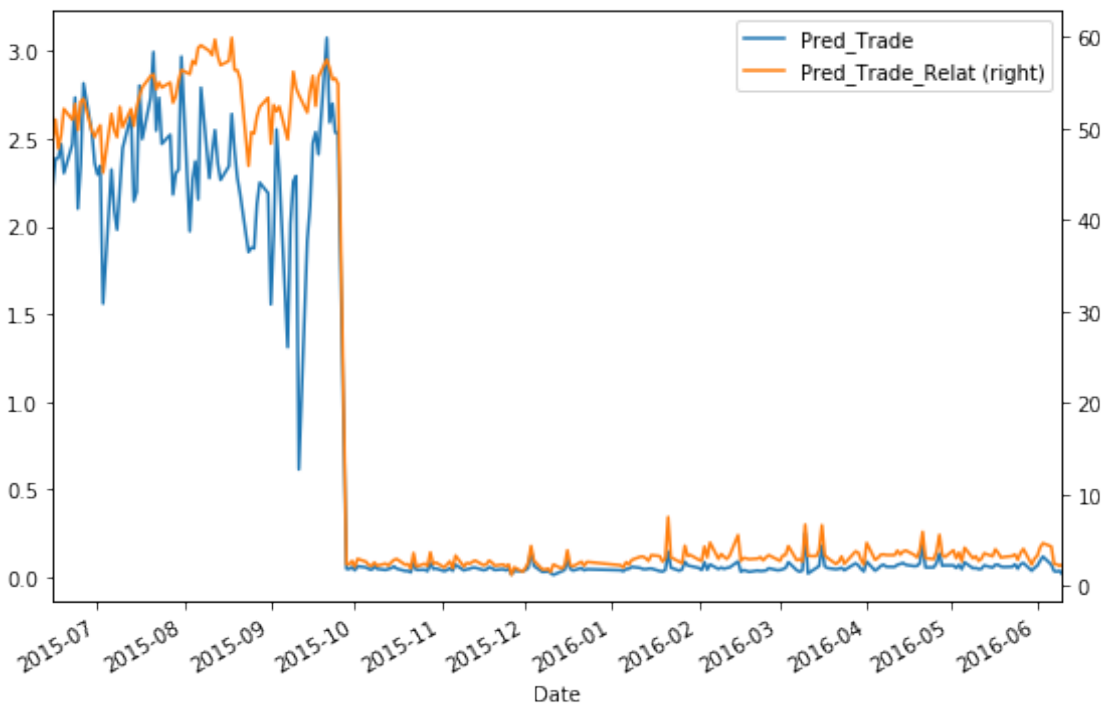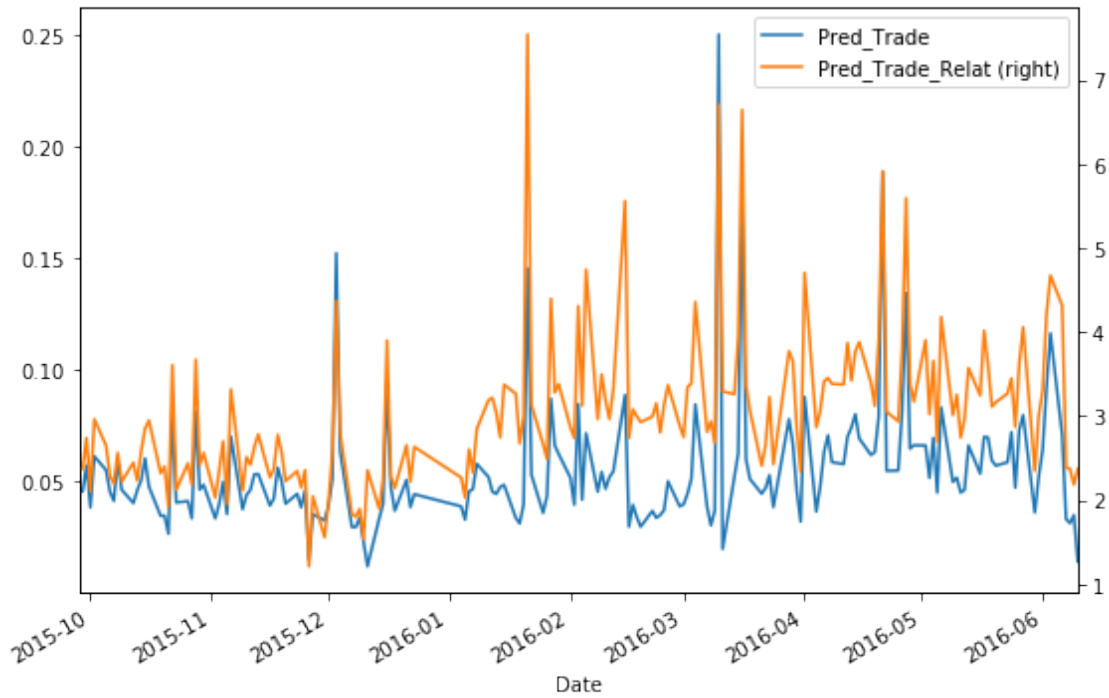
```
[138]: TRADE_STATS_TS.loc[:'2015-09-26'].plot(secondary_y=['Pred_Trade_Relat'],␣
       ↪figsize=(9,6));
```
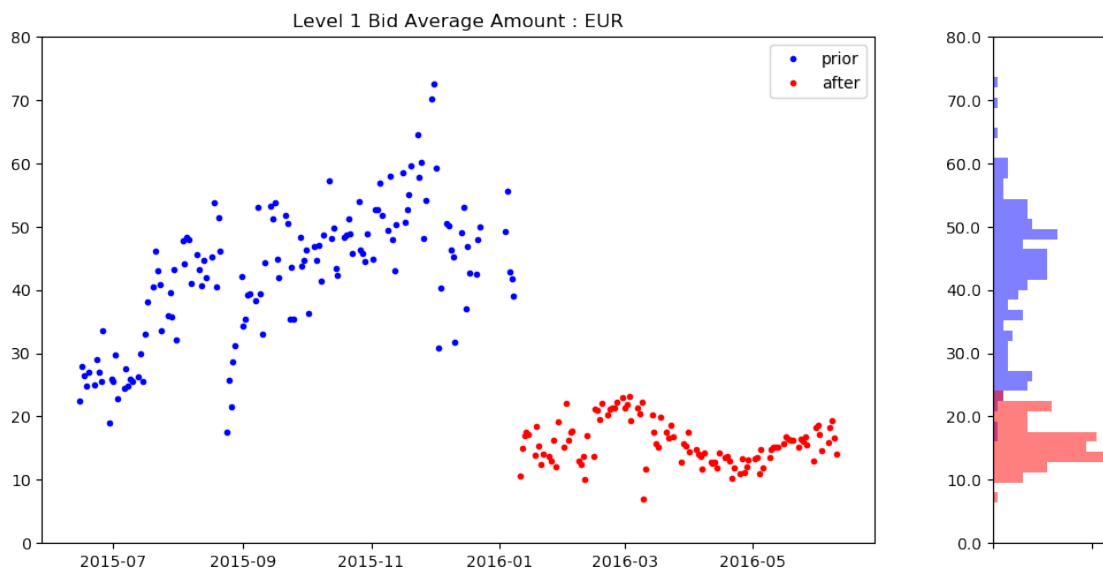


```
[139]: TRADE_STATS_TS.loc['2015-09-26':].plot(secondary_y=['Pred_Trade_Relat'],␣
       ↪figsize=(9,6));
```
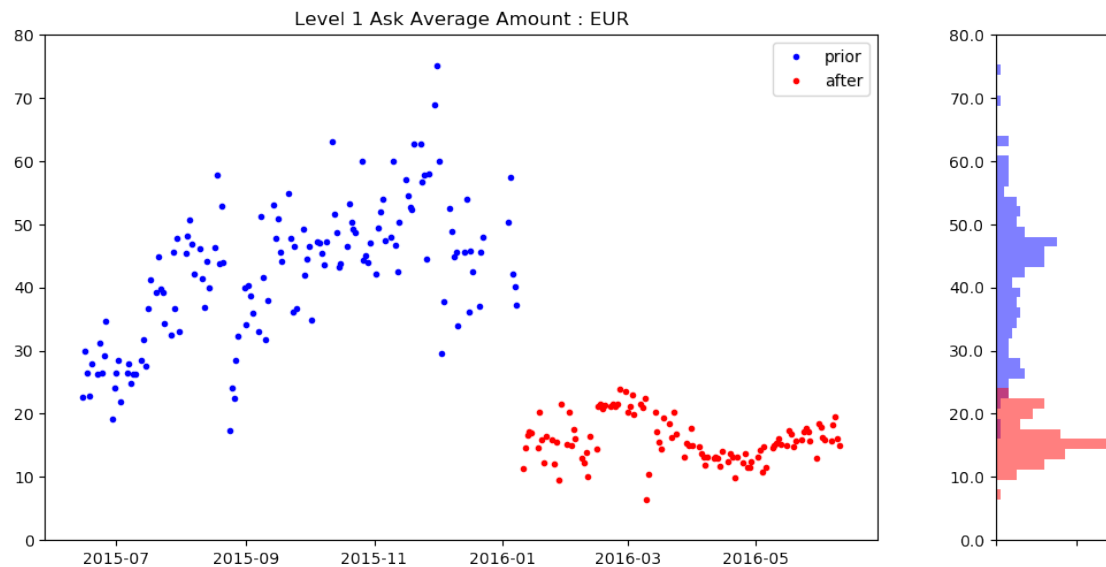
```
[140]: OB_UZ_STATS_SPREADS = cme.spread_stats(OB_UZ_STATS)
```

```
[141]: cme.time_series_hist_plot(OB_UZ_STATS_SPREADS, 'bid1qty',\
            'Level 1 Bid Average Amount : '+CURR, 0, 80, 50)
```
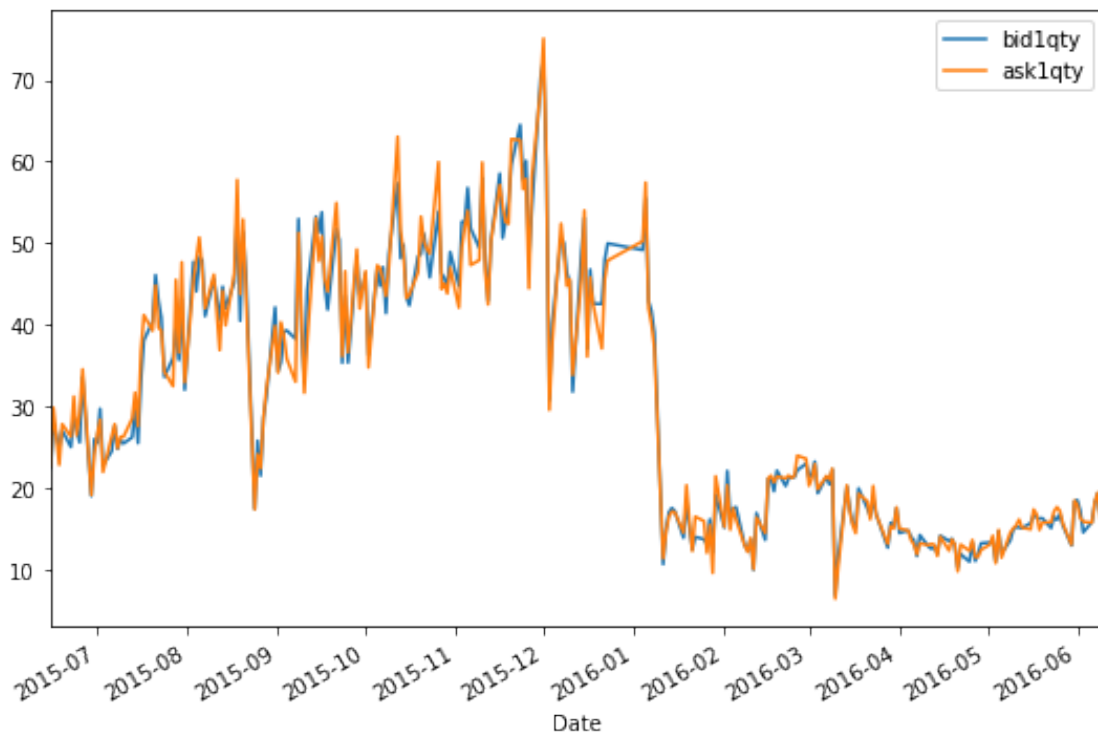

Level 1 Bid Average Amount : EUR

```
[142]: cme.time_series_hist_plot(OB_UZ_STATS_SPREADS, 'ask1qty',\
       'Level 1 Ask Average Amount : '+CURR, 0, 80, 50)
```



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

```
[144]: 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()
```

```
[144]: bid1qty    2.669760
       ask1qty    2.656826
       dtype: float64
```

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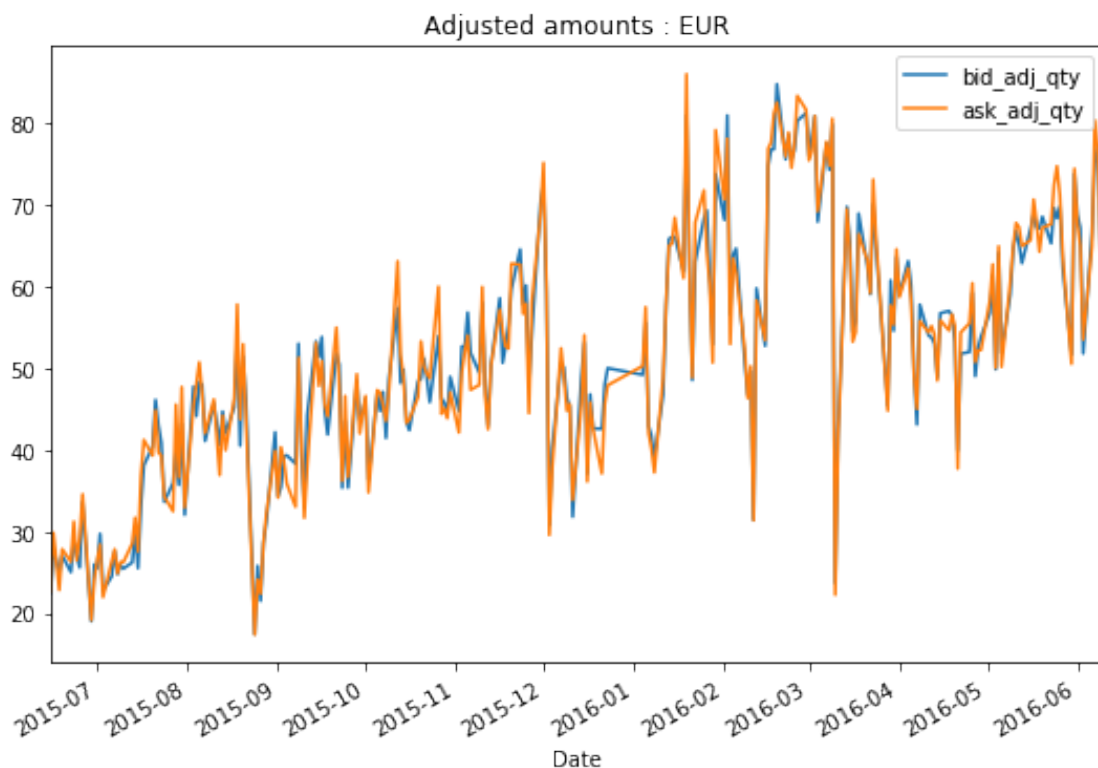


```
[146]: OB_UZ_STATS_SPREADS[['bid_adj_tomid', 'ask_adj_tomid']].plot(figsize=(9,6),\
           title='Adjusted distances between mid and best level(s) expressed in USD :
       →'+CURR);
```

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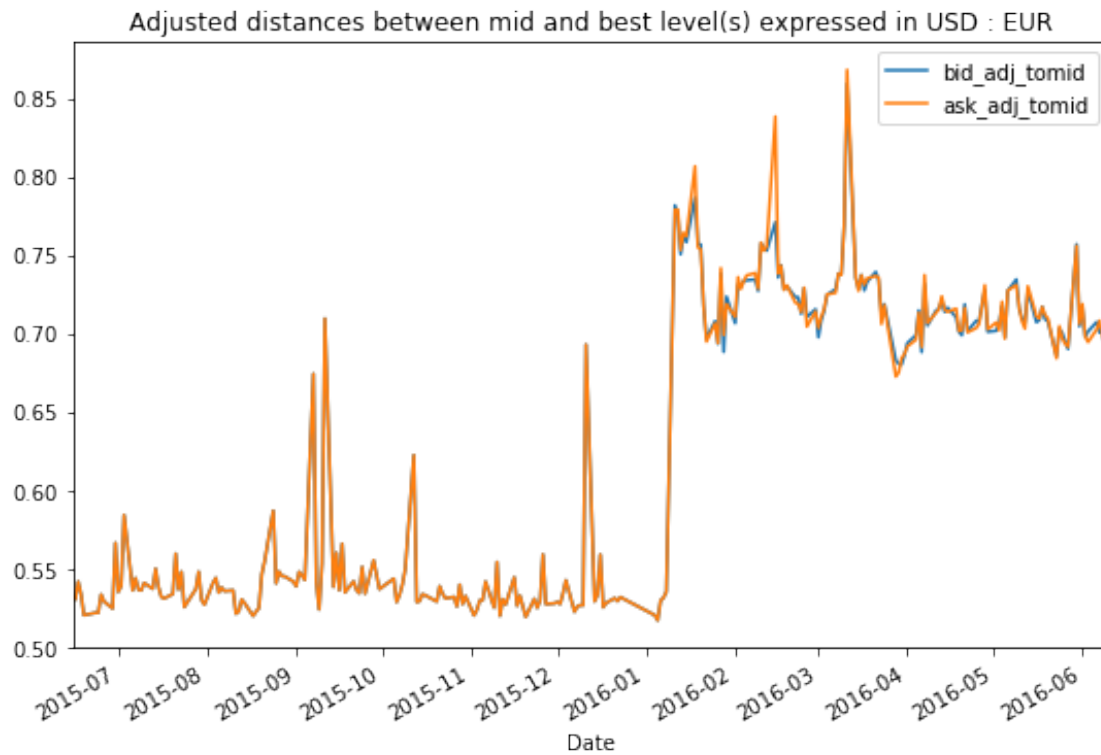
```
[147]:  plt.figure(figsize=(9, 6))
        sns.scatterplot(x='bid_adj_qty', y='bid_adj_tomid',\
                        hue='Status', data=OB_UZ_STATS_SPREADS);
        plt.title('Adjusted distances between mid and best level(s) expressed in USD␣
         ↪(y) vs Adjusted amount (x) : '+CURR);
```

Adjusted distances between mid and best level(s) expressed in USD (y) vs Adjusted amount (x) : EUR
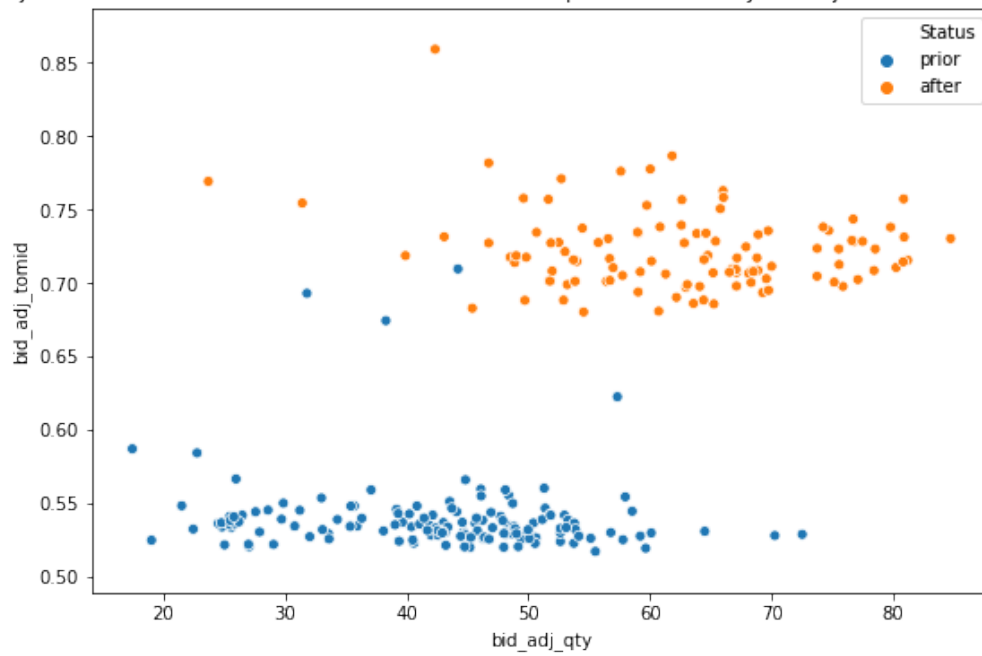
```
[148]: plt.figure(figsize=(9, 6))
       sns.scatterplot(x='ask_adj_qty', y='ask_adj_tomid',\
                       hue='Status', data=OB_UZ_STATS_SPREADS);
```
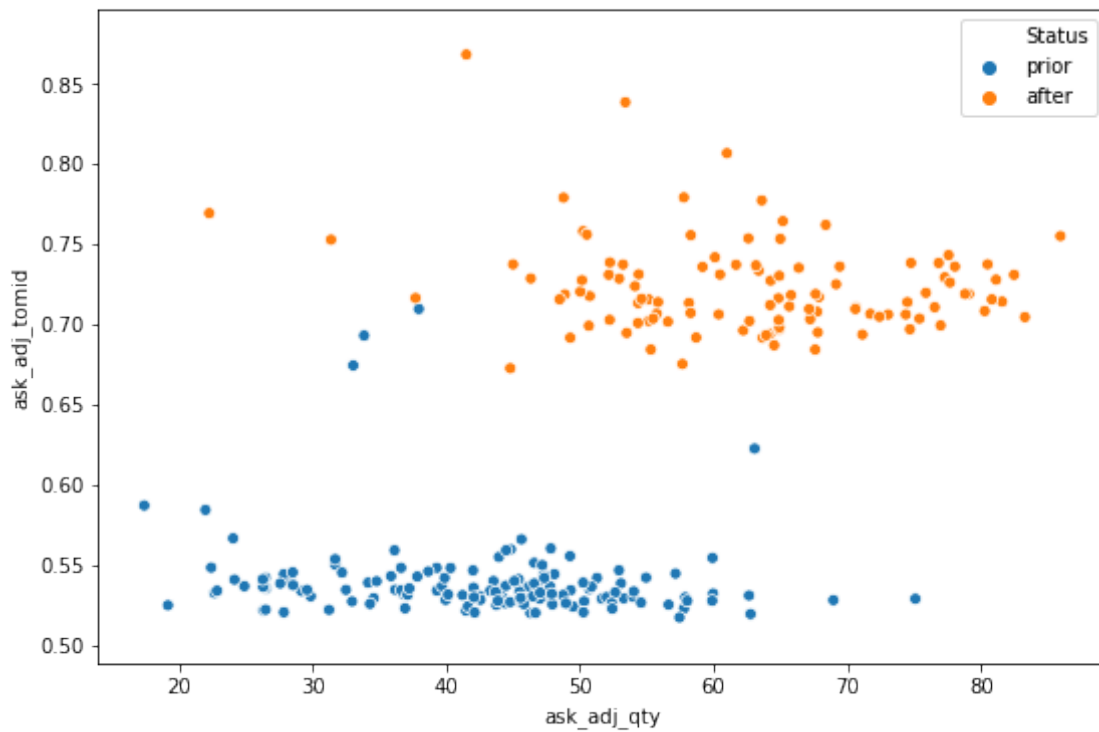
2.8.1 Costs

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

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

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

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

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

```
[154]: 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');
```


Average Cost as a function of Trade Amount : EUR - prior

```
[155]: 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');
```
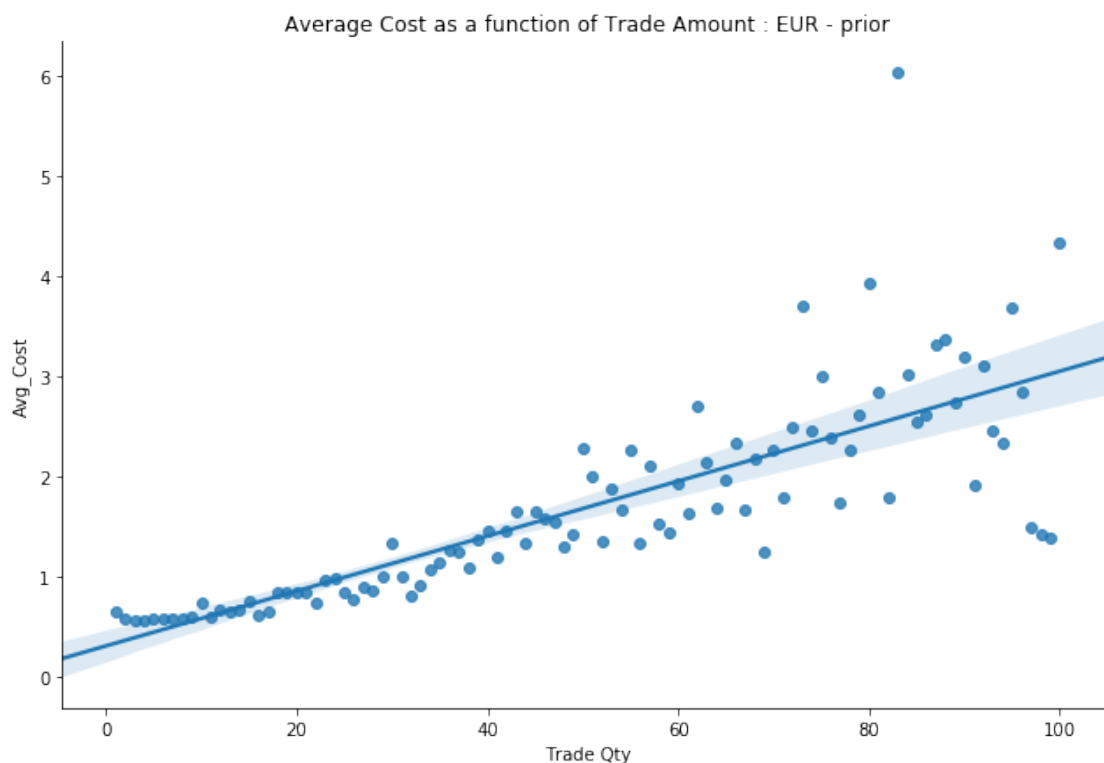
Average Cost as a function of Trade Amount : EUR - prior

```
[156]: 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: 0.805
Model: OLS   Adj. R-squared: 0.801
Method: Least Squares   F-statistic: 198.3
Date: Wed, 09 Oct 2019   Prob (F-statistic):   1.15e-18
Time: 14:37:03   Log-Likelihood: 18.551
No. Observations: 50   AIC: -33.10
Df Residuals: 48   BIC: -29.28
Df Model: 1
Covariance Type: nonrobust
==
                 coef   std err   t   P>|t| [0.025   0.975]
----
const   0.3847   0.049   7.862   0.000   0.286   0.483
Trade Qty   0.0235   0.002   14.082   0.000   0.020   0.027
==
Omnibus: 27.725   Durbin-Watson: 1.322
Prob(Omnibus):   0.000   Jarque-Bera (JB):   72.081
Skew: 1.460   Prob(JB):   2.23e-16

```
Kurtosis:                    8.106    Cond. No.                      59.5
=========================================================================
```

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

[157]: `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:                        14:37:03
No. Iterations:                    21
=========================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
-------------------------------------------------------------------------
const          0.4113      0.039     10.436      0.000       0.334       0.489
Trade Qty      0.0219      0.001     16.289      0.000       0.019       0.025
=========================================================================
```

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 .

[158]: `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:                    0.644
Model:                            OLS   Adj. R-squared:               0.641
Method:                 Least Squares   F-statistic:                  177.6
Date:                Wed, 09 Oct 2019   Prob (F-statistic):        9.96e-24
Time:                        14:37:03   Log-Likelihood:             -88.868
No. Observations:                 100   AIC:                          181.7
Df Residuals:                      98   BIC:                          186.9
Df Model:                           1
Covariance Type:            nonrobust
=========================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
-------------------------------------------------------------------------
```

```
const           0.3082      0.120       2.573       0.012       0.071       0.546
Trade Qty       0.0274      0.002      13.325       0.000       0.023       0.032
==============================================================================
Omnibus:                       64.232   Durbin-Watson:                   1.847
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              615.988
Skew:                           1.778   Prob(JB):                     1.74e-134
Kurtosis:                      14.627   Cond. No.                         117.
==============================================================================
```

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

```
[159]: 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:                         14:37:03
No. Iterations:                     24
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
const           0.3097      0.065       4.732       0.000       0.181       0.438
Trade Qty       0.0268      0.001      23.787       0.000       0.025       0.029
==============================================================================
```

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 .

```
[160]: 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');
```

Average Cost as a function of Trade Amount : EUR - after

```
[161]: 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');
```
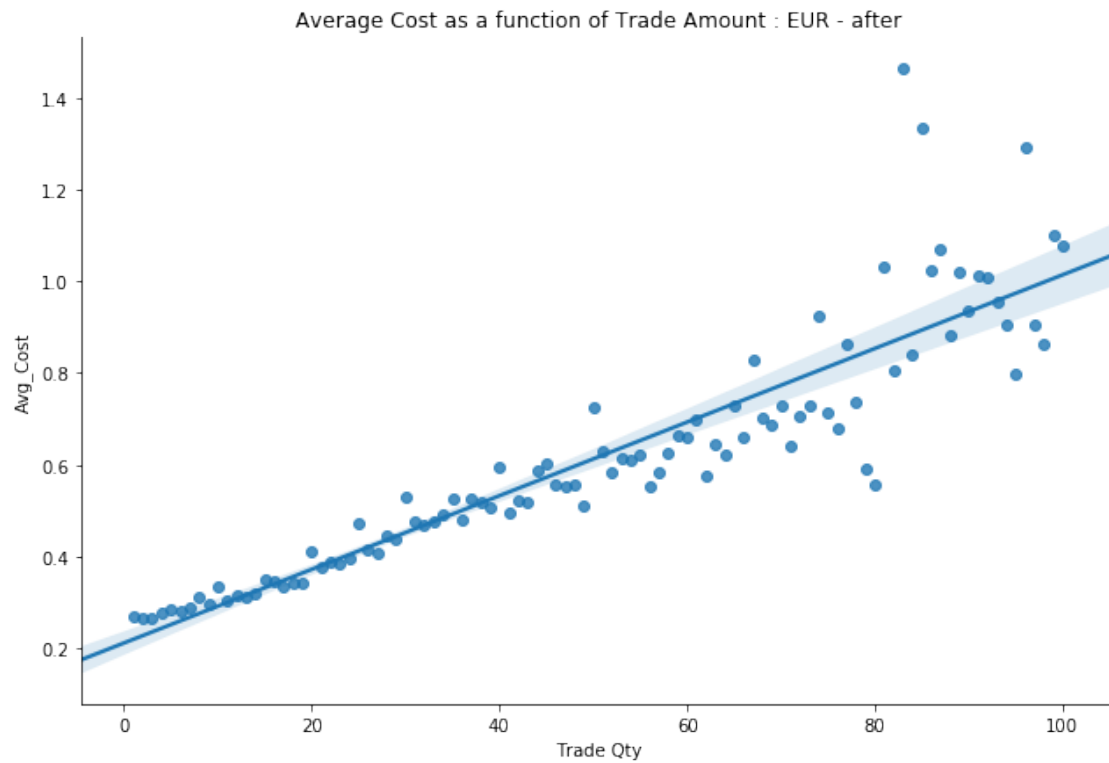
Average Cost as a function of Trade Amount : EUR - after
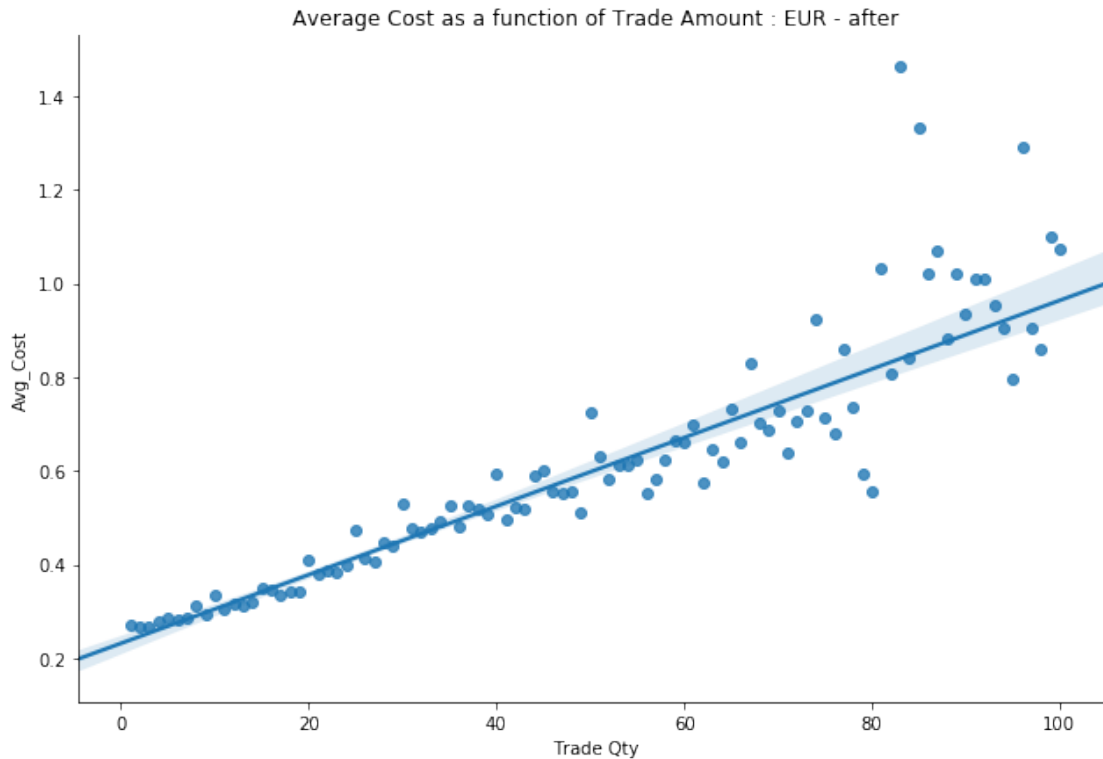
```
[162]: cme.lin_reg(cme.cost_mean(AFTER_COST_STATS, 50).reset_index(), 'Trade Qty',␣
       ↪'Avg_Cost')
```

```
                            OLS Regression Results
==============================================================================
Dep. Variable:               Avg_Cost   R-squared:                       0.913
Model:                            OLS   Adj. R-squared:                  0.911
Method:                 Least Squares   F-statistic:                     502.2
Date:                Wed, 09 Oct 2019   Prob (F-statistic):           4.53e-27
Time:                        14:37:12   Log-Likelihood:                 100.33
No. Observations:                  50   AIC:                            -196.7
Df Residuals:                      48   BIC:                            -192.8
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const          0.2382      0.010     24.989      0.000       0.219       0.257
Trade Qty      0.0073      0.000     22.409      0.000       0.007       0.008
==============================================================================
Omnibus:                       17.728   Durbin-Watson:                   2.031
Prob(Omnibus):                  0.000   Jarque-Bera (JB):               29.482
Skew:                           1.065   Prob(JB):                     3.96e-07
```

```
Kurtosis:                       6.100   Cond. No.                       59.5
==============================================================================
```

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

[163]: `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:                          14:37:12
No. Iterations:                      22
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
const          0.2411      0.007     34.604      0.000       0.227       0.255
Trade Qty      0.0070      0.000     29.473      0.000       0.007       0.007
==============================================================================
```

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 .

[164]: `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:                     0.818
Model:                              OLS   Adj. R-squared:                0.817
Method:                   Least Squares   F-statistic:                   441.7
Date:                  Wed, 09 Oct 2019   Prob (F-statistic):         4.38e-38
Time:                          14:37:12   Log-Likelihood:               79.683
No. Observations:                   100   AIC:                          -155.4
Df Residuals:                        98   BIC:                          -150.2
Df Model:                             1
Covariance Type:              nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
```

```
const           0.2118      0.022       9.538      0.000      0.168      0.256
Trade Qty       0.0080      0.000      21.017      0.000      0.007      0.009
==============================================================================
Omnibus:                       67.692   Durbin-Watson:                   1.981
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              485.858
Skew:                           2.059   Prob(JB):                     3.14e-106
Kurtosis:                      12.982   Cond. No.                         117.
==============================================================================

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

[165]:
```python
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:                        14:37:12
No. Iterations:                    33
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
const          0.2315      0.011     21.285      0.000      0.210      0.253
Trade Qty      0.0073      0.000     39.174      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 .
```
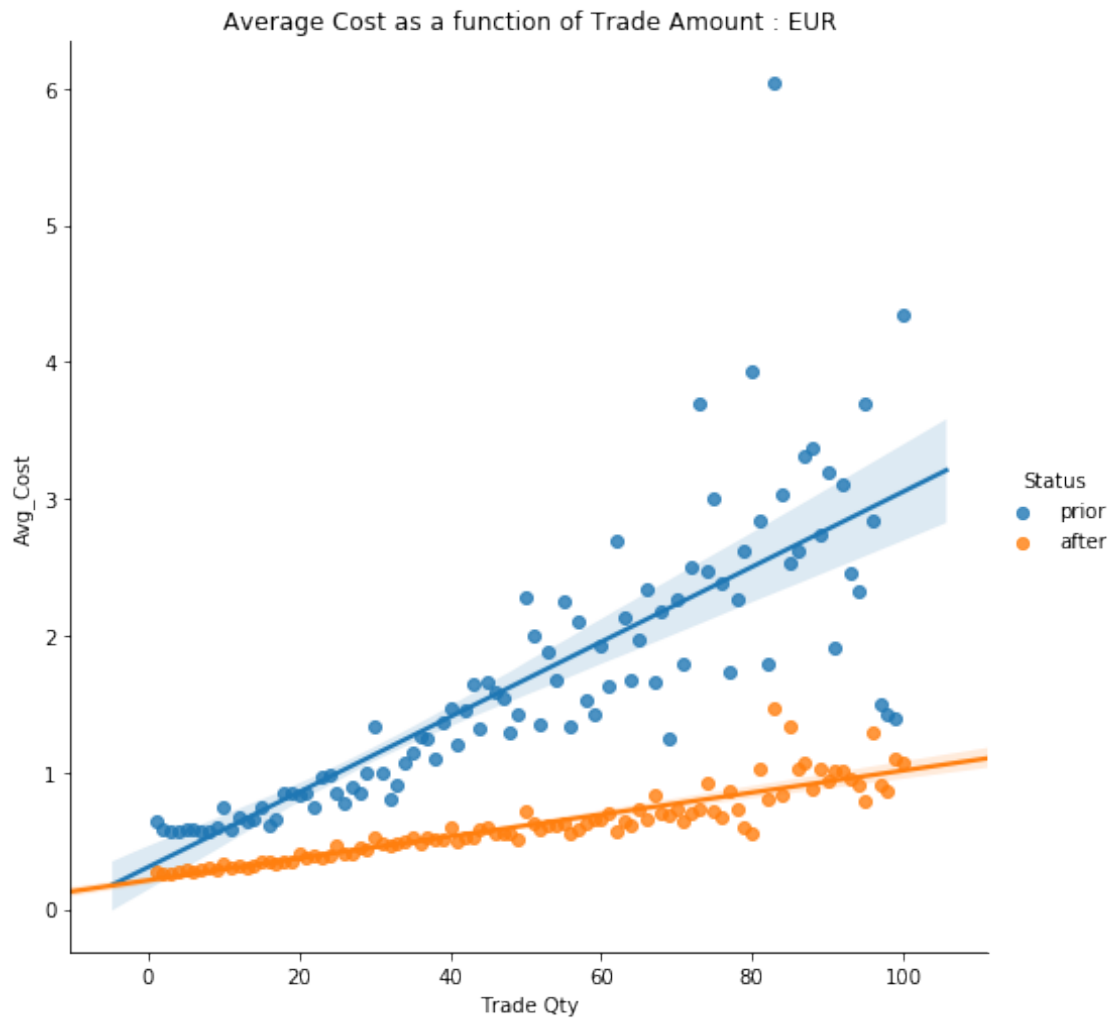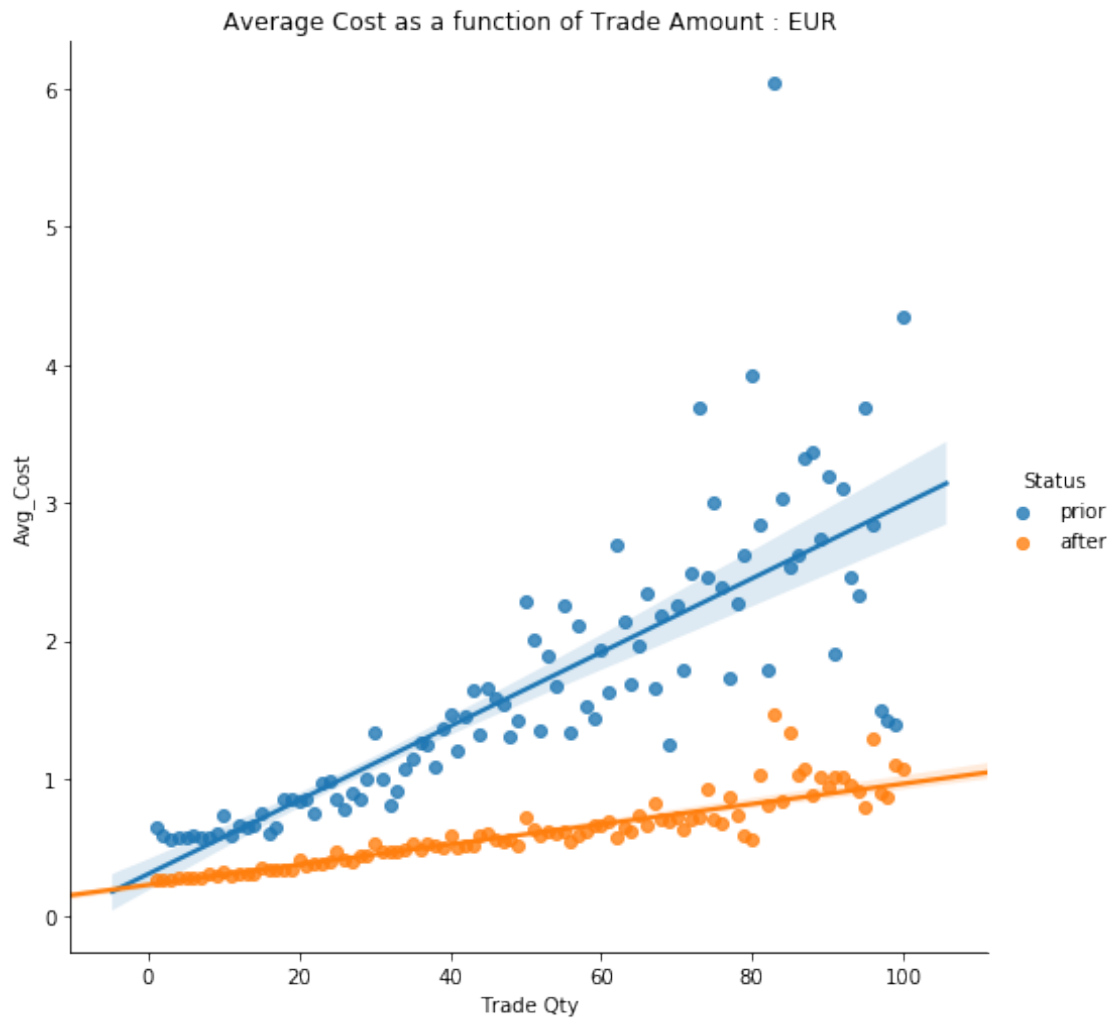
[166]:
```python
cme.regr_plot(MEAN_COST_STATS.reset_index(), 'Trade Qty', 'Avg_Cost',\
    'Average Cost as a function of Trade Amount : '+CURR)
```
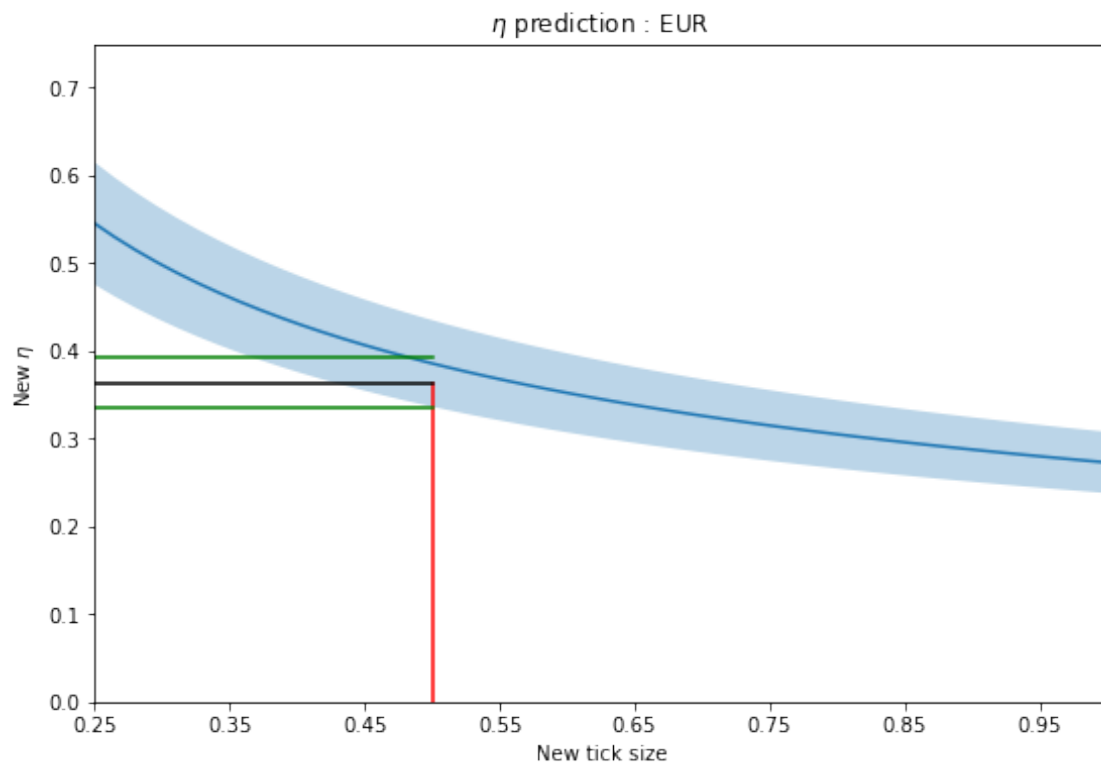
Average Cost as a function of Trade Amount : EUR

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

Average Cost as a function of Trade Amount : EUR

2.9 Eta prediction

```
[168]: 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 : EUR

[ ]: