CME_Tick_Changes_MXN

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 = 'MXN'
```

[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 = 12.5
TICK_AFTER = 5.0
```

[10]:
```
PRIOR_CDATES_LIST = [['6MM4', '20140317'], ['6MM4', '20140318'], ['6MM4',␣
↪'20140319'],\
   ['6MM4', '20140320'], ['6MM4', '20140321'], ['6MM4', '20140324'], ['6MM4',␣
↪'20140325'],\
   ['6MM4', '20140326'], ['6MM4', '20140327'], ['6MM4', '20140328'], ['6MM4',␣
↪'20140331'],\
   ['6MM4', '20140401'], ['6MM4', '20140402'], ['6MM4', '20140403'], ['6MM4',␣
↪'20140404'],\
   ['6MM4', '20140407'], ['6MM4', '20140408'], ['6MM4', '20140409'], ['6MM4',␣
↪'20140410'],\
   ['6MM4', '20140411'], ['6MM4', '20140414'], ['6MM4', '20140415'], ['6MM4',␣
↪'20140416'],\
   ['6MM4', '20140417'], ['6MM4', '20140421'], ['6MM4', '20140422'], ['6MM4',␣
↪'20140423'],\
   ['6MM4', '20140424'], ['6MM4', '20140425'], ['6MM4', '20140428'], ['6MM4',␣
↪'20140429'],\
   ['6MM4', '20140430'], ['6MM4', '20140501'], ['6MM4', '20140502'], ['6MM4',␣
↪'20140505'],\
   ['6MM4', '20140506'], ['6MM4', '20140507'], ['6MM4', '20140508'], ['6MM4',␣
↪'20140509'],\
   ['6MM4', '20140512'], ['6MM4', '20140513'], ['6MM4', '20140514'], ['6MM4',␣
↪'20140515'],\
   ['6MM4', '20140516'], ['6MM4', '20140519'], ['6MM4', '20140520'], ['6MM4',␣
↪'20140521'],\
   ['6MM4', '20140522'], ['6MM4', '20140523'], ['6MM4', '20140526'], ['6MM4',␣
↪'20140527'],\
   ['6MM4', '20140528'], ['6MM4', '20140529'], ['6MM4', '20140530'], ['6MM4',␣
↪'20140602'],\
   ['6MM4', '20140603'], ['6MM4', '20140604'], ['6MM4', '20140605'], ['6MM4',␣
↪'20140606'],\
   ['6MM4', '20140609'], ['6MM4', '20140610'], ['6MM4', '20140611'], ['6MM4',␣
↪'20140612'],\
```

```
   ['6MM4', '20140613'], ['6MU4', '20140616'], ['6MU4', '20140617'], ['6MU4',␣
↪'20140618'],\
   ['6MU4', '20140619'], ['6MU4', '20140620'], ['6MU4', '20140623'], ['6MU4',␣
↪'20140624'],\
   ['6MU4', '20140625'], ['6MU4', '20140626'], ['6MU4', '20140627'], ['6MU4',␣
↪'20140630'],\
   ['6MU4', '20140701'], ['6MU4', '20140702'], ['6MU4', '20140703'], ['6MU4',␣
↪'20140704'],\
   ['6MU4', '20140707'], ['6MU4', '20140708'], ['6MU4', '20140709'], ['6MU4',␣
↪'20140710'],\
   ['6MU4', '20140711']]
```

[11]:
```
AFTER_CDATES_LIST = [['6MU4', '20140715'], ['6MU4', '20140716'], ['6MU4',␣
↪'20140717'],\
   ['6MU4', '20140718'], ['6MU4', '20140721'], ['6MU4', '20140722'], ['6MU4',␣
↪'20140723'],\
   ['6MU4', '20140724'], ['6MU4', '20140725'], ['6MU4', '20140728'], ['6MU4',␣
↪'20140729'],\
   ['6MU4', '20140730'], ['6MU4', '20140731'], ['6MU4', '20140801'], ['6MU4',␣
↪'20140804'],\
   ['6MU4', '20140805'], ['6MU4', '20140806'], ['6MU4', '20140807'], ['6MU4',␣
↪'20140808'],\
   ['6MU4', '20140811'], ['6MU4', '20140812'], ['6MU4', '20140813'], ['6MU4',␣
↪'20140814'],\
   ['6MU4', '20140815'], ['6MU4', '20140818'], ['6MU4', '20140819'], ['6MU4',␣
↪'20140820'],\
   ['6MU4', '20140821'], ['6MU4', '20140822'], ['6MU4', '20140825'], ['6MU4',␣
↪'20140826'],\
   ['6MU4', '20140827'], ['6MU4', '20140828'], ['6MU4', '20140829'], ['6MU4',␣
↪'20140901'],\
   ['6MU4', '20140902'], ['6MU4', '20140903'], ['6MU4', '20140904'], ['6MU4',␣
↪'20140905'],\
   ['6MU4', '20140908'], ['6MU4', '20140909'], ['6MU4', '20140910'], ['6MU4',␣
↪'20140911'],\
   ['6MU4', '20140912'], ['6MZ4', '20140915'], ['6MZ4', '20140916'], ['6MZ4',␣
↪'20140917'],\
   ['6MZ4', '20140918'], ['6MZ4', '20140919'], ['6MZ4', '20140922'], ['6MZ4',␣
↪'20140923'],\
   ['6MZ4', '20140924'], ['6MZ4', '20140925'], ['6MZ4', '20140926'], ['6MZ4',␣
↪'20140929'],\
   ['6MZ4', '20140930'], ['6MZ4', '20141001'], ['6MZ4', '20141002'], ['6MZ4',␣
↪'20141003'],\
   ['6MZ4', '20141006'], ['6MZ4', '20141007'], ['6MZ4', '20141008'], ['6MZ4',␣
↪'20141009'],\
```

```
   ['6MZ4', '20141010'], ['6MZ4', '20141013'], ['6MZ4', '20141014'], ['6MZ4',␣
↪'20141015'],\
   ['6MZ4', '20141016'], ['6MZ4', '20141017'], ['6MZ4', '20141020'], ['6MZ4',␣
↪'20141021'],\
   ['6MZ4', '20141022'], ['6MZ4', '20141023'], ['6MZ4', '20141024'], ['6MZ4',␣
↪'20141027'],\
   ['6MZ4', '20141028'], ['6MZ4', '20141029'], ['6MZ4', '20141030'], ['6MZ4',␣
↪'20141031'],\
   ['6MZ4', '20141103'], ['6MZ4', '20141104'], ['6MZ4', '20141105'], ['6MZ4',␣
↪'20141106'],\
   ['6MZ4', '20141107']]
```

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]:

Status	Tick	chgavg	ndfpr_pred	ndfpr	M	Volume	\
prior	12.5	25.17000	256.60544	249.84524	2644.28571	20400.2619	
after	5.0	10.21075	966.66534	892.17857	5582.34524	30952.7500	

Status	eta1	S1	lambda1	twspr1	duration	dt_avg	rvxe	\
prior	0.19875	0.99429	0.99444	1.02879	141.46641	138.38556	0.00320	
after	0.34215	0.98851	0.98386	1.08102	38.49505	40.19669	0.00334	

Status	spot_avg
prior	76522.04811
after	75182.68548

[49]:
```
TABLE_MATHIEU_ERR
```

[49]:
Status	Tick	chgavg	ndfpr_pred	ndfpr	M	Volume	\
prior	0.0	0.53189	126.40942	114.22547	1180.26795	10556.19409	
after	0.0	0.50171	526.59335	444.39159	2413.06592	13483.77326	

Status	eta1	S1	lambda1	twspr1	duration	dt_avg	rvxe	\
prior	0.06323	0.01274	0.01694	0.05368	93.16961	68.46709	0.00098	
after	0.06006	0.02162	0.03323	0.13462	21.53793	20.22299	0.00103	

Status	spot_avg
prior	637.03525
after	1183.06835

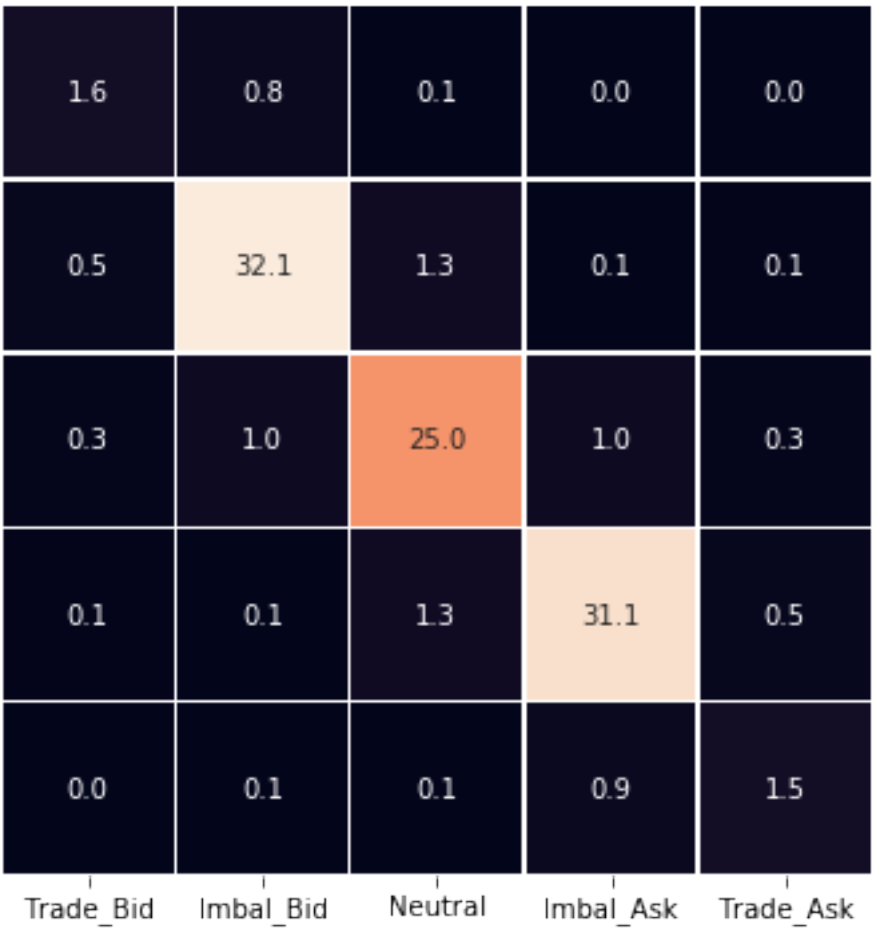
[50]:
```
cme.avg_perc_mat(PRIOR_IMBAL_STATS, pd.to_datetime(PRIOR_CDATES['Date']))
```

[50]:
	Trade_Bid	Imbal_Bid	Neutral	Imbal_Ask	Trade_Ask	Total Cols
Trade_Bid	1.56	0.84	0.07	0.04	0.00	2.50
Imbal_Bid	0.51	32.12	1.26	0.05	0.14	34.08
Neutral	0.30	1.02	25.04	1.04	0.32	27.73
Imbal_Ask	0.13	0.05	1.27	31.15	0.54	33.15
Trade_Ask	0.00	0.05	0.09	0.87	1.53	2.53
Total Rows	2.50	34.08	27.73	33.15	2.53	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	1.05	0.71	0.13	0.04	0.00	1.93
Imbal_Bid	0.42	29.35	1.32	0.36	0.16	31.62
Neutral	0.29	1.16	30.37	1.14	0.29	33.25
Imbal_Ask	0.16	0.37	1.30	28.97	0.44	31.24
Trade_Ask	0.00	0.04	0.13	0.73	1.07	1.97
Total Rows	1.93	31.62	33.25	31.24	1.97	100.00

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



[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	0.01	0.00	0.03	32.65	0.01	0.01	1.48	0.18	34.38
D T	0.00	0.01	0.17	10.50	0.00	0.00	1.98	0.72	13.39
D T+F	0.00	0.01	0.09	3.35	0.00	0.00	0.72	0.31	4.47
F	22.96	4.36	0.00	0.02	11.38	9.01	0.00	0.02	47.76
Total Rows	22.98	4.38	0.30	46.52	11.40	9.02	4.18	1.23	100.00

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

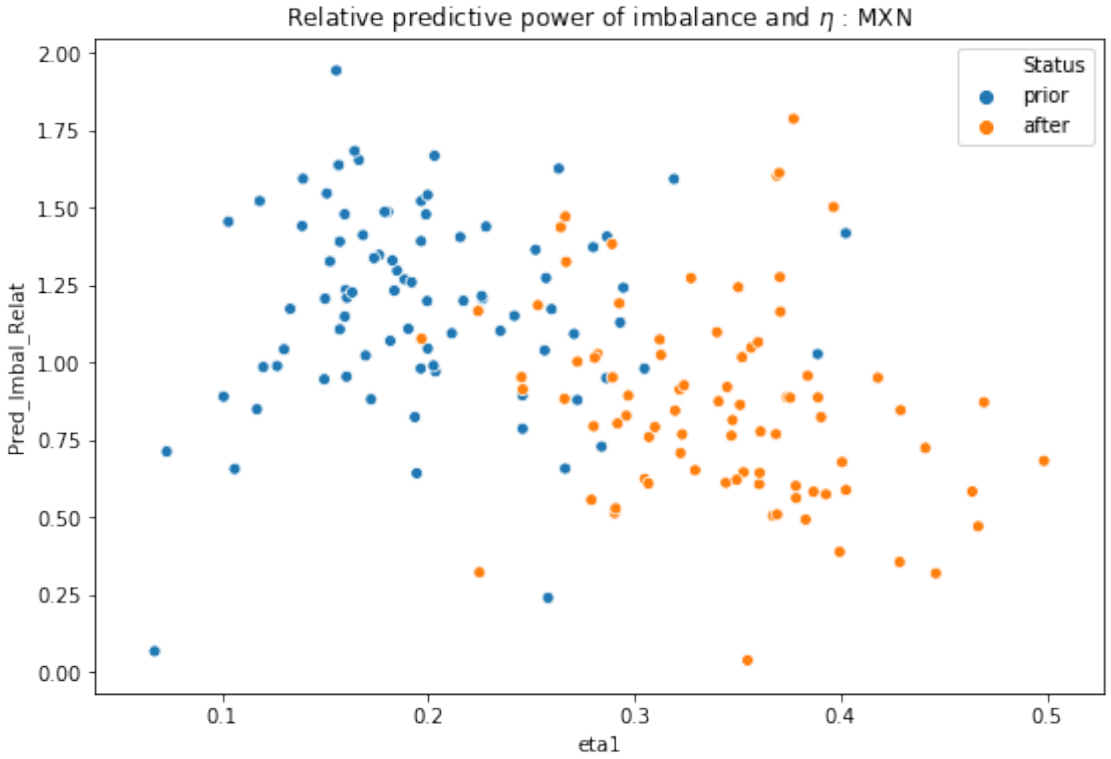
[54]:

	same				oppo				Total Cols
	D C	D T	D T+F	F	D C	D T	D T+F	F	
D C	0.02	0.01	0.13	28.61	0.02	0.01	0.92	1.00	30.71
D T	0.01	0.05	0.29	13.44	0.01	0.01	1.79	1.80	17.39
D T+F	0.01	0.02	0.17	2.48	0.01	0.00	0.55	0.61	3.85
F	22.30	6.62	0.00	0.04	8.34	10.68	0.00	0.05	48.04

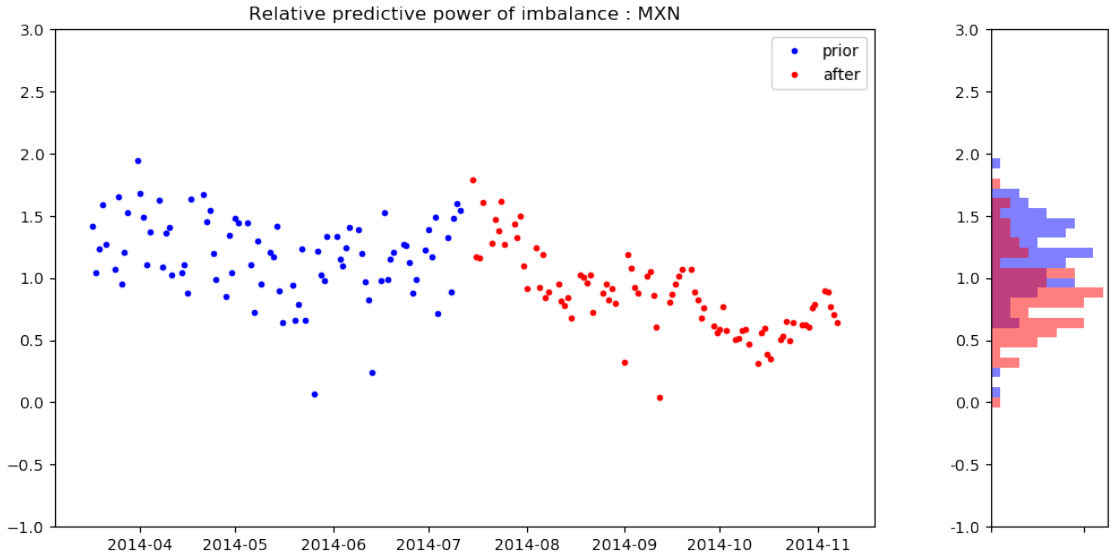
```
Total Rows  22.34  6.69  0.60  44.58  8.38  10.70  3.26  3.46     100.00
```

2.8 Charts and Regressions

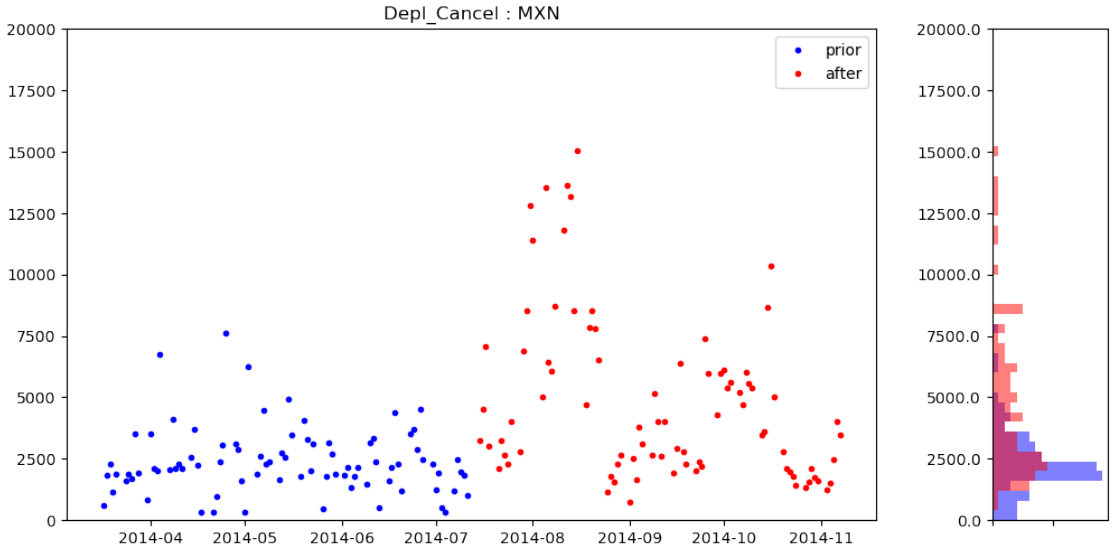
[55]:
```
plt.figure(figsize=(9, 6))
sns.scatterplot(x='eta1', y='Pred_Imbal_Relat', hue='Status',\
           data=IMBAL_STATS_TS);
plt.title('Relative predictive power of imbalance and $\eta$ : '+CURR);
```



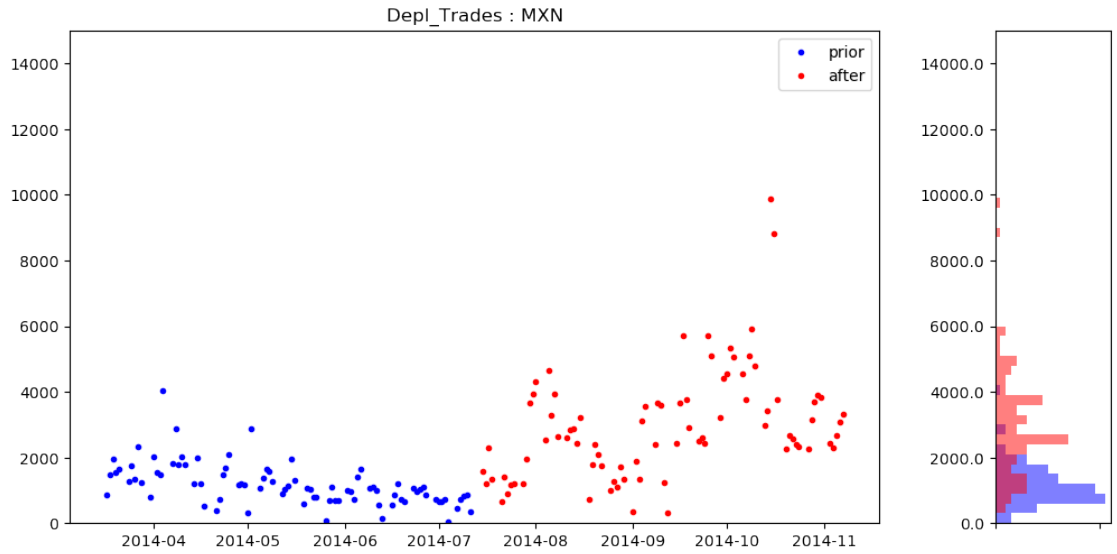
[163]:
```
cme.time_series_hist_plot(IMBAL_STATS_TS, 'Pred_Imbal_Relat',\
    'Relative predictive power of imbalance : '+CURR, -1.0, 3.0, 50)
```



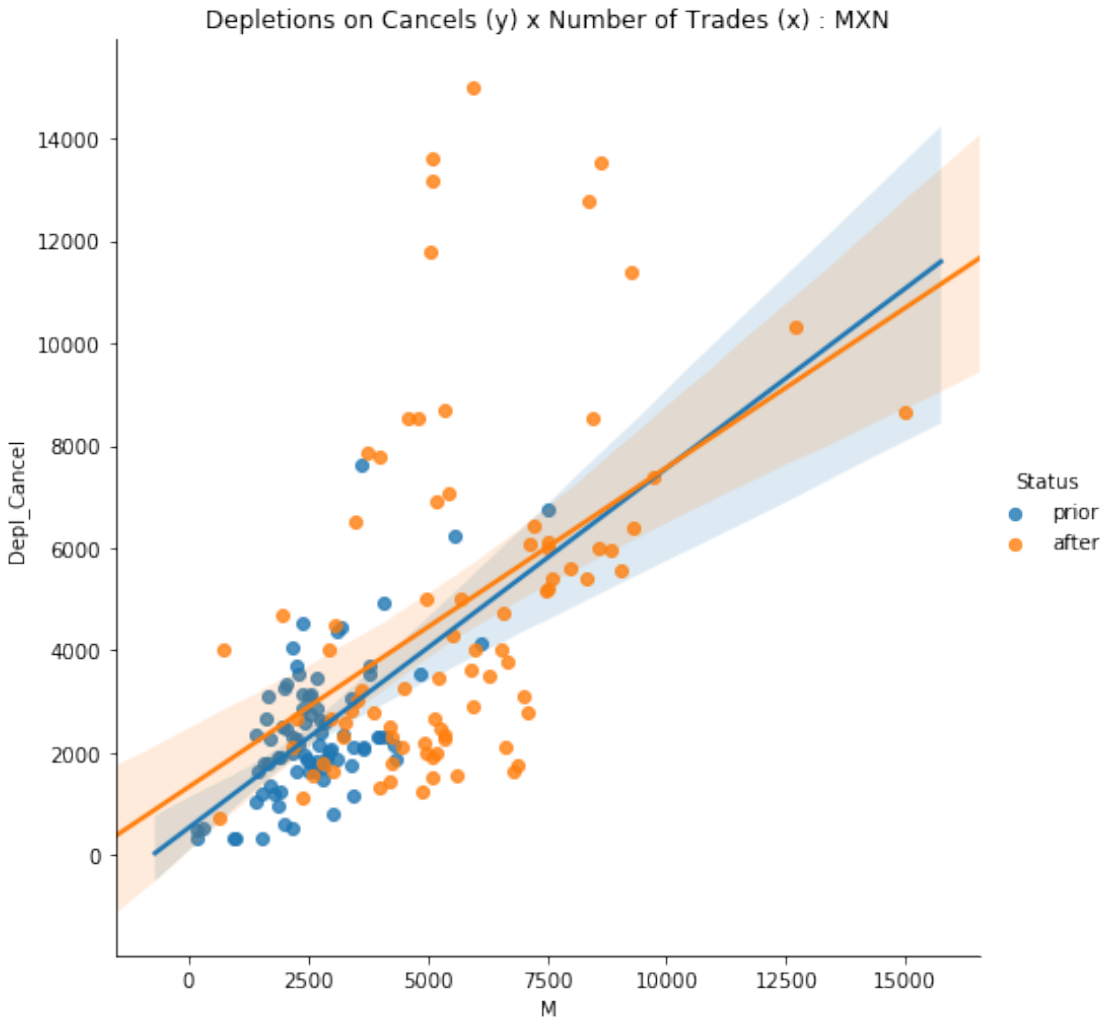
[164]:
```
cme.time_series_hist_plot(ABSDEPL_STATS_TS, 'Depl_Cancel',\
    'Depl_Cancel : '+CURR, 0.0, 20000.0, 50)
```



[165]:
```
cme.time_series_hist_plot(ABSDEPL_STATS_TS, 'Depl_Trades',\
    'Depl_Trades : '+CURR, 0.0, 15000.0, 50)
```



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



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

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

OLS Regression Results

Dep. Variable:	Depl_Cancel	R-squared:	0.365
Model:	OLS	Adj. R-squared:	0.361
Method:	Least Squares	F-statistic:	95.54
Date:	Wed, 09 Oct 2019	Prob (F-statistic):	4.16e-18
Time:	17:06:28	Log-Likelihood:	-1534.2
No. Observations:	168	AIC:	3072.
Df Residuals:	166	BIC:	3079.
Df Model:	1		
Covariance Type:	nonrobust		

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

```
const        680.8132    345.517      1.970      0.050      -1.362    1362.988
M              0.7097      0.073      9.774      0.000       0.566       0.853
==============================================================================
Omnibus:                       84.075   Durbin-Watson:                   0.599
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              311.987
Skew:                           1.994   Prob(JB):                     1.79e-68
Kurtosis:                       8.353   Cond. No.                     9.46e+03
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
[2] The condition number is large, 9.46e+03. 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:                       0.956
Model:                            OLS   Adj. R-squared:                  0.955
Method:                 Least Squares   F-statistic:                     3568.
Date:                Wed, 09 Oct 2019   Prob (F-statistic):          3.79e-114
Time:                        17:06:28   Log-Likelihood:                -1209.8
No. Observations:                 168   AIC:                             2424.
Df Residuals:                     166   BIC:                             2430.
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const       -508.8236     50.088    -10.159      0.000    -607.714    -409.933
M              0.6288      0.011     59.733      0.000       0.608       0.650
==============================================================================
Omnibus:                       15.012   Durbin-Watson:                   0.889
Prob(Omnibus):                  0.001   Jarque-Bera (JB):               47.548
Skew:                          -0.094   Prob(JB):                     4.73e-11
Kurtosis:                       5.600   Cond. No.                     9.46e+03
==============================================================================

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

[2] The condition number is large, 9.46e+03. This might indicate that there are strong multicollinearity or other numerical problems.

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

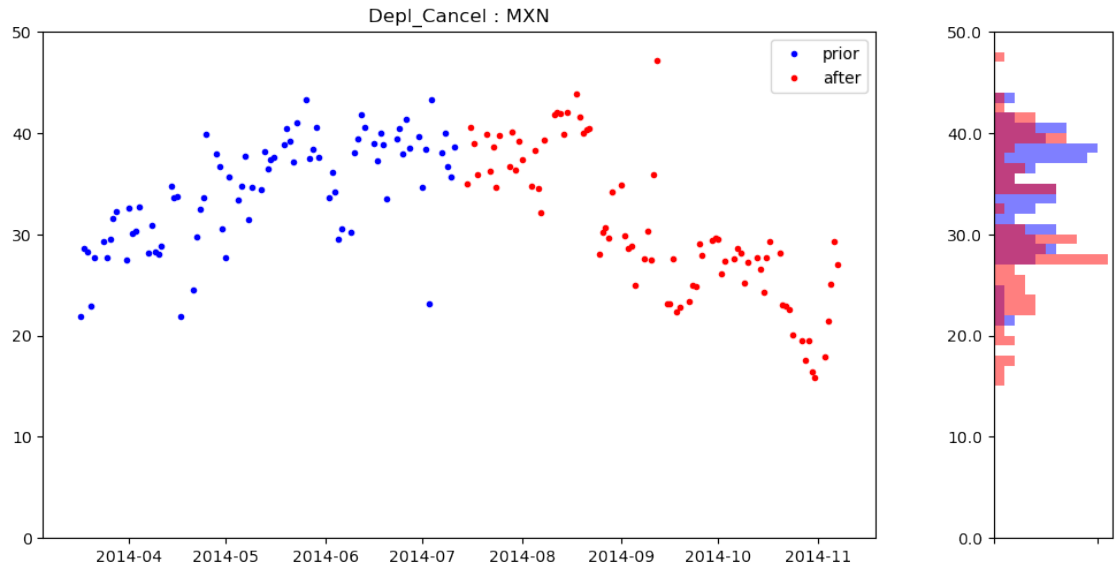
```
                            OLS Regression Results
==============================================================================
Dep. Variable:            Depl_Trades   R-squared:                       0.929
Model:                            OLS   Adj. R-squared:                  0.928
Method:                 Least Squares   F-statistic:                     1066.
Date:                Wed, 09 Oct 2019   Prob (F-statistic):           9.37e-49
Time:                        17:06:28   Log-Likelihood:                -551.08
No. Observations:                  84   AIC:                             1106.
Df Residuals:                      82   BIC:                             1111.
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const       -208.8841     46.557     -4.487      0.000    -301.500    -116.268
M              0.5254      0.016     32.646      0.000       0.493       0.557
==============================================================================
Omnibus:                        8.562   Durbin-Watson:                   1.517
Prob(Omnibus):                  0.014   Jarque-Bera (JB):                8.196
Skew:                          -0.666   Prob(JB):                       0.0166
Kurtosis:                       3.752   Cond. No.                     7.13e+03
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.
[2] The condition number is large, 7.13e+03. This might indicate that there are strong multicollinearity or other numerical problems.
```

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

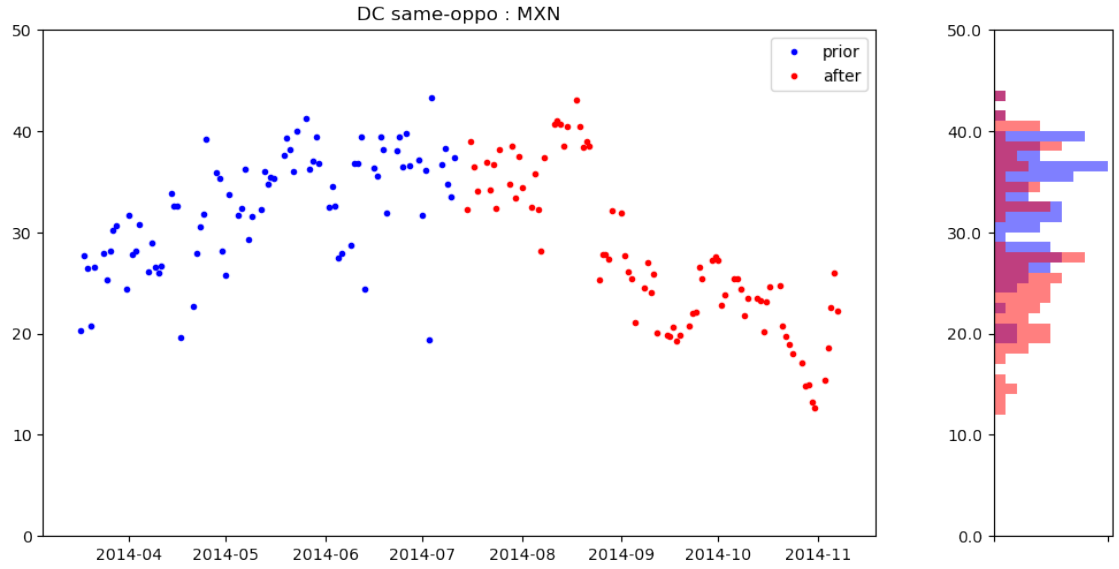
```
                            OLS Regression Results
==============================================================================
Dep. Variable:            Depl_Trades   R-squared:                       0.942
Model:                            OLS   Adj. R-squared:                  0.942
Method:                 Least Squares   F-statistic:                     1340.
Date:                Wed, 09 Oct 2019   Prob (F-statistic):           1.44e-52
Time:                        17:06:28   Log-Likelihood:                -621.60
No. Observations:                  84   AIC:                             1247.
Df Residuals:                      82   BIC:                             1252.
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
```

```
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const       -749.3499    110.737     -6.767      0.000    -969.642    -529.058
M              0.6671      0.018     36.601      0.000       0.631       0.703
==============================================================================
Omnibus:                        6.862   Durbin-Watson:                   0.787
Prob(Omnibus):                  0.032   Jarque-Bera (JB):                7.154
Skew:                          -0.456   Prob(JB):                       0.0280
Kurtosis:                       4.101   Cond. No.                     1.54e+04
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
[2] The condition number is large, 1.54e+04. This might indicate that there are
strong multicollinearity or other numerical problems.
```

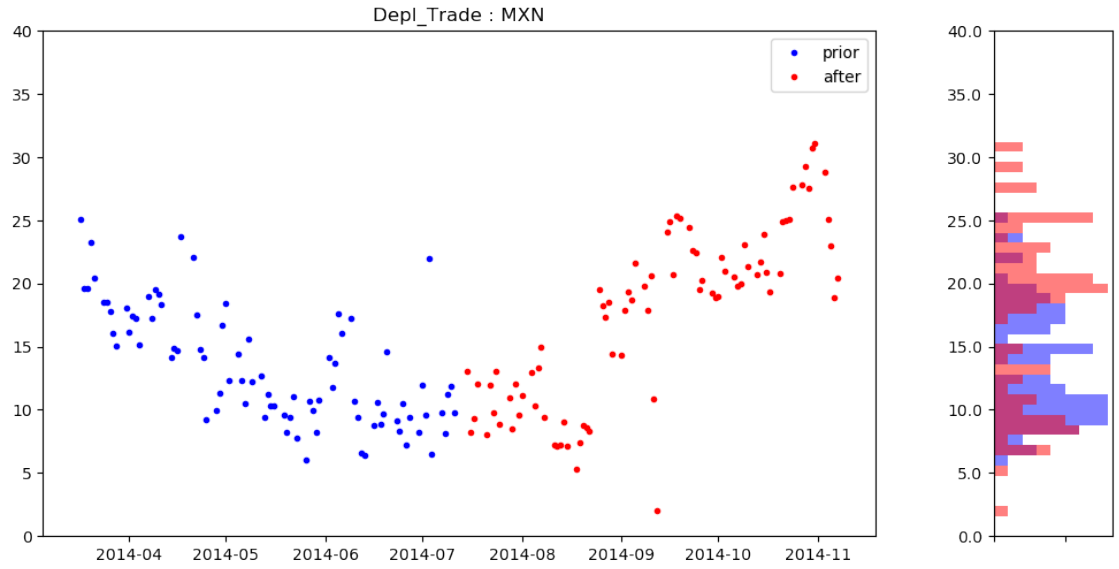
[167]:
```
cme.time_series_hist_plot(DEPL_STATS_TS, 'Depl_Cancel',\
    'Depl_Cancel : '+CURR, 0, 50, 50)
```



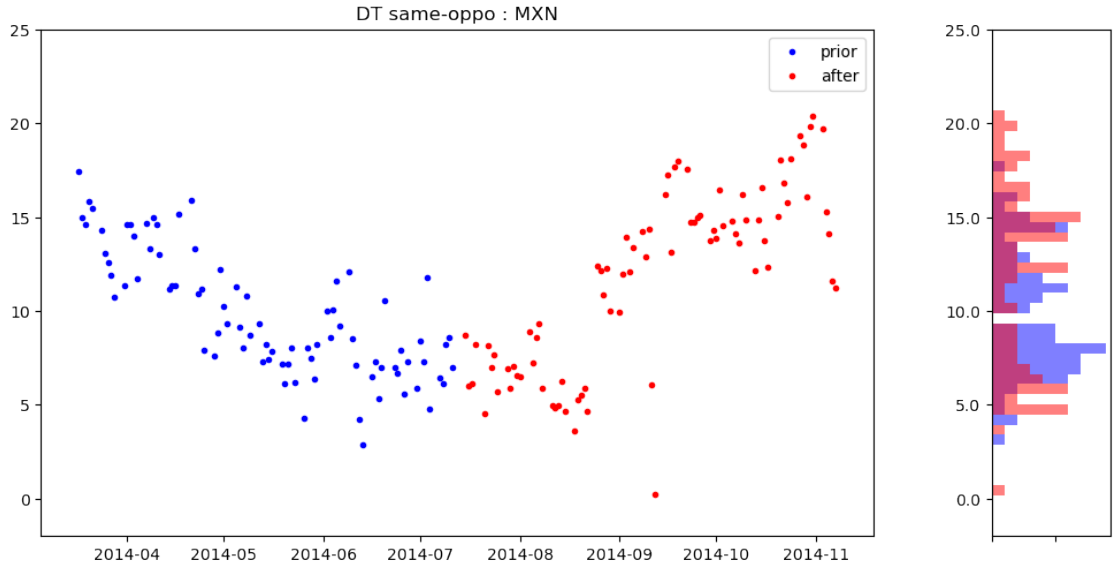
[168]:
```
cme.time_series_hist_plot(DEPL_STATS_TS, 'DC same-oppo',\
    'DC same-oppo : '+CURR, 0, 50, 50)
```



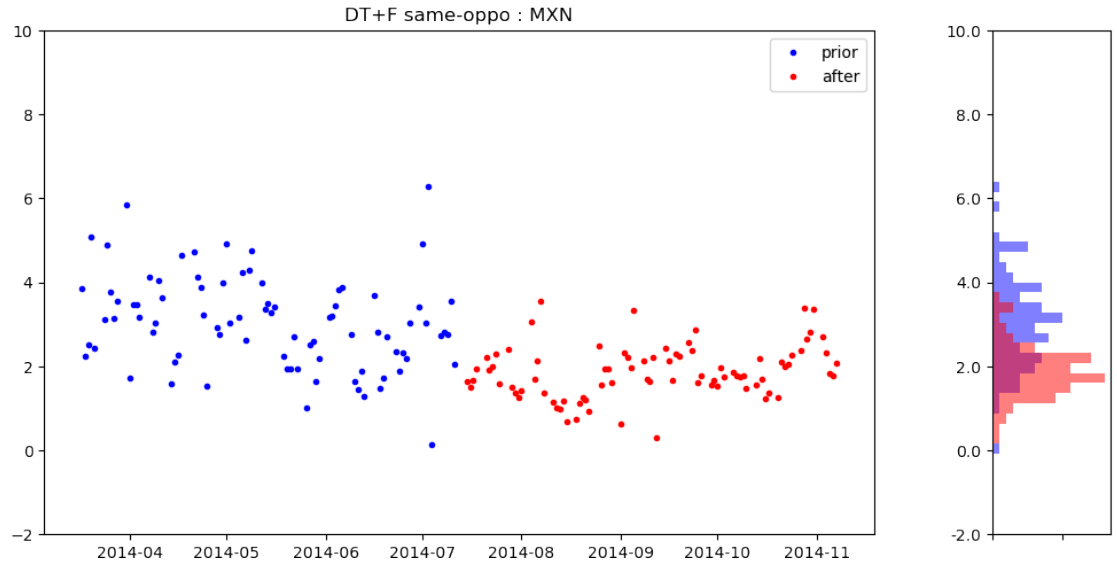
[67]:
```
cme.time_series_hist_plot(DEPL_STATS_TS, 'Depl_Trade',\
    'Depl_Trade : '+CURR, 0, 40, 50)
```



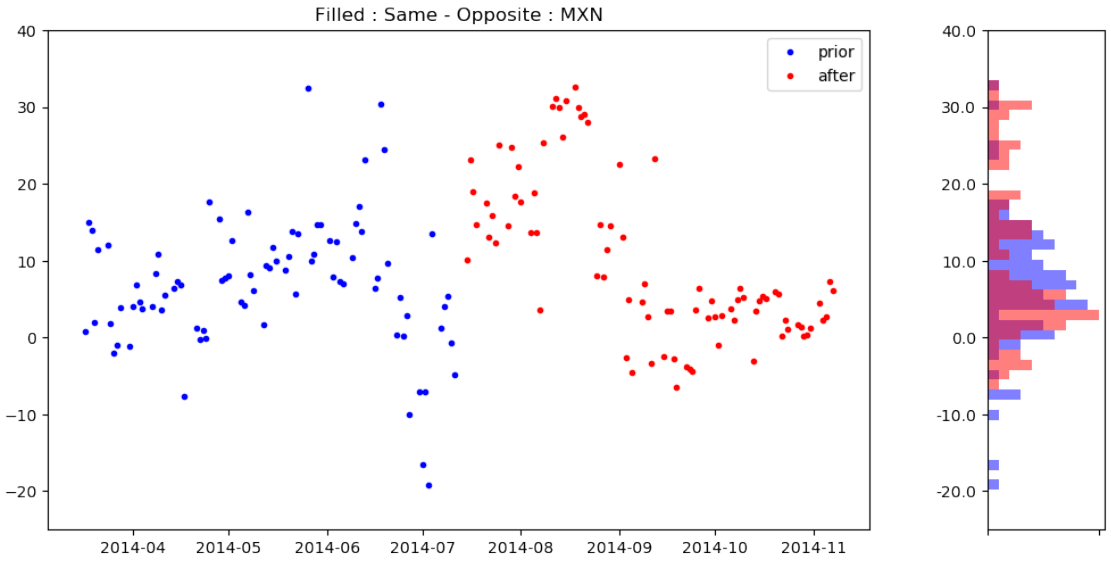
[170]:
```
cme.time_series_hist_plot(DEPL_STATS_TS, 'DT same-oppo',\
    'DT same-oppo : '+CURR, -2, 25, 50)
```



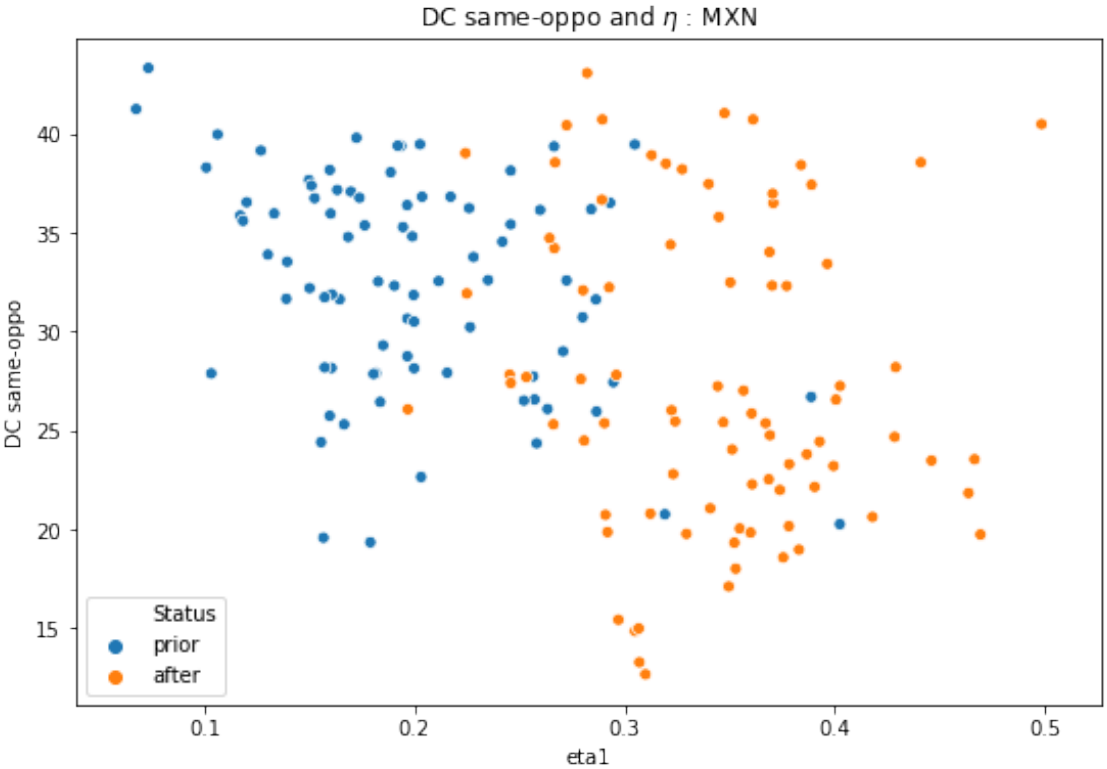
[172]:
```
cme.time_series_hist_plot(DEPL_STATS_TS, 'DT+F same-oppo',\
    'DT+F same-oppo : '+CURR, -2, 10, 50)
```



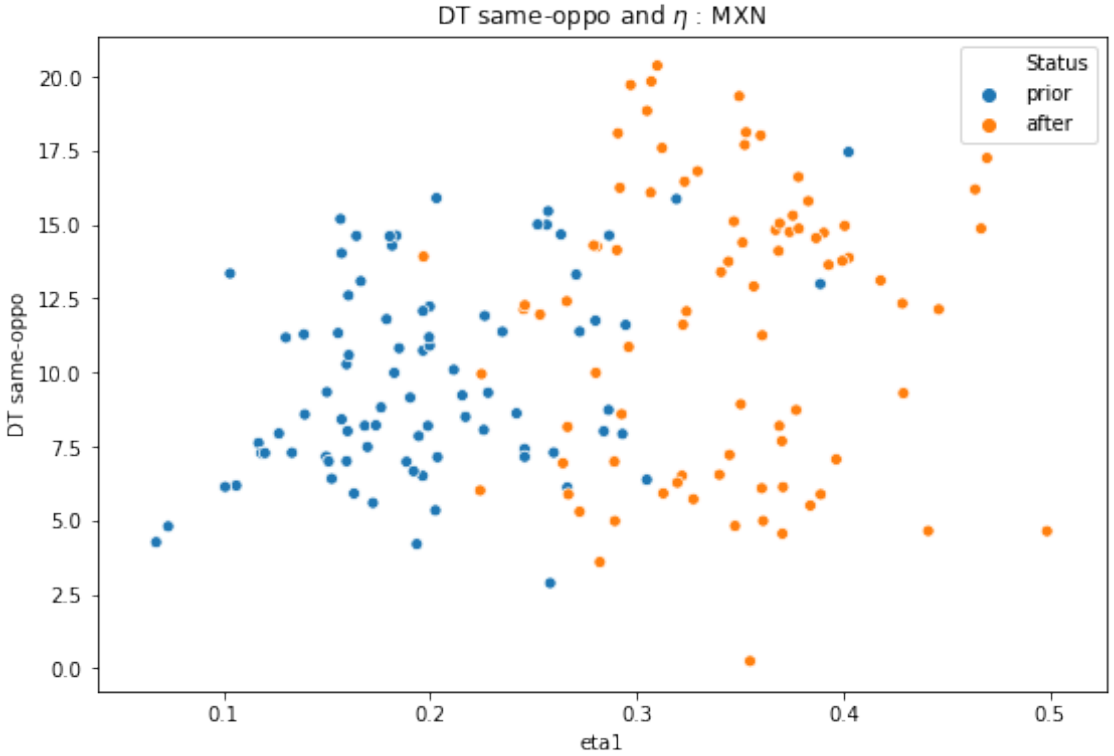
[175]:
```
cme.time_series_hist_plot(DEPL_STATS_TS, 'Fill same-oppo',\
    'Filled : Same - Opposite : '+CURR, -25, 40, 50)
```



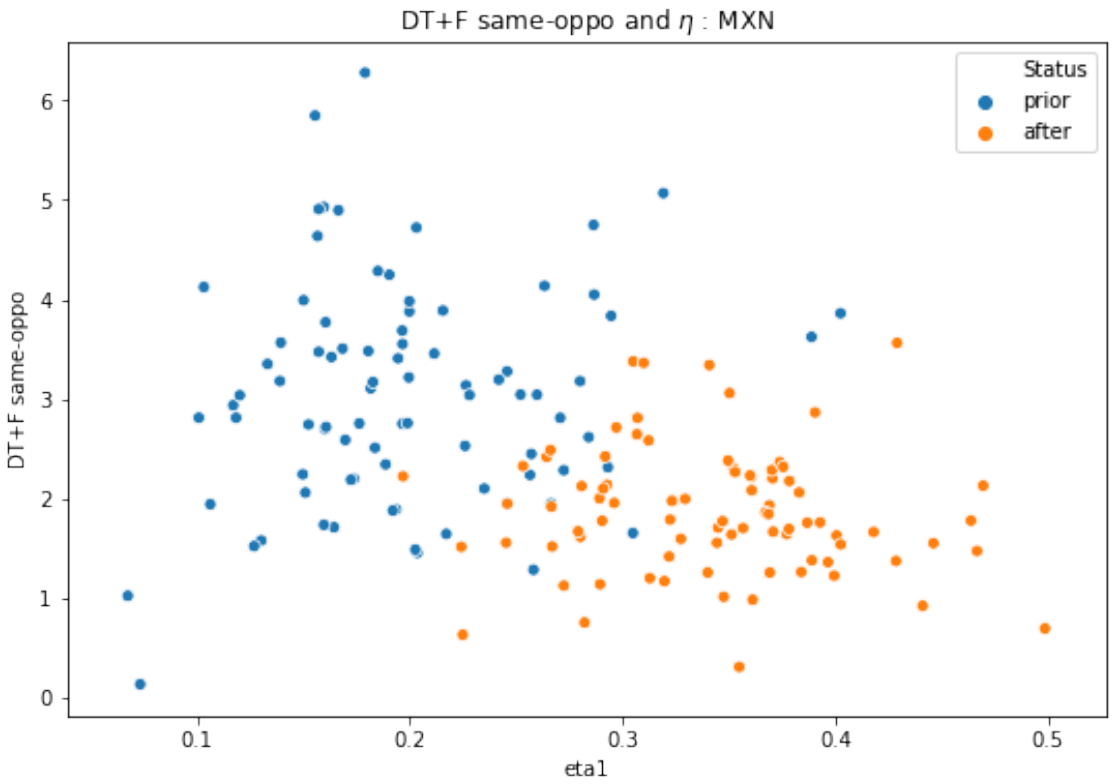
[71]:
```
plt.figure(figsize=(9, 6))
sns.scatterplot(x='eta1', y='DC same-oppo', hue='Status',\
           data=DEPL_STATS_TS);
plt.title('DC same-oppo and $\eta$ : '+CURR);
```



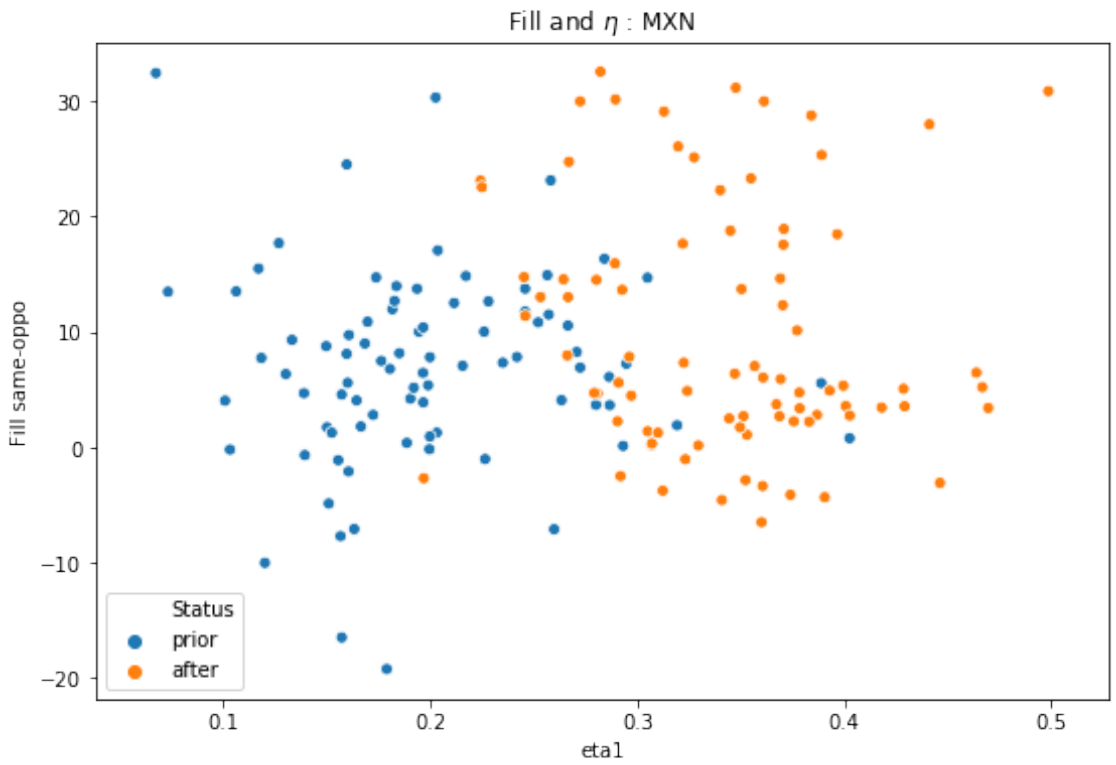
[72]:
```
plt.figure(figsize=(9, 6))
sns.scatterplot(x='eta1', y='DT same-oppo', hue='Status',\
            data=DEPL_STATS_TS);
plt.title('DT same-oppo and $\eta$ : '+CURR);
```



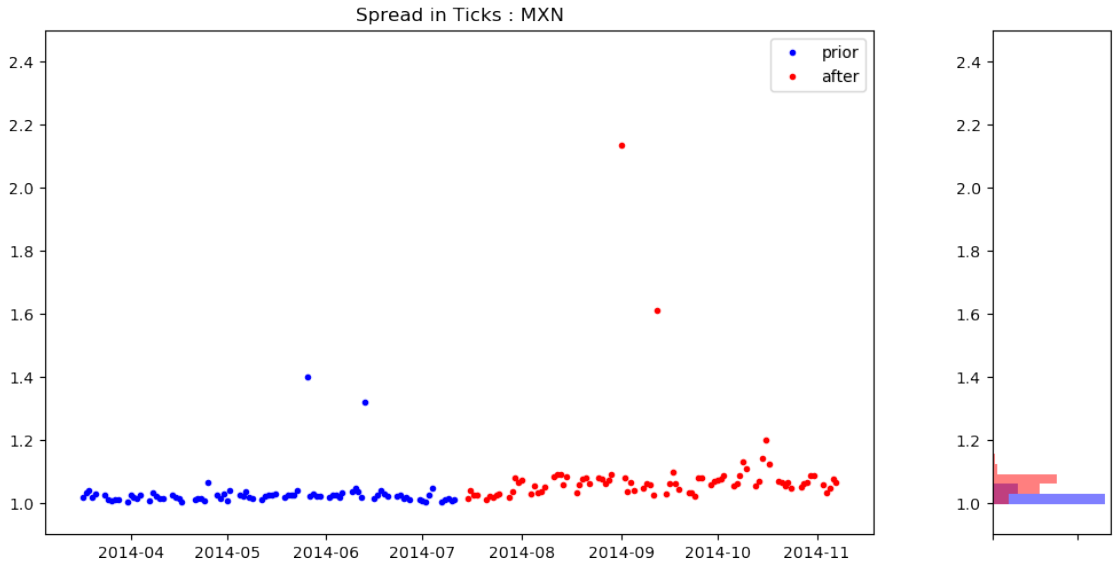
[73]:
```
plt.figure(figsize=(9, 6))
sns.scatterplot(x='eta1', y='DT+F same-oppo', hue='Status',\
            data=DEPL_STATS_TS);
plt.title('DT+F same-oppo and $\eta$ : '+CURR);
```



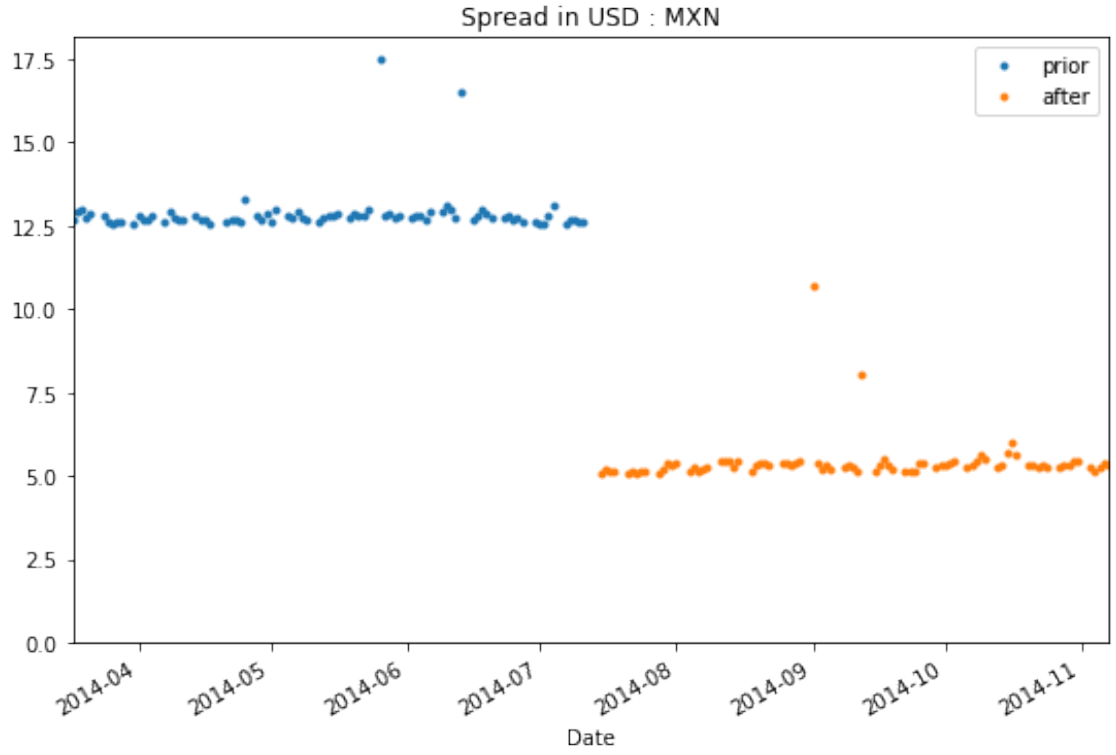
[74]:
```
plt.figure(figsize=(9, 6))
sns.scatterplot(x='eta1', y='Fill same-oppo', hue='Status',\
           data=DEPL_STATS_TS);
plt.title('Fill and $\eta$ : '+CURR);
```



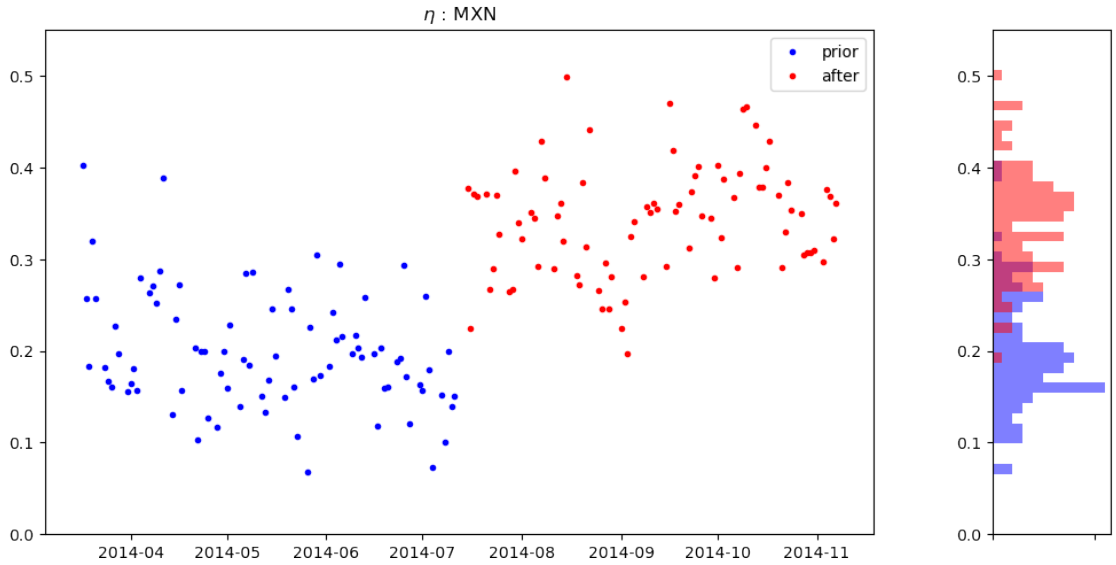
[178]:
```
cme.time_series_hist_plot(OB_UZ_STATS, 'twspr1',\
    'Spread in Ticks : '+CURR, 0.9, 2.5, 50)
```



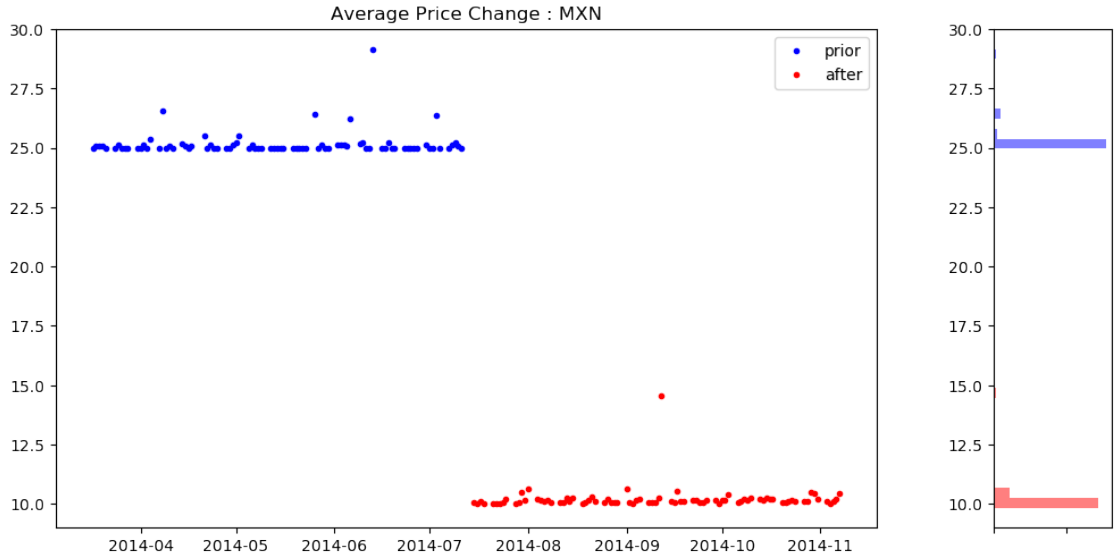
[76]:
```
cme.twspr_plot_USD(OB_UZ_STATS, CURR)
```



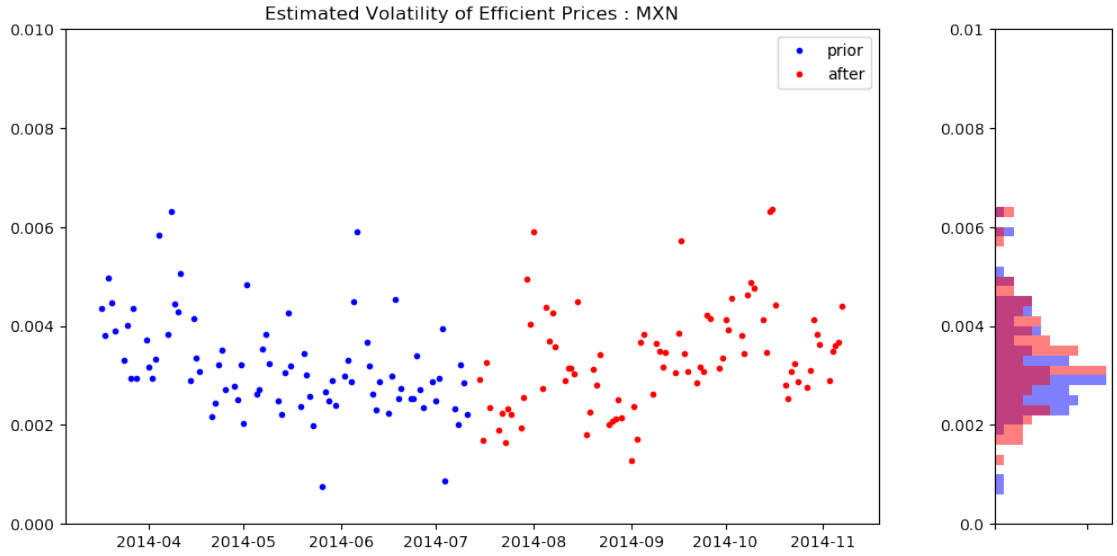
[179]:
```
cme.time_series_hist_plot(OB_UZ_STATS, 'eta1',\
    '$\eta$ : '+CURR, 0, 0.55, 50)
```



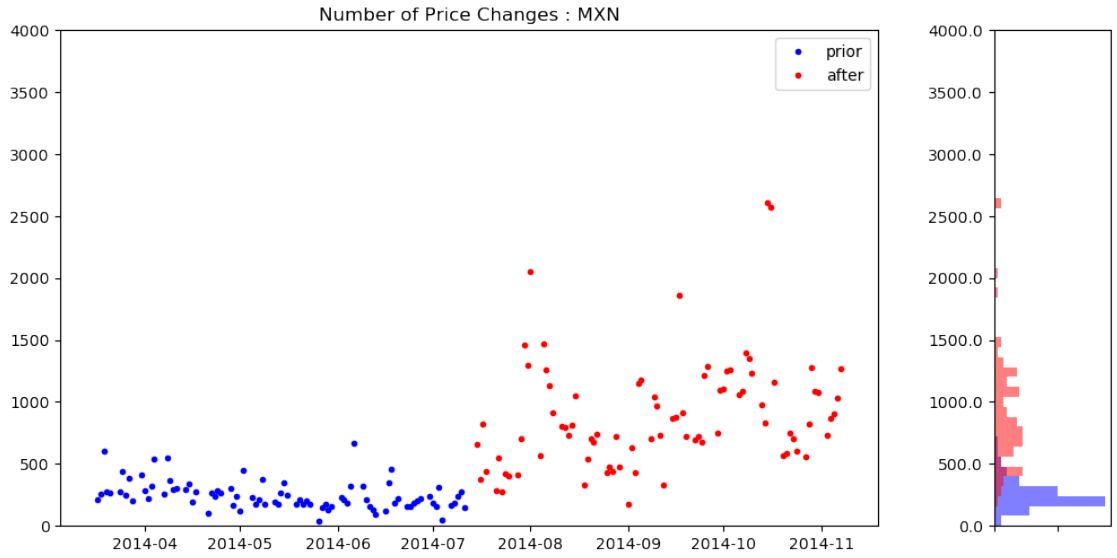
[184]:
```
cme.time_series_hist_plot(OB_UZ_STATS, 'chgavg',\
    'Average Price Change : '+CURR, 9, 30, 50)
```



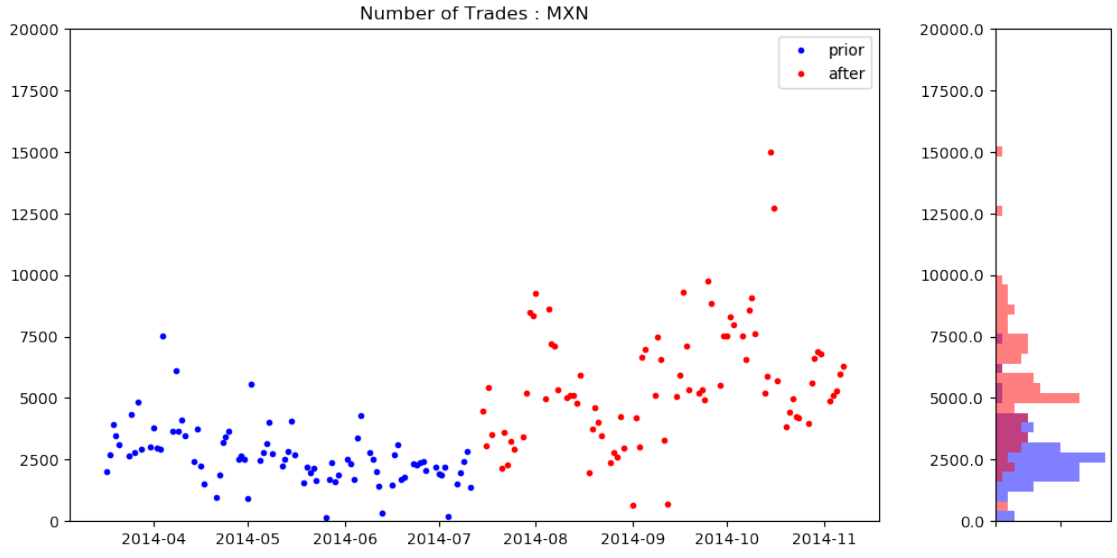
[186]:
```
cme.time_series_hist_plot(OB_UZ_STATS, 'rvxe',\
    'Estimated Volatility of Efficient Prices : '+CURR, 0, 0.010, 50)
```



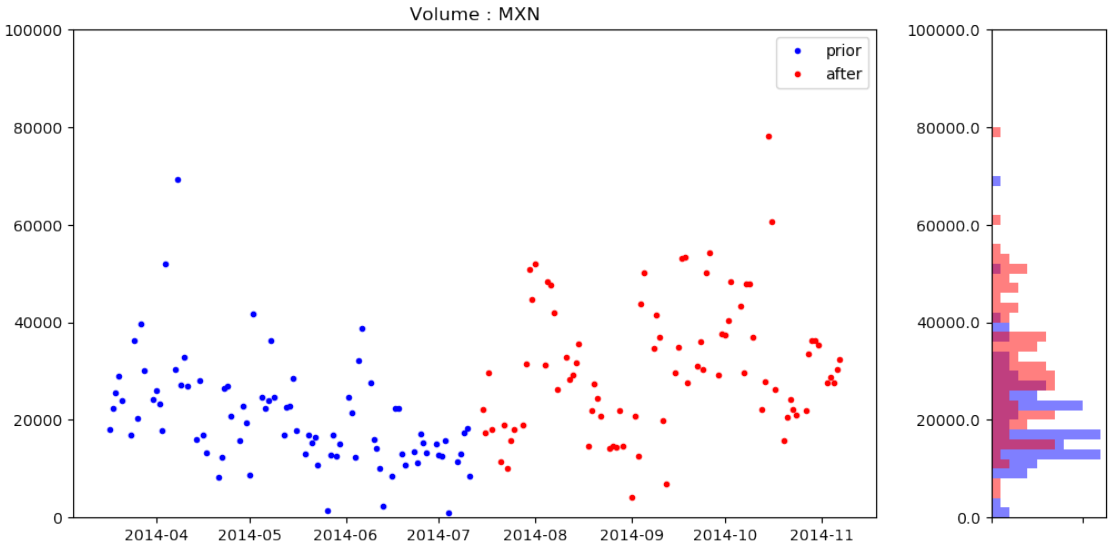
[187]:
```
cme.time_series_hist_plot(OB_UZ_STATS, 'ndfpr',\
    'Number of Price Changes : '+CURR, 0, 4000, 50)
```



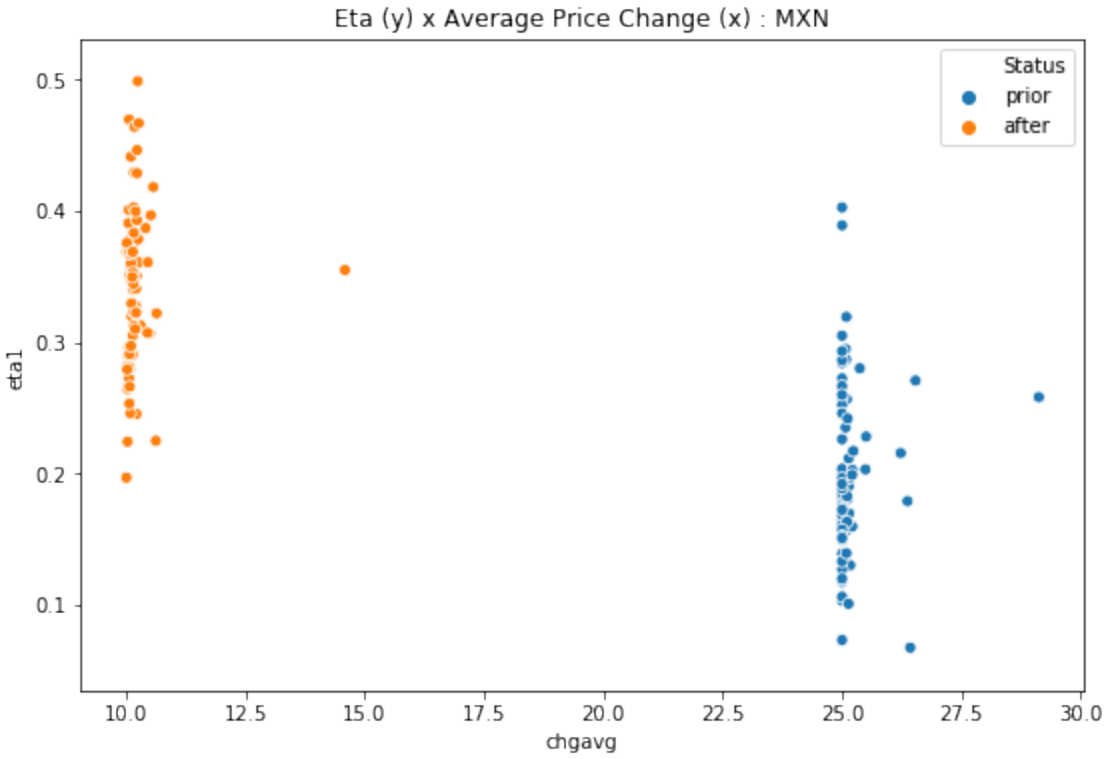
[189]:
```
cme.time_series_hist_plot(OB_UZ_STATS, 'M',\
    'Number of Trades : '+CURR, 0, 20000, 50)
```



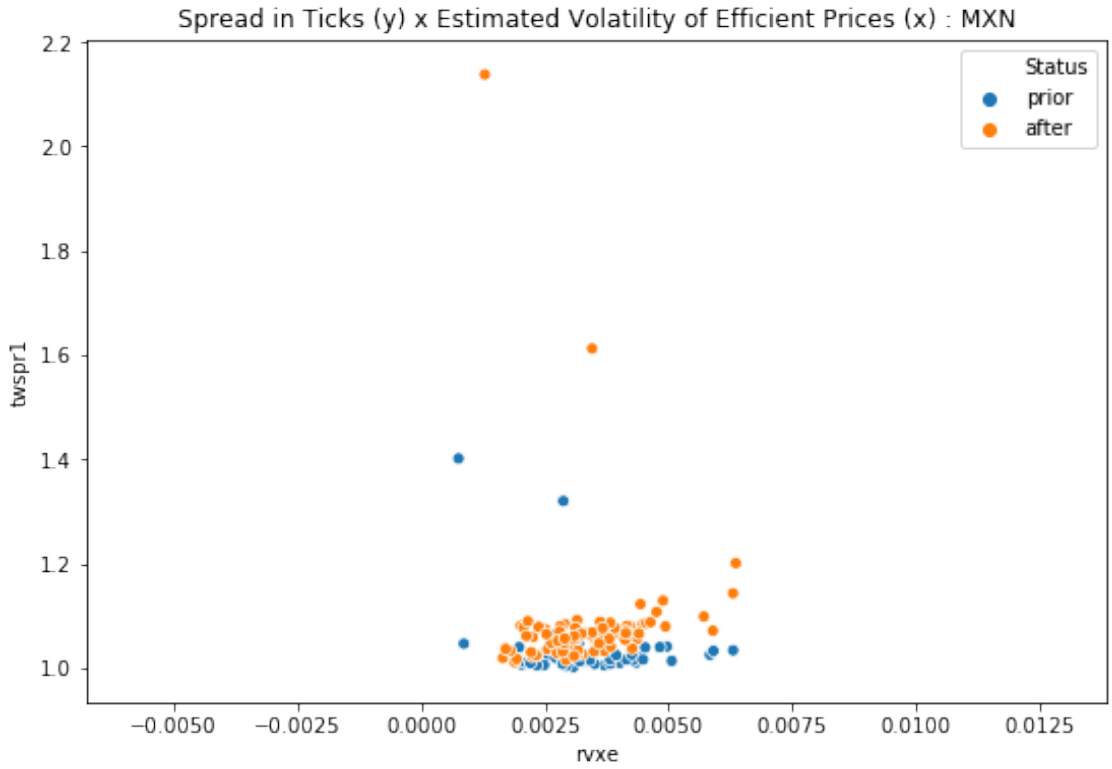
[190]:
```
cme.time_series_hist_plot(OB_UZ_STATS, 'Volume',\
    'Volume : '+CURR, 0, 100000, 50)
```



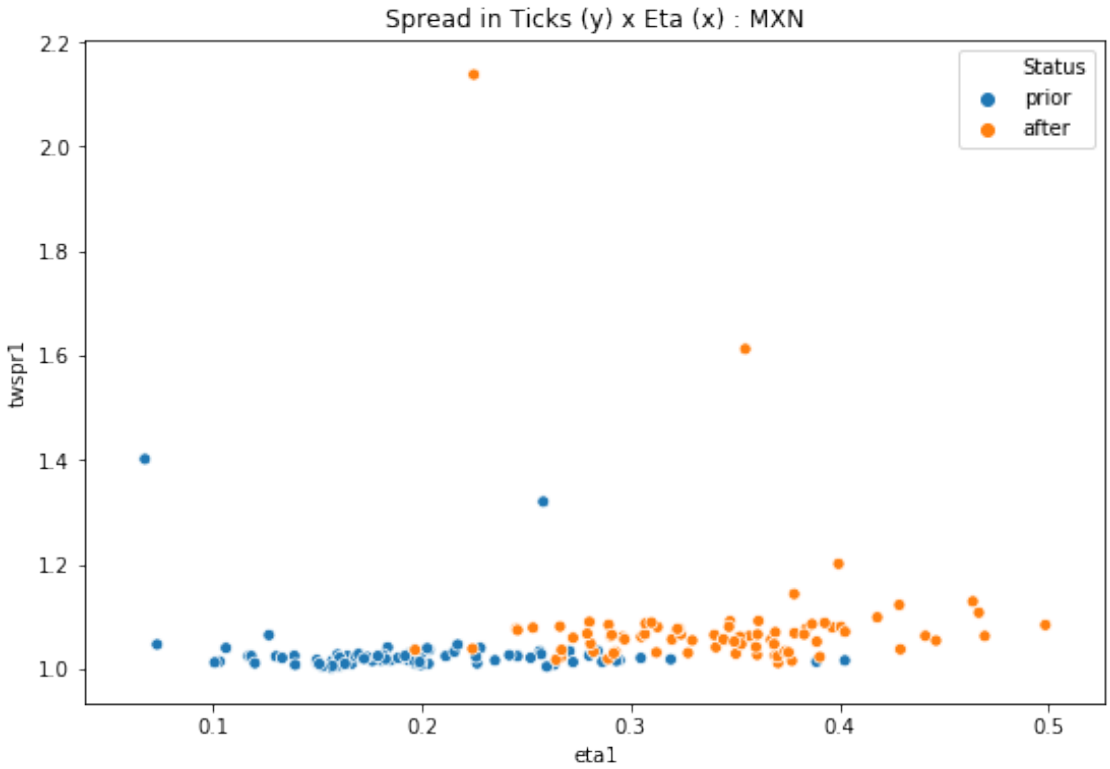
[83]:
```
cme.scatter_plot(OB_UZ_STATS, 'chgavg', 'eta1',\
    'Eta (y) x Average Price Change (x) : '+CURR)
```



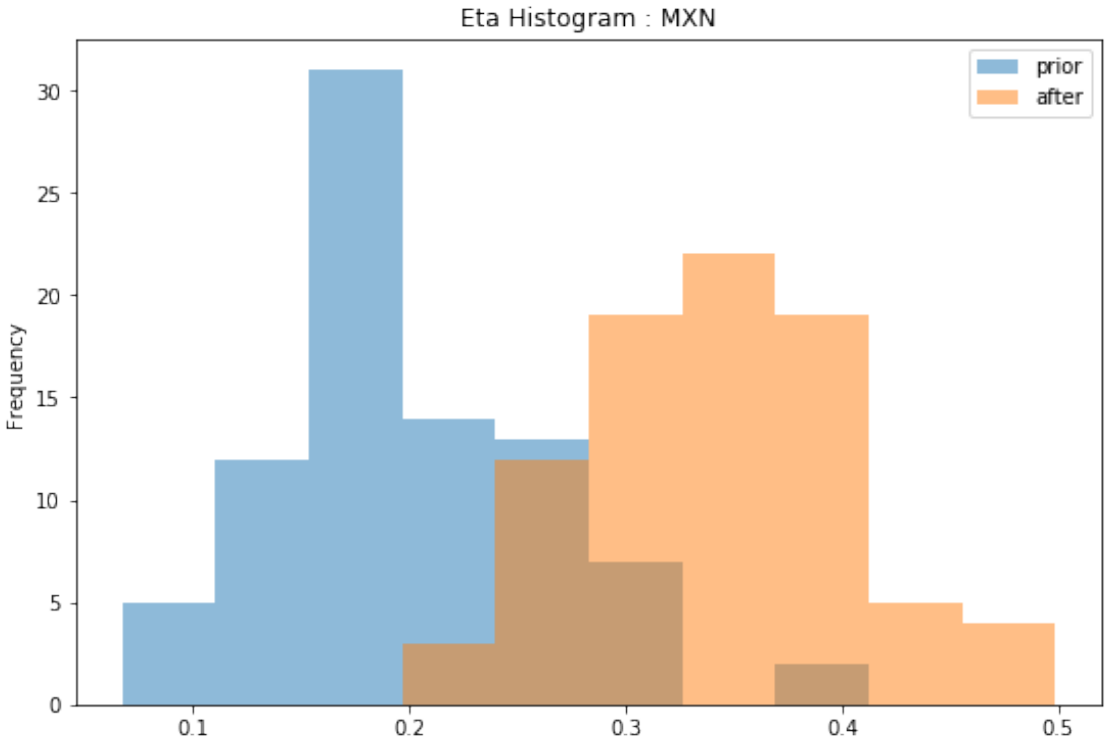
[84]:
```
cme.scatter_plot(OB_UZ_STATS, 'rvxe', 'twspr1',\
    'Spread in Ticks (y) x Estimated Volatility of Efficient Prices (x) :␣
↪'+CURR)
```



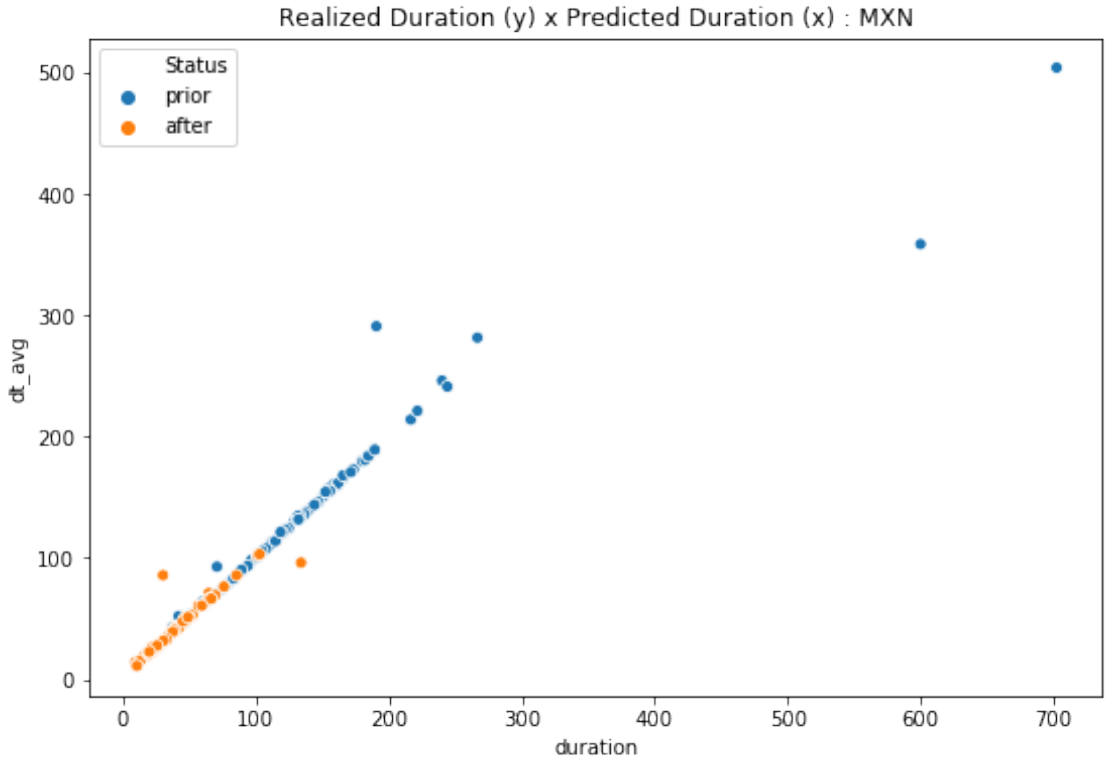
[85]:
```
cme.scatter_plot(OB_UZ_STATS, 'eta1', 'twspr1',\
    'Spread in Ticks (y) x Eta (x) : '+CURR)
```



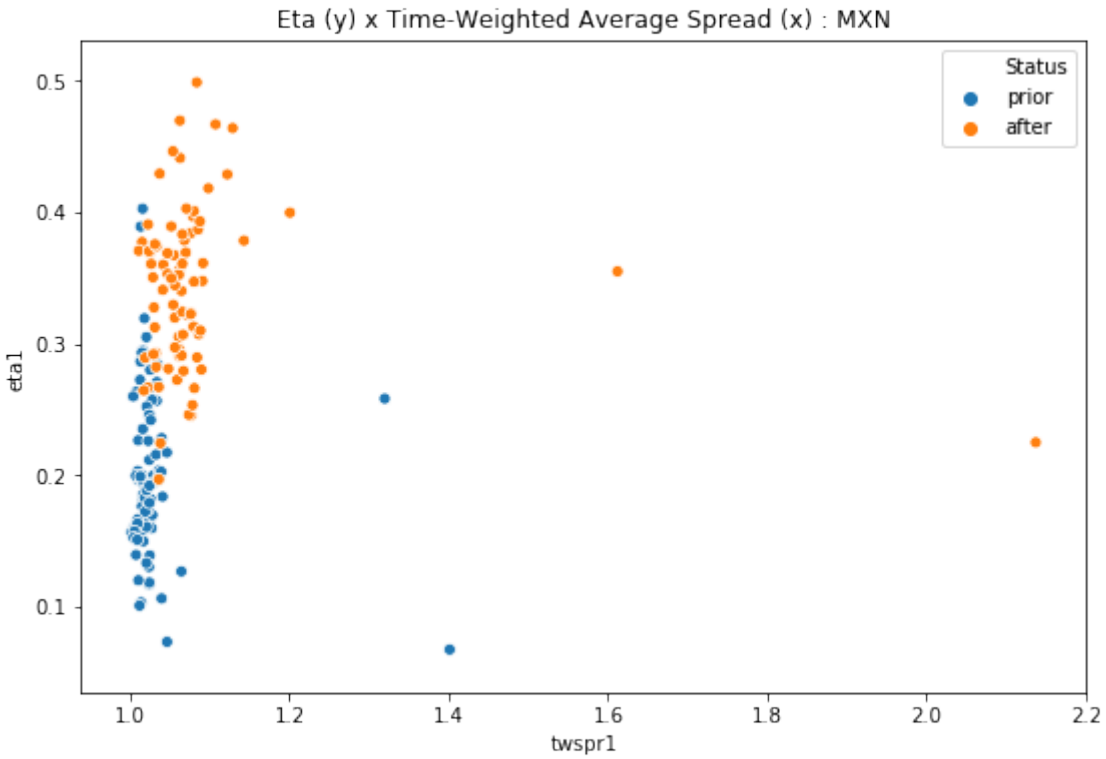
[86]:
```
cme.time_series_hist(OB_UZ_STATS, 'eta1',\
    'Eta Histogram : '+CURR)
```



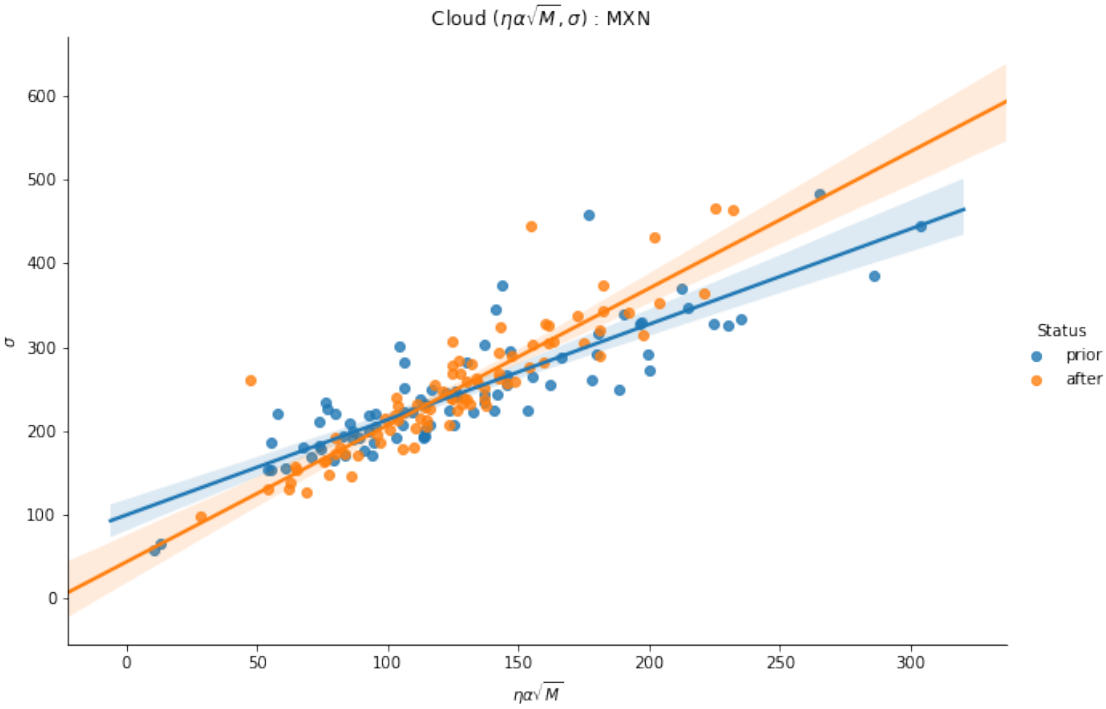
[87]:
```
cme.scatter_plot(OB_UZ_STATS, 'duration', 'dt_avg',\
    'Realized Duration (y) x Predicted Duration (x) : '+CURR)
```



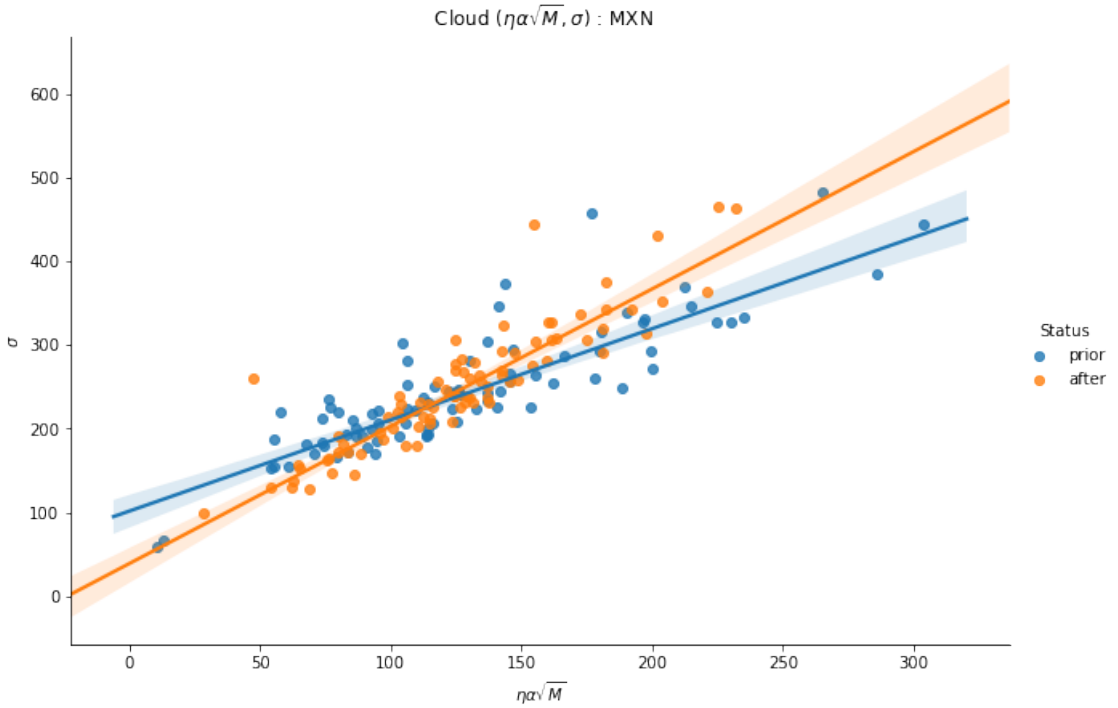
[88]:
```
cme.scatter_plot(OB_UZ_STATS, 'twspr1', 'eta1',\
    'Eta (y) x Time-Weighted Average Spread (x) : '+CURR)
```



[89]:
```
cme.cloud1(OB_UZ_STATS, CURR)
```



[90]:
```
cme.cloud1(OB_UZ_STATS, CURR, True)
```



[91]:
```
cme.lin_reg(PRIOR_OB_UZ_STATS, ['eta*alpha*sqrt(M)', 'S*sqrt(M)'], 'sigma')
```

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                  sigma   R-squared:                       0.814
Model:                            OLS   Adj. R-squared:                  0.810
Method:                 Least Squares   F-statistic:                     177.6
Date:                Wed, 09 Oct 2019   Prob (F-statistic):           2.44e-30
Time:                        17:06:44   Log-Likelihood:                -410.15
No. Observations:                  84   AIC:                             826.3
Df Residuals:                      81   BIC:                             833.6
Df Model:                           2
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const         23.1958     16.678      1.391      0.168      -9.988
```

```
56.379
eta*alpha*sqrt(M)     0.7462      0.096      7.745      0.000       0.554
0.938
S*sqrt(M)             0.1976      0.037      5.390      0.000       0.125
0.270
==============================================================================
Omnibus:                       39.438   Durbin-Watson:                   1.825
Prob(Omnibus):                  0.000   Jarque-Bera (JB):               94.054
Skew:                           1.673   Prob(JB):                     3.77e-21
Kurtosis:                       6.959   Cond. No.                     3.15e+03
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
[2] The condition number is large, 3.15e+03. This might indicate that there are
strong multicollinearity or other numerical problems.
```

[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:                   84
Model:                             RLM   Df Residuals:                       81
Method:                           IRLS   Df Model:                            2
Norm:                          HuberT
Scale Est.:                       mad
Cov Type:                          H1
Date:                Wed, 09 Oct 2019
Time:                        17:06:44
No. Iterations:                    12
==============================================================================
=====
                         coef    std err          z      P>|z|      [0.025
0.975]
------------------------------------------------------------------------------
-----
const                 26.9172     11.834      2.274      0.023       3.722
50.112
eta*alpha*sqrt(M)     0.7628      0.068     11.158      0.000       0.629
0.897
S*sqrt(M)             0.1814      0.026      6.973      0.000       0.130
0.232
==============================================================================
=====

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:                       0.855
Model:                            OLS   Adj. R-squared:                  0.852
Method:                 Least Squares   F-statistic:                     239.3
Date:                Wed, 09 Oct 2019   Prob (F-statistic):           1.01e-34
Time:                        17:06:44   Log-Likelihood:                -400.99
No. Observations:                  84   AIC:                             808.0
Df Residuals:                      81   BIC:                             815.3
Df Model:                           2
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const        -11.2804     15.237     -0.740      0.461     -41.596      19.036
eta*alpha*sqrt(M)     0.9511      0.160      5.938      0.000       0.632       1.270
S*sqrt(M)      0.3617      0.075      4.850      0.000       0.213       0.510
==============================================================================
Omnibus:                       72.210   Durbin-Watson:                   1.744
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              485.959
Skew:                           2.690   Prob(JB):                    2.99e-106
Kurtosis:                      13.484   Cond. No.                     2.02e+03
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.
[2] The condition number is large, 2.02e+03. This might indicate that there are
strong multicollinearity or other numerical problems.
```

[94]:
```
cme.lin_reg_rob(AFTER_OB_UZ_STATS, ['eta*alpha*sqrt(M)', 'S*sqrt(M)'], 'sigma')
```

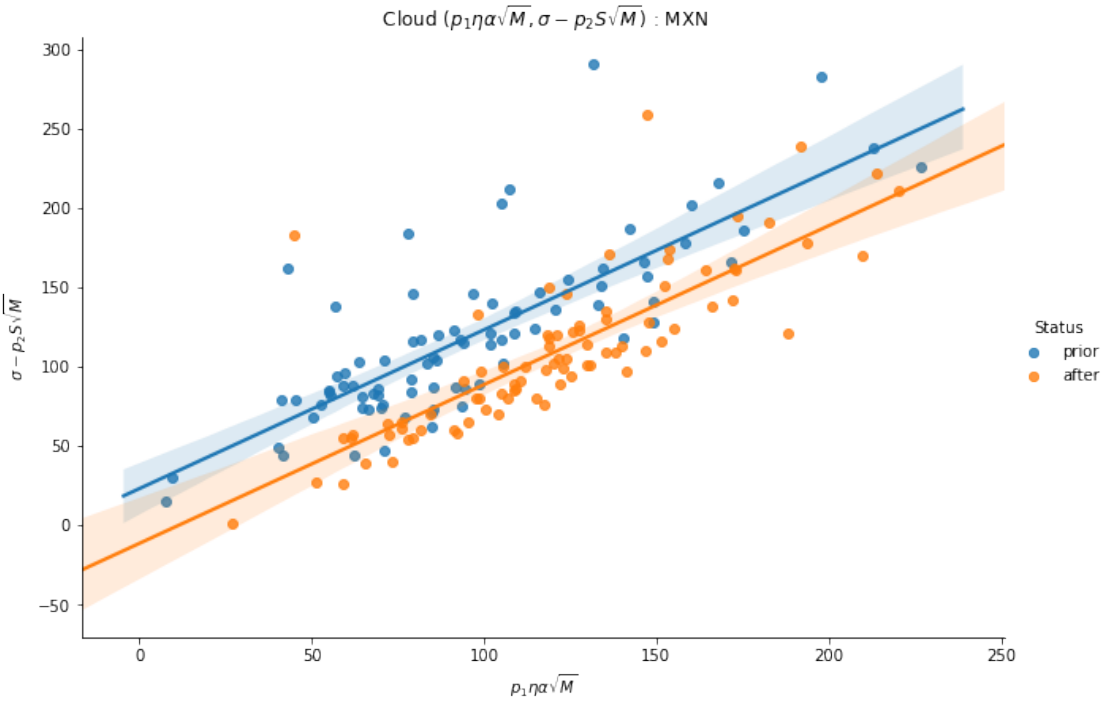
```
                    Robust linear Model Regression Results
==============================================================================
Dep. Variable:                  sigma   No. Observations:                   84
Model:                            RLM   Df Residuals:                       81
Method:                          IRLS   Df Model:                            2
Norm:                          HuberT
Scale Est.:                       mad
Cov Type:                          H1
```

```
Date:                Wed, 09 Oct 2019
Time:                        17:06:44
No. Iterations:                 11
==============================================================================
=====
                         coef    std err          z      P>|z|      [0.025
0.975]
------------------------------------------------------------------------------
-----
const                -19.3702      9.618     -2.014      0.044     -38.221
-0.519
eta*alpha*sqrt(M)      1.0260      0.101     10.148      0.000       0.828
1.224
S*sqrt(M)              0.3482      0.047      7.397      0.000       0.256
0.440
==============================================================================
=====
```

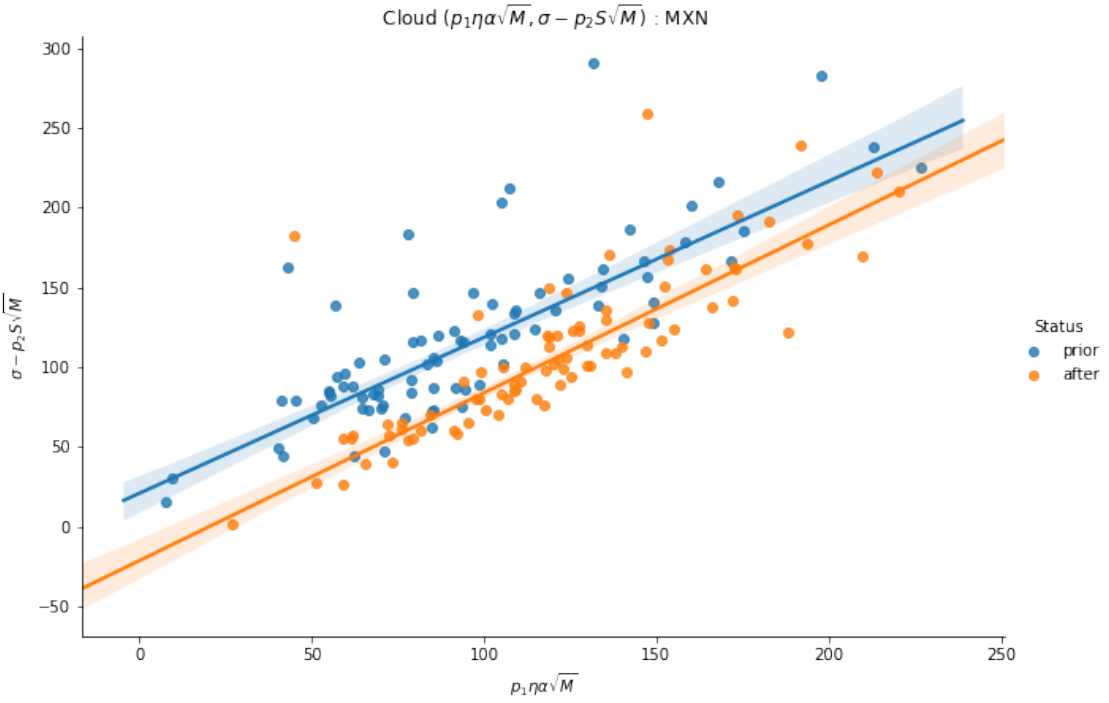
If the model instance has been used for another fit with different fit parameters, then the fit options might not be the correct ones anymore .

[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)']
```

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



[97]:
```
cme.cloud2(OB_UZ_STATS, CURR, True)
```



[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:                       0.634
Model:                            OLS   Adj. R-squared:                  0.629
Method:                 Least Squares   F-statistic:                     141.7
Date:                Wed, 09 Oct 2019   Prob (F-statistic):           1.47e-19
Time:                        17:06:52   Log-Likelihood:                -410.15
No. Observations:                  84   AIC:                             824.3
Df Residuals:                      82   BIC:                             829.2
Df Model:                           1
Covariance Type:            nonrobust
================================================================================
========
                           coef    std err          t      P>|t|      [0.025
0.975]
--------------------------------------------------------------------------------
--------
const                    23.1958      8.745      2.652      0.010       5.799
40.592
p1*eta*alpha*sqrt(M)      1.0000      0.084     11.906      0.000       0.833
1.167
==============================================================================
Omnibus:                       39.438   Durbin-Watson:                   1.825
Prob(Omnibus):                  0.000   Jarque-Bera (JB):               94.054
Skew:                           1.673   Prob(JB):                     3.77e-21
Kurtosis:                       6.959   Cond. No.                         258.
==============================================================================

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:                   84
Model:                            RLM   Df Residuals:                       82
Method:                          IRLS   Df Model:                           1
Norm:                          HuberT
Scale Est.:                       mad
Cov Type:                          H1
Date:                Wed, 09 Oct 2019
Time:                        17:06:52
```

```
No. Iterations:                    13
==============================================================================
========
                             coef    std err          z      P>|z|      [0.025
0.975]
------------------------------------------------------------------------------
--------
const                     20.8415      6.500      3.206      0.001       8.102
33.581
p1*eta*alpha*sqrt(M)      0.9780      0.062     15.666      0.000       0.856
1.100
==============================================================================
========

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

[100]:
```
cme.lin_reg(OB_UZ_STATS[OB_UZ_STATS['Status']=='after'],␣
↪['p1*eta*alpha*sqrt(M)'], 'sigma-p2*S*sqrt(M)')
```

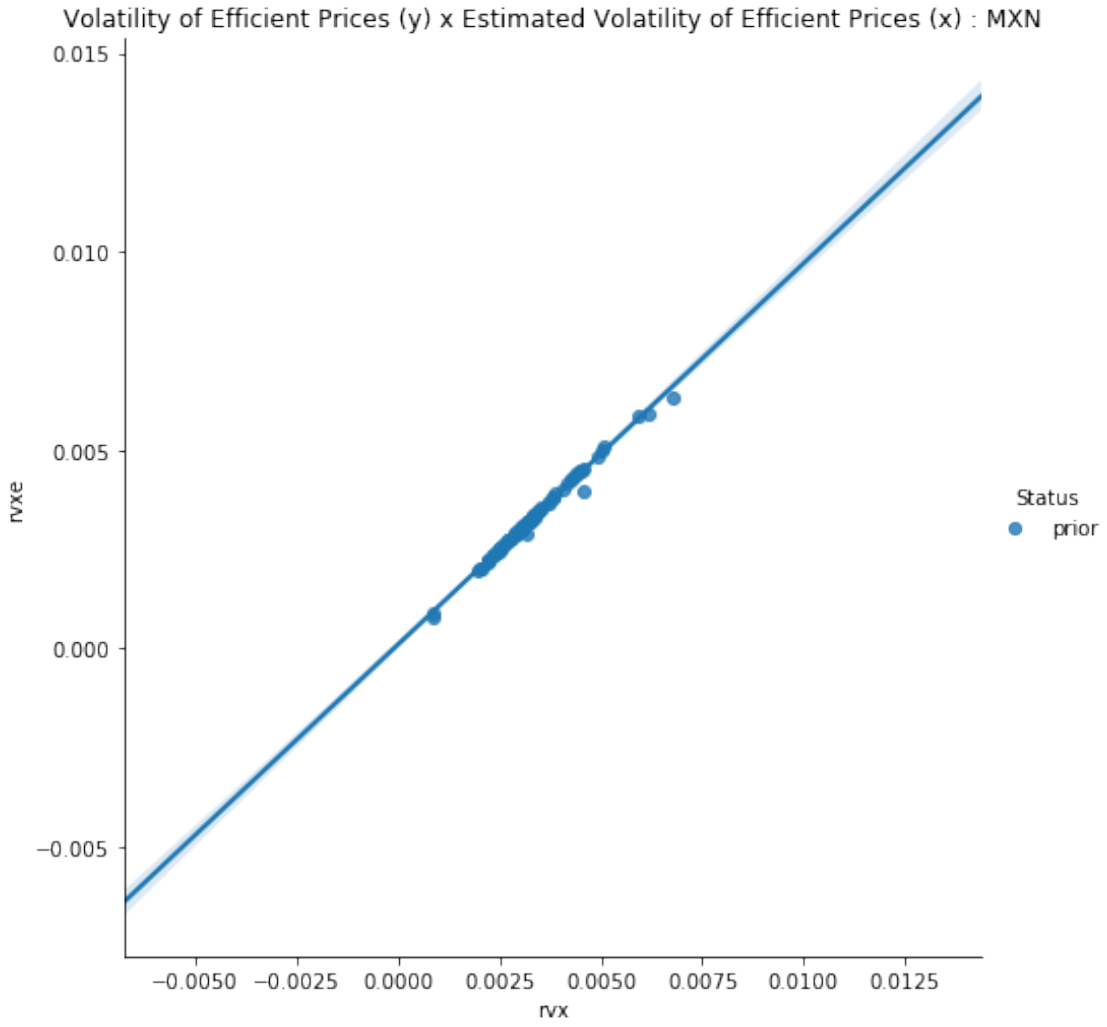
```
                            OLS Regression Results
==============================================================================
Dep. Variable:     sigma-p2*S*sqrt(M)   R-squared:                       0.656
Model:                            OLS   Adj. R-squared:                  0.652
Method:                 Least Squares   F-statistic:                     156.2
Date:                Wed, 09 Oct 2019   Prob (F-statistic):           1.11e-20
Time:                        17:06:52   Log-Likelihood:                -400.99
No. Observations:                  84   AIC:                             806.0
Df Residuals:                      82   BIC:                             810.9
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
========
                             coef    std err          t      P>|t|      [0.025
0.975]
------------------------------------------------------------------------------
--------
const                    -11.2804     10.155     -1.111      0.270     -31.482
8.922
p1*eta*alpha*sqrt(M)      1.0000      0.080     12.498      0.000       0.841
1.159
==============================================================================
Omnibus:                       72.210   Durbin-Watson:                   1.744
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              485.959
Skew:                           2.690   Prob(JB):                    2.99e-106
Kurtosis:                      13.484   Cond. No.                         408.
==============================================================================
```

```
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:                   84
Model:                            RLM   Df Residuals:                       82
Method:                          IRLS   Df Model:                            1
Norm:                         HuberT
Scale Est.:                      mad
Cov Type:                         H1
Date:                Wed, 09 Oct 2019
Time:                        17:06:52
No. Iterations:                    13
==============================================================================
========
                             coef    std err          z      P>|z|      [0.025
0.975]
------------------------------------------------------------------------------
--------
const                    -21.3722      6.349     -3.366      0.001     -33.816
-8.929
p1*eta*alpha*sqrt(M)       1.0518      0.050     21.027      0.000       0.954
1.150
==============================================================================
========

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)
```



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

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                   rvxe   R-squared:                       0.994
Model:                            OLS   Adj. R-squared:                  0.994
Method:                 Least Squares   F-statistic:                 1.354e+04
Date:                Wed, 09 Oct 2019   Prob (F-statistic):           8.08e-93
Time:                        17:06:53   Log-Likelihood:                 188.88
No. Observations:                  84   AIC:                            -373.8
Df Residuals:                      82   BIC:                            -368.9
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
```

```
const          0.0183      0.050      0.366      0.715      -0.081       0.118
rvx            1.0048      0.009    116.362      0.000       0.988       1.022
==============================================================================
Omnibus:                      103.840   Durbin-Watson:                   2.145
Prob(Omnibus):                  0.000   Jarque-Bera (JB):             1303.342
Skew:                          -4.170   Prob(JB):                    9.61e-284
Kurtosis:                      20.402   Cond. No.                        106.
==============================================================================

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)
```

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

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

OLS Regression Results

Dep. Variable:	ndfpr	R-squared:	0.761
Model:	OLS	Adj. R-squared:	0.758
Method:	Least Squares	F-statistic:	260.8
Date:	Wed, 09 Oct 2019	Prob (F-statistic):	3.42e-27
Time:	17:07:00	Log-Likelihood:	4.3279
No. Observations:	84	AIC:	-4.656

```
Df Residuals:                       82   BIC:                            0.2058
Df Model:                            1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const         12.6313      0.447     28.238      0.000      11.741      13.521
rvxe           1.2450      0.077     16.148      0.000       1.092       1.398
==============================================================================
Omnibus:                        3.313   Durbin-Watson:                   1.814
Prob(Omnibus):                  0.191   Jarque-Bera (JB):                2.571
Skew:                          -0.376   Prob(JB):                        0.277
Kurtosis:                       3.411   Cond. No.                         105.
==============================================================================

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:                   84
Model:                            RLM   Df Residuals:                       82
Method:                          IRLS   Df Model:                            1
Norm:                          HuberT
Scale Est.:                       mad
Cov Type:                          H1
Date:                Wed, 09 Oct 2019
Time:                        17:07:00
No. Iterations:                    16
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
const         12.6699      0.468     27.090      0.000      11.753      13.587
rvxe           1.2506      0.081     15.514      0.000       1.093       1.409
==============================================================================

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:                       0.885
Model:                            OLS   Adj. R-squared:                  0.884
```

```
Method:                 Least Squares   F-statistic:                     632.2
Date:                Wed, 09 Oct 2019   Prob (F-statistic):           2.69e-40
Time:                        17:07:00   Log-Likelihood:                 31.903
No. Observations:                  84   AIC:                            -59.81
Df Residuals:                      82   BIC:                            -54.94
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const         15.0767      0.335     45.072      0.000      14.411      15.742
rvxe           1.4608      0.058     25.143      0.000       1.345       1.576
==============================================================================
Omnibus:                       69.607   Durbin-Watson:                   1.926
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              650.084
Skew:                          -2.362   Prob(JB):                    6.86e-142
Kurtosis:                      15.783   Cond. No.                        109.
==============================================================================

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:                   84
Model:                            RLM   Df Residuals:                       82
Method:                          IRLS   Df Model:                            1
Norm:                          HuberT
Scale Est.:                       mad
Cov Type:                          H1
Date:                Wed, 09 Oct 2019
Time:                        17:07:00
No. Iterations:                    13
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
const         15.1552      0.265     57.165      0.000      14.636      15.675
rvxe           1.4730      0.046     31.989      0.000       1.383       1.563
==============================================================================

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)
```

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

[112]:
```
cme.lin_reg(PRIOR_OB_UZ_STATS, 'rvxe', 'M', True)
```

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                      M   R-squared:                       0.688
Model:                            OLS   Adj. R-squared:                  0.685
Method:                 Least Squares   F-statistic:                     181.1
Date:                Wed, 09 Oct 2019   Prob (F-statistic):           1.83e-22
Time:                        17:07:06   Log-Likelihood:                -26.197
No. Observations:                  84   AIC:                             56.39
Df Residuals:                      82   BIC:                             61.26
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
```

```
const         16.3983      0.643     25.489      0.000      15.119      17.678
rvxe           1.4923      0.111     13.459      0.000       1.272       1.713
==============================================================================
Omnibus:                       66.060   Durbin-Watson:                   1.538
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              489.845
Skew:                          -2.310   Prob(JB):                    4.28e-107
Kurtosis:                      13.890   Cond. No.                        105.
==============================================================================

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:                   84
Model:                            RLM   Df Residuals:                       82
Method:                          IRLS   Df Model:                            1
Norm:                         HuberT
Scale Est.:                      mad
Cov Type:                         H1
Date:                Wed, 09 Oct 2019
Time:                        17:07:06
No. Iterations:                    22
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
const         15.6809      0.484     32.383      0.000      14.732      16.630
rvxe           1.3628      0.083     16.329      0.000       1.199       1.526
==============================================================================

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)
```

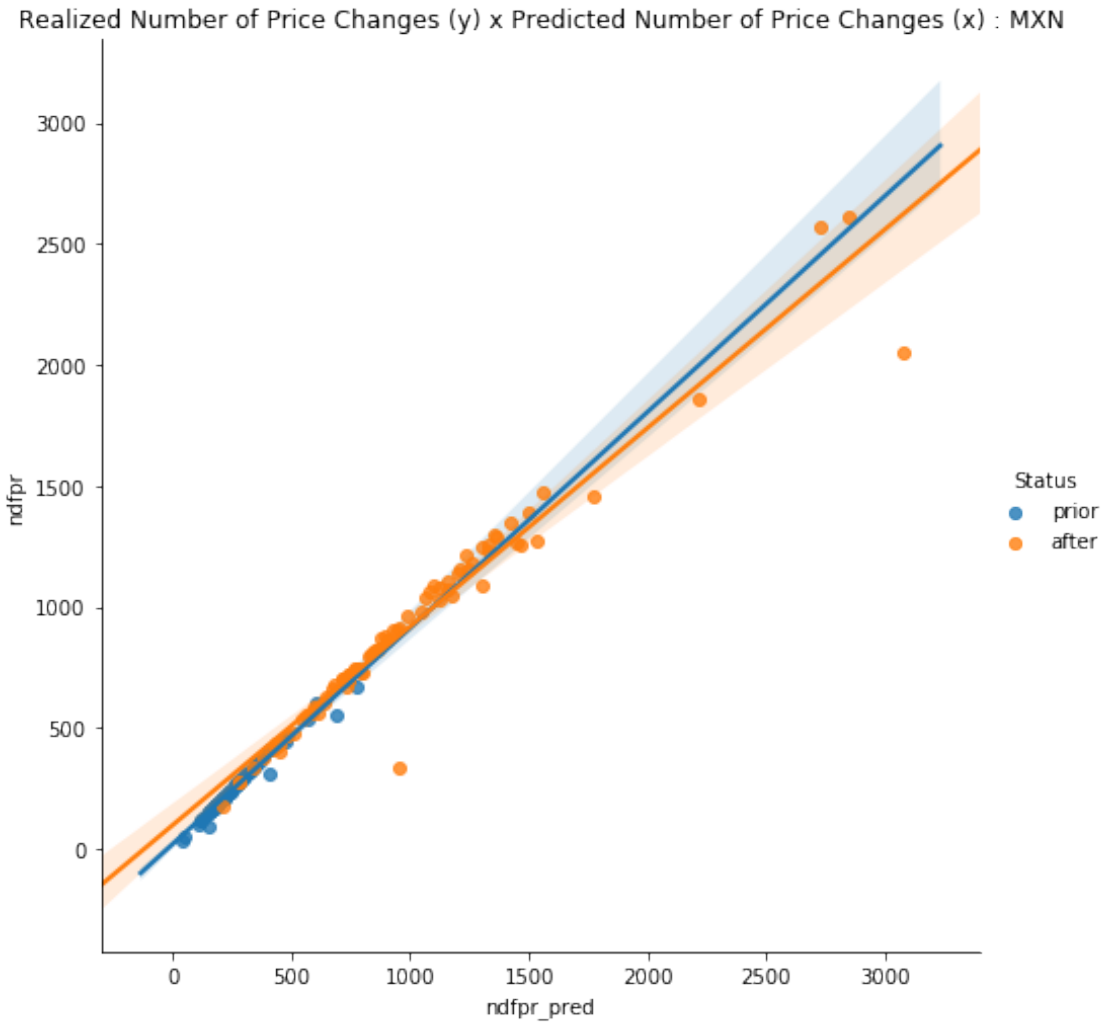
```
                            OLS Regression Results
==============================================================================
Dep. Variable:                      M   R-squared:                       0.657
Model:                            OLS   Adj. R-squared:                  0.653
Method:                 Least Squares   F-statistic:                     157.1
Date:                Wed, 09 Oct 2019   Prob (F-statistic):           9.51e-21
Time:                        17:07:06   Log-Likelihood:                -17.191
No. Observations:                  84   AIC:                             38.38
Df Residuals:                      82   BIC:                             43.24
Df Model:                           1
```

```
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const         16.0304      0.600     26.713      0.000      14.837      17.224
rvxe           1.3063      0.104     12.533      0.000       1.099       1.514
==============================================================================
Omnibus:                      111.418   Durbin-Watson:                   1.701
Prob(Omnibus):                  0.000   Jarque-Bera (JB):             2551.270
Skew:                          -4.253   Prob(JB):                         0.00
Kurtosis:                      28.624   Cond. No.                         109.
==============================================================================

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

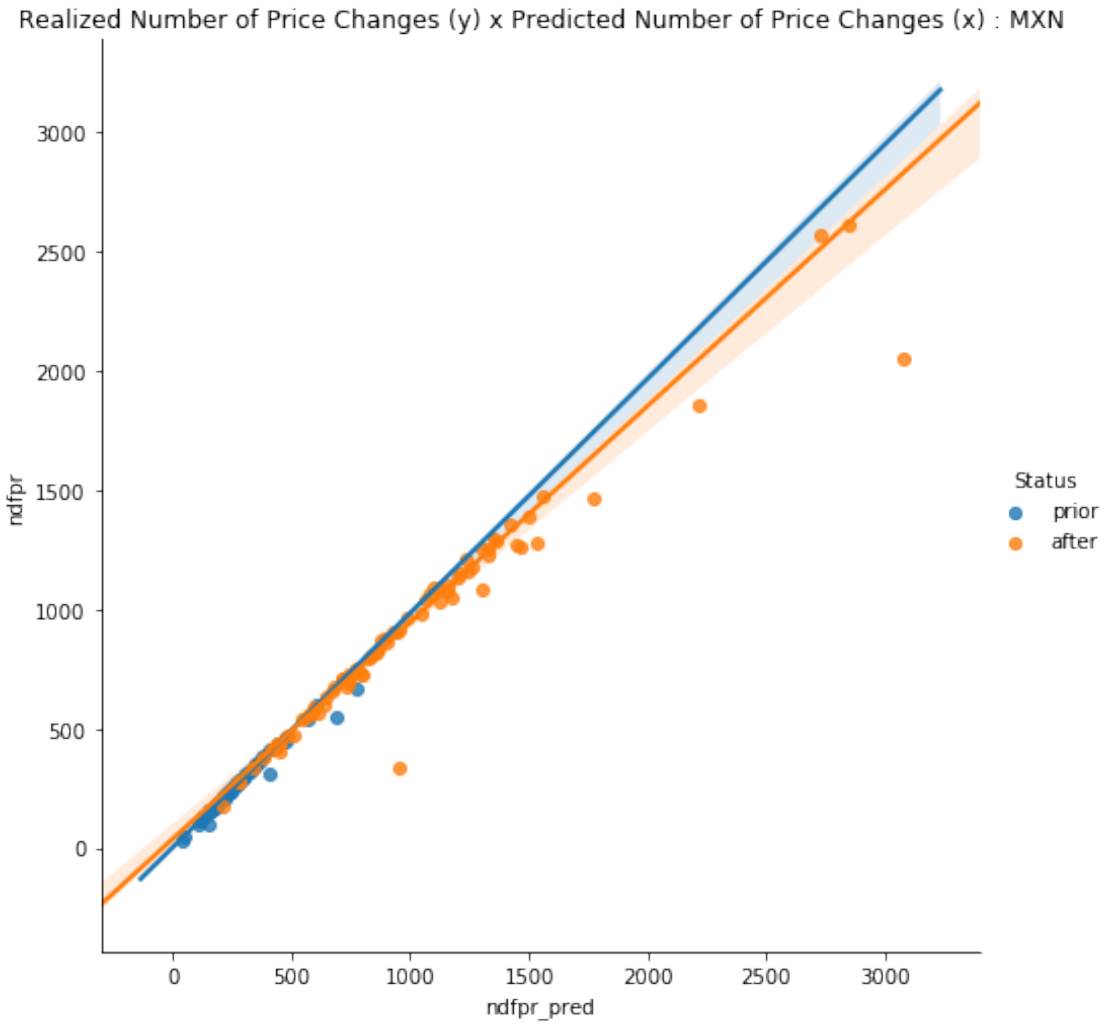
[115]:
```
cme.lin_reg_rob(AFTER_OB_UZ_STATS, 'rvxe', 'M', True)
```

```
                    Robust linear Model Regression Results
==============================================================================
Dep. Variable:                      M   No. Observations:                   84
Model:                            RLM   Df Residuals:                       82
Method:                          IRLS   Df Model:                            1
Norm:                         HuberT
Scale Est.:                      mad
Cov Type:                         H1
Date:                Wed, 09 Oct 2019
Time:                        17:07:06
No. Iterations:                    19
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
const         15.7653      0.352     44.737      0.000      15.075      16.456
rvxe           1.2535      0.061     20.480      0.000       1.134       1.373
==============================================================================

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)
```



[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)
```



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

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                  ndfpr   R-squared:                       0.976
Model:                            OLS   Adj. R-squared:                  0.976
Method:                 Least Squares   F-statistic:                     3383.
Date:                Wed, 09 Oct 2019   Prob (F-statistic):           1.95e-68
Time:                        17:07:22   Log-Likelihood:                -359.46
No. Observations:                  84   AIC:                             722.9
Df Residuals:                      82   BIC:                             727.8
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
```

```
const          20.7331      4.386      4.727      0.000      12.007      29.459
ndfpr_pred      0.8929      0.015     58.160      0.000       0.862       0.923
==============================================================================
Omnibus:                       68.854   Durbin-Watson:                   1.870
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              407.755
Skew:                          -2.590   Prob(JB):                     2.86e-89
Kurtosis:                      12.469   Cond. No.                         650.
==============================================================================

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

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

```
                    Robust linear Model Regression Results
==============================================================================
Dep. Variable:                  ndfpr   No. Observations:                   84
Model:                            RLM   Df Residuals:                       82
Method:                          IRLS   Df Model:                            1
Norm:                          HuberT
Scale Est.:                       mad
Cov Type:                          H1
Date:                Wed, 09 Oct 2019
Time:                        17:07:22
No. Iterations:                    25
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
const          2.6557      0.639      4.154      0.000       1.403       3.909
ndfpr_pred     0.9822      0.002    438.947      0.000       0.978       0.987
==============================================================================

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')
```

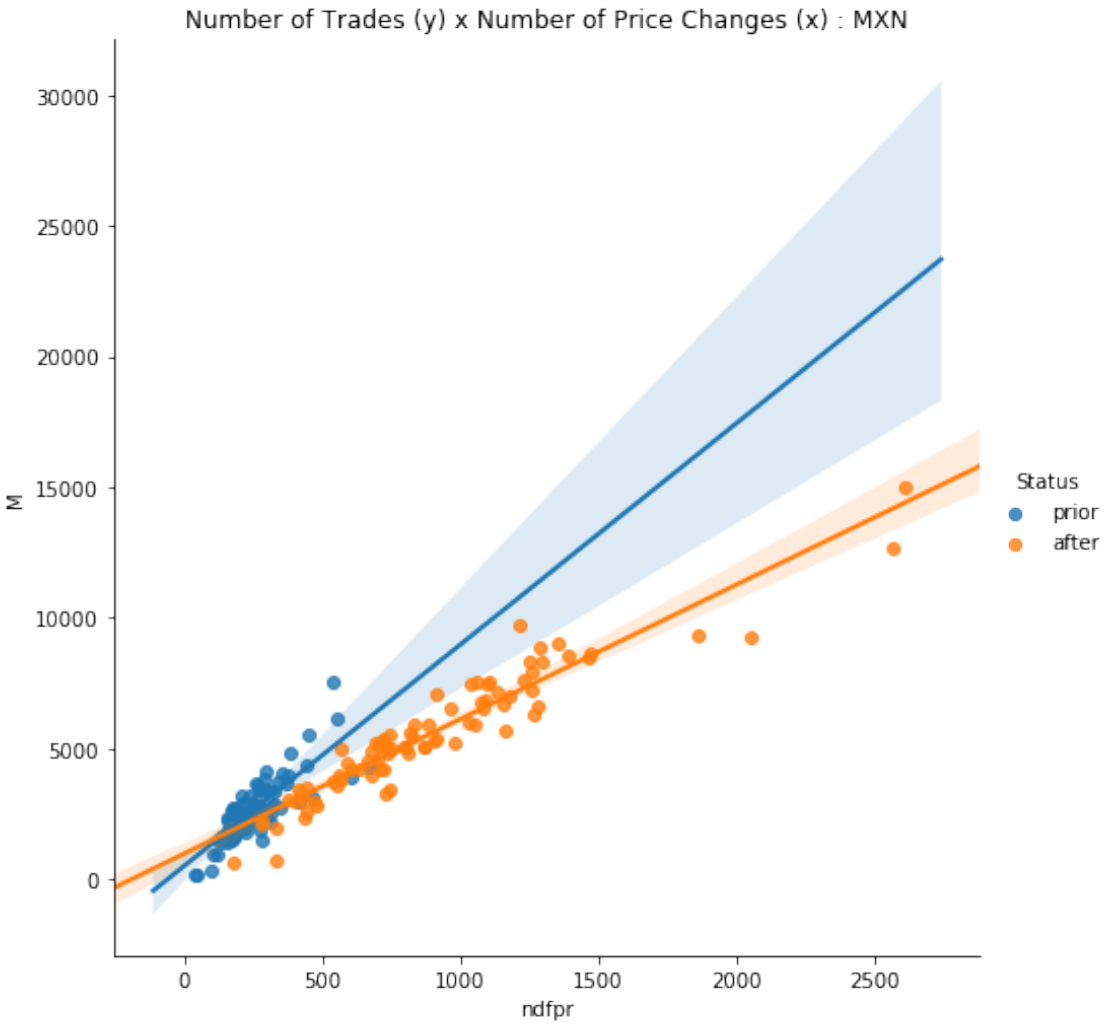
```
                            OLS Regression Results
==============================================================================
Dep. Variable:                  ndfpr   R-squared:                       0.946
Model:                            OLS   Adj. R-squared:                  0.945
Method:                 Least Squares   F-statistic:                     1429.
Date:                Wed, 09 Oct 2019   Prob (F-statistic):           1.18e-53
Time:                        17:07:22   Log-Likelihood:                -508.43
No. Observations:                  84   AIC:                             1021.
Df Residuals:                      82   BIC:                             1026.
Df Model:                           1
```

```
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const         98.8534     23.865      4.142      0.000      51.379     146.328
ndfpr_pred     0.8207      0.022     37.803      0.000       0.777       0.864
==============================================================================
Omnibus:                       97.464   Durbin-Watson:                   1.833
Prob(Omnibus):                  0.000   Jarque-Bera (JB):             1429.968
Skew:                          -3.649   Prob(JB):                    3.06e-311
Kurtosis:                      21.849   Cond. No.                     2.31e+03
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
[2] The condition number is large, 2.31e+03. This might indicate that there are
strong multicollinearity or other numerical problems.
```

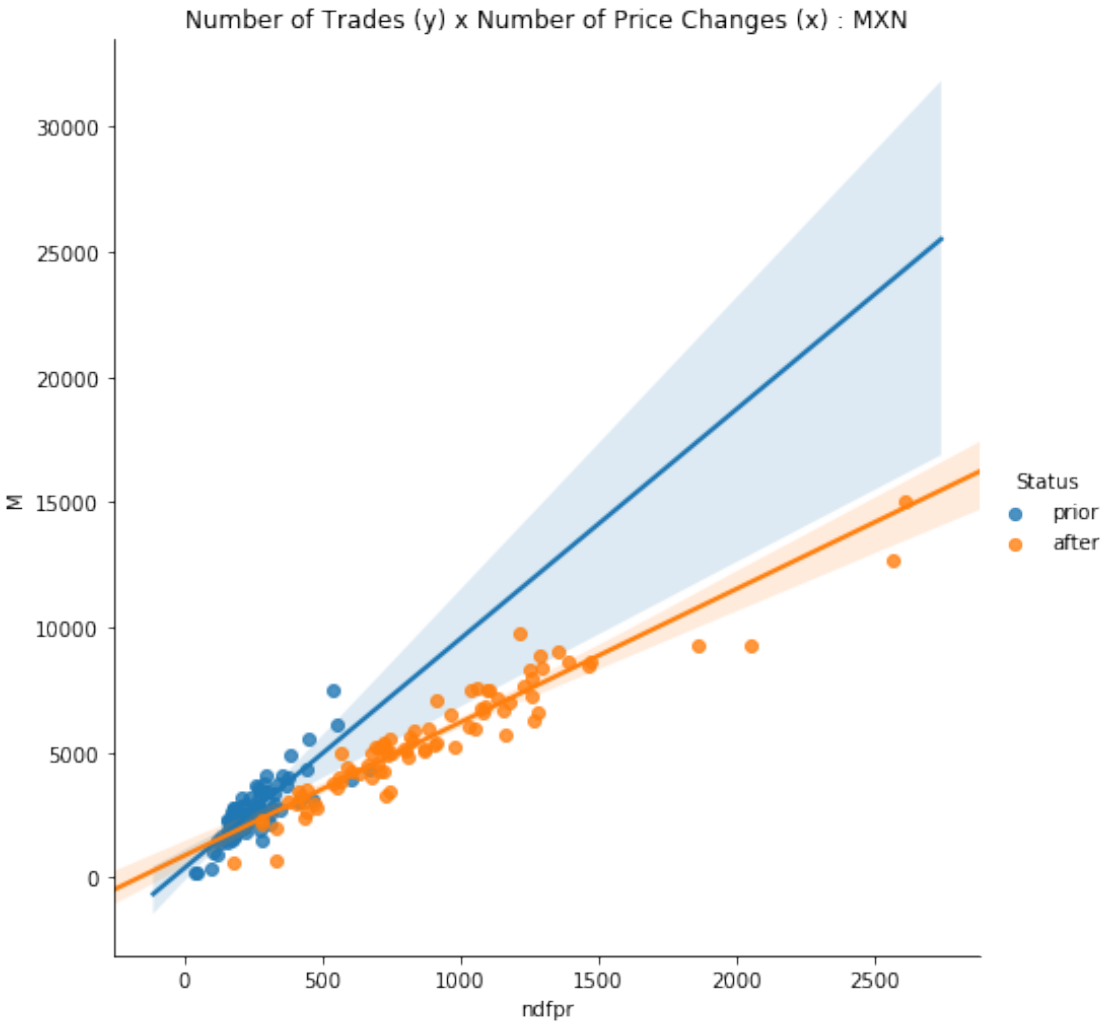
[121]:
```
cme.lin_reg_rob(AFTER_OB_UZ_STATS, 'ndfpr_pred', 'ndfpr')
```

```
                    Robust linear Model Regression Results
==============================================================================
Dep. Variable:                   ndfpr   No. Observations:                   84
Model:                             RLM   Df Residuals:                       82
Method:                           IRLS   Df Model:                            1
Norm:                          HuberT
Scale Est.:                       mad
Cov Type:                          H1
Date:                Wed, 09 Oct 2019
Time:                        17:07:22
No. Iterations:                    22
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
const         38.0357      5.953      6.389      0.000      26.368      49.704
ndfpr_pred     0.9073      0.005    167.541      0.000       0.897       0.918
==============================================================================

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)
```



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



[124]:
```
cme.lin_reg(PRIOR_OB_UZ_STATS, 'ndfpr', 'M')
```

OLS Regression Results

Dep. Variable:	M	R-squared:	0.670
Model:	OLS	Adj. R-squared:	0.666
Method:	Least Squares	F-statistic:	166.8
Date:	Wed, 09 Oct 2019	Prob (F-statistic):	1.84e-21
Time:	17:07:29	Log-Likelihood:	-666.25
No. Observations:	84	AIC:	1336.
Df Residuals:	82	BIC:	1341.
Df Model:	1		
Covariance Type:	nonrobust		

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

```
const        530.5214    179.781      2.951      0.004     172.881     888.162
ndfpr          8.4603      0.655     12.915      0.000       7.157       9.763
==============================================================================
Omnibus:                        5.853   Durbin-Watson:                   1.684
Prob(Omnibus):                  0.054   Jarque-Bera (JB):                8.913
Skew:                           0.103   Prob(JB):                       0.0116
Kurtosis:                       4.582   Cond. No.                         663.
==============================================================================

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

[125]:
```
cme.lin_reg_rob(PRIOR_OB_UZ_STATS, 'ndfpr', 'M')
```

```
                    Robust linear Model Regression Results
==============================================================================
Dep. Variable:                      M   No. Observations:                   84
Model:                            RLM   Df Residuals:                       82
Method:                          IRLS   Df Model:                            1
Norm:                         HuberT
Scale Est.:                      mad
Cov Type:                         H1
Date:                Wed, 09 Oct 2019
Time:                        17:07:29
No. Iterations:                    13
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
const        385.9906    165.371      2.334      0.020      61.869     710.112
ndfpr          9.1676      0.603     15.214      0.000       7.987      10.349
==============================================================================

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 .
```

[126]:
```
cme.lin_reg(AFTER_OB_UZ_STATS, 'ndfpr', 'M')
```

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                      M   R-squared:                       0.896
Model:                            OLS   Adj. R-squared:                  0.895
Method:                 Least Squares   F-statistic:                     709.8
Date:                Wed, 09 Oct 2019   Prob (F-statistic):           3.90e-42
Time:                        17:07:29   Log-Likelihood:                -677.70
No. Observations:                  84   AIC:                             1359.
Df Residuals:                      82   BIC:                             1364.
Df Model:                           1
```

```
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const        995.5011    192.119      5.182      0.000     613.316    1377.687
ndfpr          5.1412      0.193     26.641      0.000       4.757       5.525
==============================================================================
Omnibus:                        4.755   Durbin-Watson:                   1.418
Prob(Omnibus):                  0.093   Jarque-Bera (JB):                5.276
Skew:                          -0.236   Prob(JB):                       0.0715
Kurtosis:                       4.133   Cond. No.                     2.24e+03
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
[2] The condition number is large, 2.24e+03. This might indicate that there are
strong multicollinearity or other numerical problems.
```

[127]:
```
cme.lin_reg_rob(AFTER_OB_UZ_STATS, 'ndfpr', 'M')
```

```
                    Robust linear Model Regression Results
==============================================================================
Dep. Variable:                      M   No. Observations:                   84
Model:                            RLM   Df Residuals:                       82
Method:                          IRLS   Df Model:                            1
Norm:                         HuberT
Scale Est.:                      mad
Cov Type:                         H1
Date:                Wed, 09 Oct 2019
Time:                        17:07:29
No. Iterations:                     9
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
const        879.7374    165.766      5.307      0.000     554.843    1204.632
ndfpr          5.3280      0.167     31.999      0.000       5.002       5.654
==============================================================================

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 .
```

[128]:
```
cme.regr_plot(PRIOR_OB_UZ_STATS, 'M', 'Volume',\
    'Volume (y) x Number of Trades (x) : '+CURR)
```

[129]:
```
cme.regr_plot(PRIOR_OB_UZ_STATS, 'M', 'Volume',\
    'Volume (y) x Number of Trades (x) : '+CURR, True)
```

[130]:
```
cme.lin_reg(PRIOR_OB_UZ_STATS, 'M', 'Volume')
```

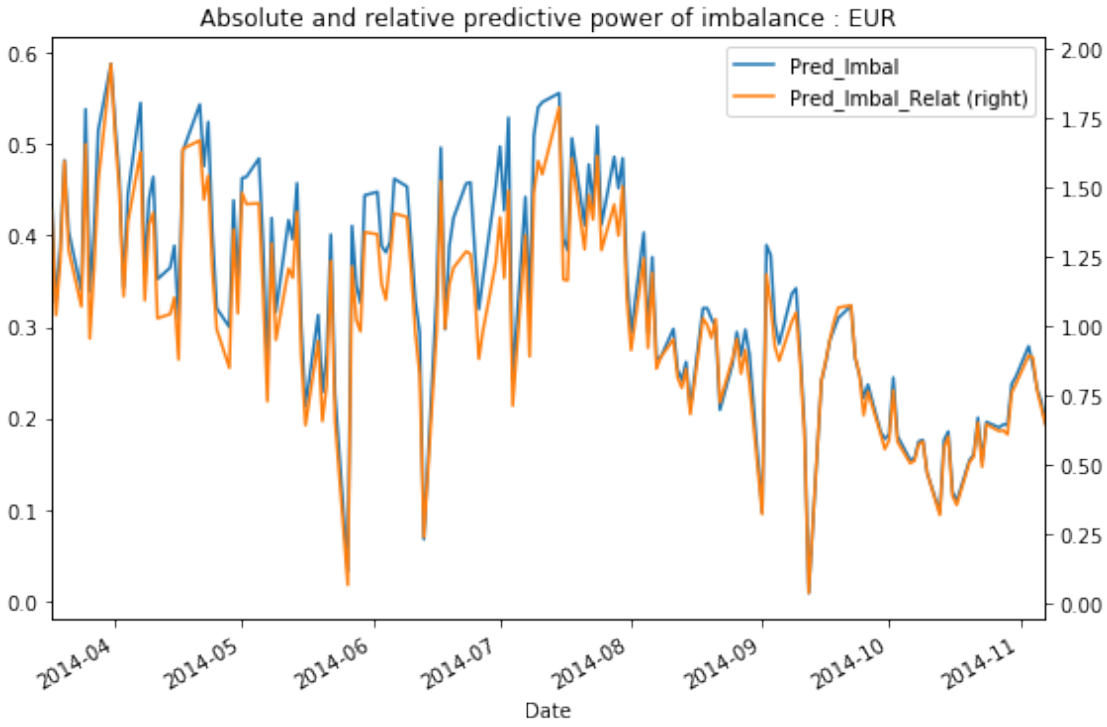
```
                            OLS Regression Results
==============================================================================
Dep. Variable:                 Volume   R-squared:                       0.879
Model:                            OLS   Adj. R-squared:                  0.877
Method:                 Least Squares   F-statistic:                     594.2
Date:                Wed, 09 Oct 2019   Prob (F-statistic):           2.54e-39
Time:                        17:07:32   Log-Likelihood:                -808.29
No. Observations:                  84   AIC:                             1621.
Df Residuals:                      82   BIC:                             1625.
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
```

```
const      -1769.6711    994.980     -1.779      0.079   -3749.003     209.661
M              8.3841      0.344     24.376      0.000       7.700       9.068
==============================================================================
Omnibus:                       49.210   Durbin-Watson:                   1.724
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              294.010
Skew:                           1.624   Prob(JB):                     1.43e-64
Kurtosis:                      11.571   Cond. No.                     7.13e+03
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
[2] The condition number is large, 7.13e+03. This might indicate that there are
strong multicollinearity or other numerical problems.
```

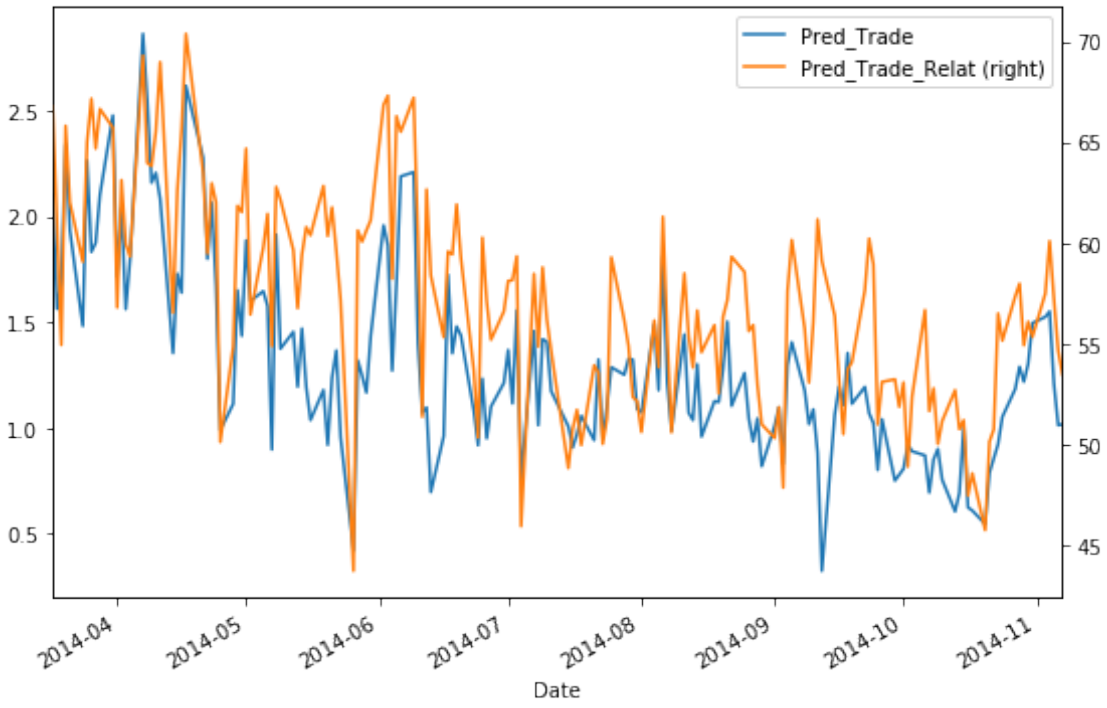
[131]:
```
cme.lin_reg_rob(PRIOR_OB_UZ_STATS, 'M', 'Volume')
```

```
                    Robust linear Model Regression Results
==============================================================================
Dep. Variable:                 Volume   No. Observations:                   84
Model:                            RLM   Df Residuals:                       82
Method:                          IRLS   Df Model:                            1
Norm:                          HuberT
Scale Est.:                       mad
Cov Type:                          H1
Date:                Wed, 09 Oct 2019
Time:                        17:07:32
No. Iterations:                     8
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
const       -961.0500    745.022     -1.290      0.197   -2421.267     499.167
M              7.9699      0.258     30.947      0.000       7.465       8.475
==============================================================================

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

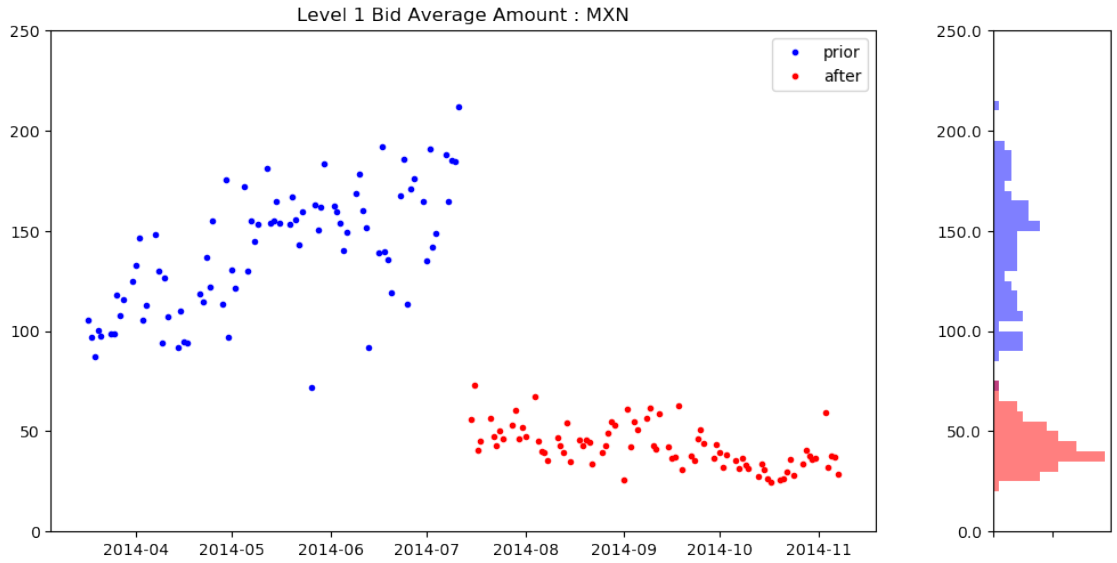


[133]:
```
TRADE_STATS_TS.plot(secondary_y=['Pred_Trade_Relat'], figsize=(9,6));
```

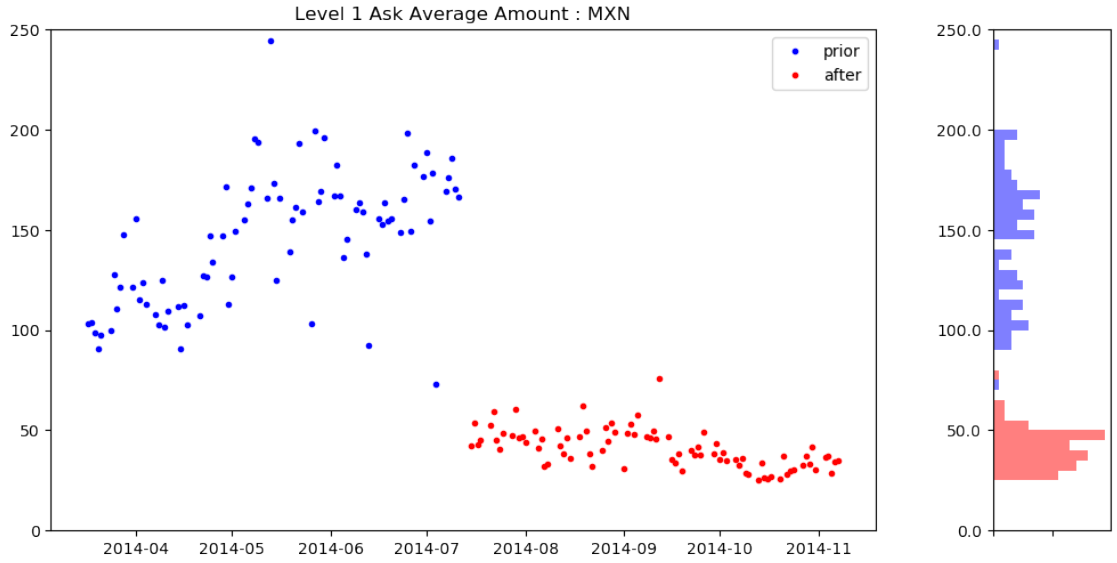


[134]:
```
OB_UZ_STATS_SPREADS = cme.spread_stats(OB_UZ_STATS)
```

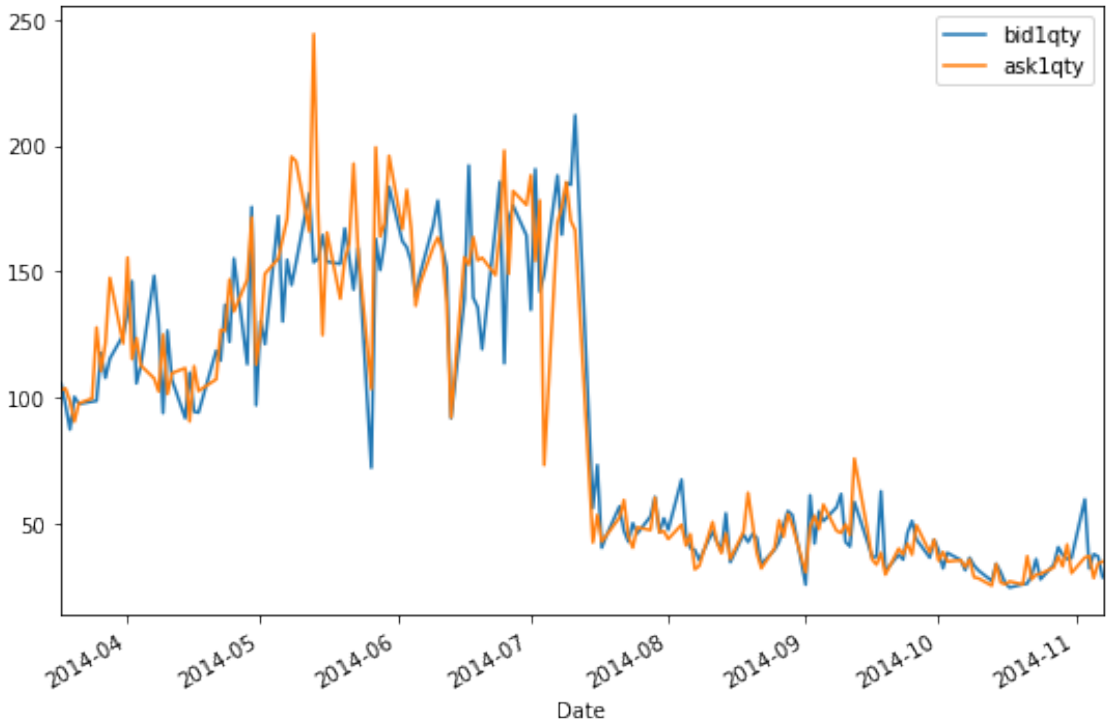
[193]:
```
cme.time_series_hist_plot(OB_UZ_STATS_SPREADS, 'bid1qty',\
    'Level 1 Bid Average Amount : '+CURR, 0, 250, 50)
```



[194]:
```
cme.time_series_hist_plot(OB_UZ_STATS_SPREADS, 'ask1qty',\
    'Level 1 Ask Average Amount : '+CURR, 0, 250, 50)
```



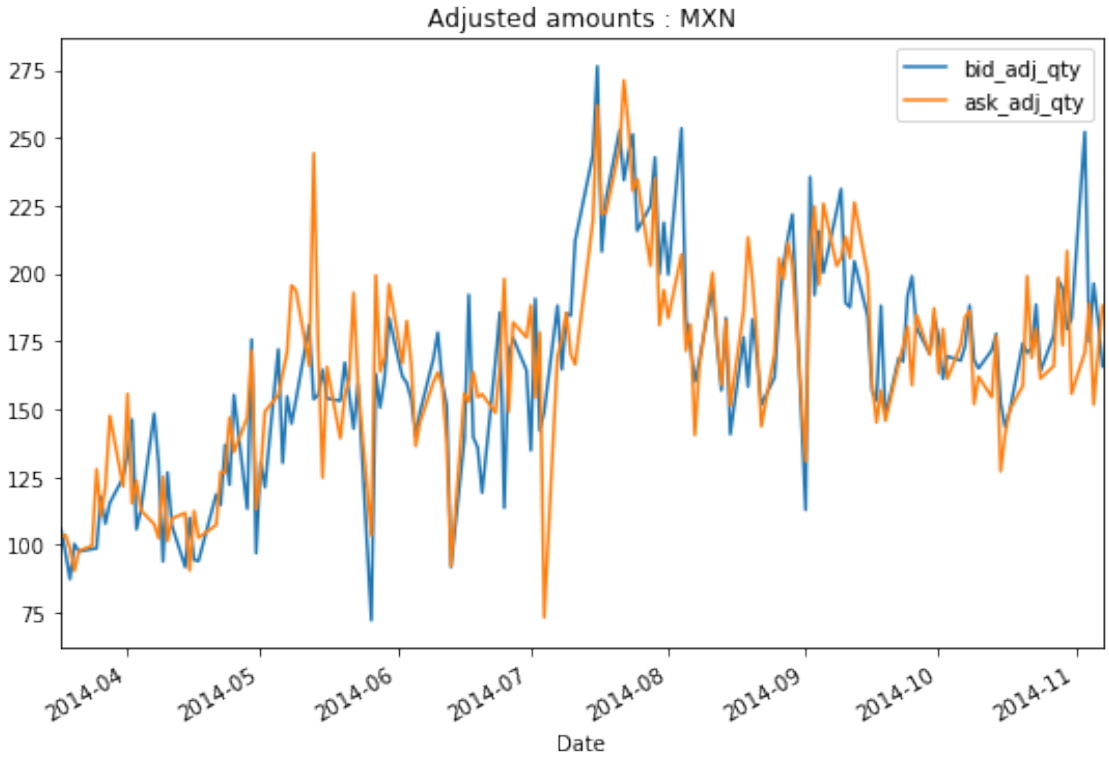
[137]:
```
OB_UZ_STATS_SPREADS[['bid1qty', 'ask1qty']].plot(figsize=(9,6));
```



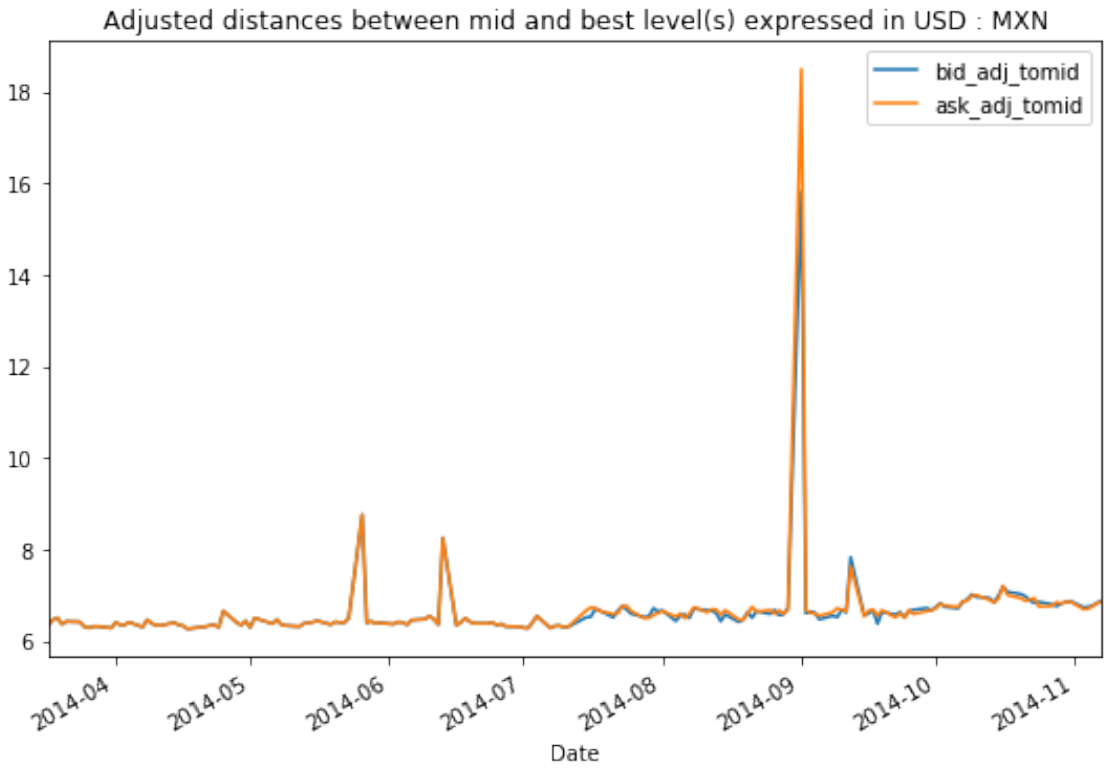
[138]:
```
OB_UZ_STATS_SPREADS[OB_UZ_STATS_SPREADS['Status'] == 'prior'][['bid1qty',␣
↪'ask1qty']].mean()/\
   OB_UZ_STATS_SPREADS[OB_UZ_STATS_SPREADS['Status'] == 'after'][['bid1qty',␣
↪'ask1qty']].mean()
```

[138]:
```
bid1qty    3.306712
ask1qty    3.551708
dtype: float64
```

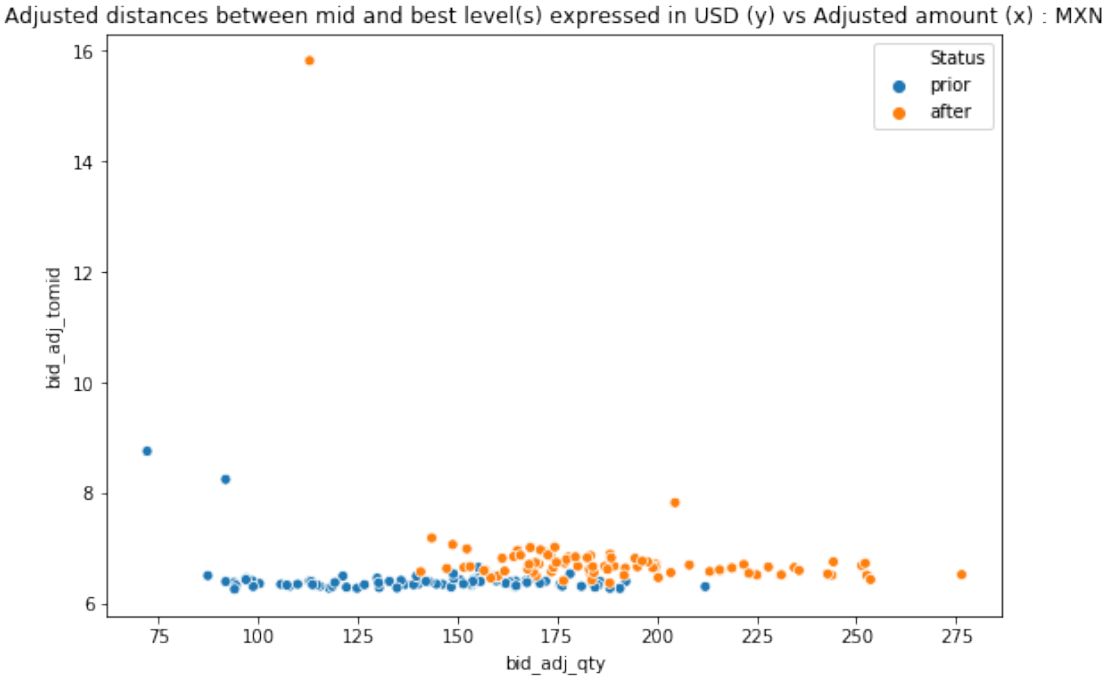
[139]:
```
OB_UZ_STATS_SPREADS[['bid_adj_qty', 'ask_adj_qty']].plot(figsize=(9,6),\
    title='Adjusted amounts : '+CURR);
```



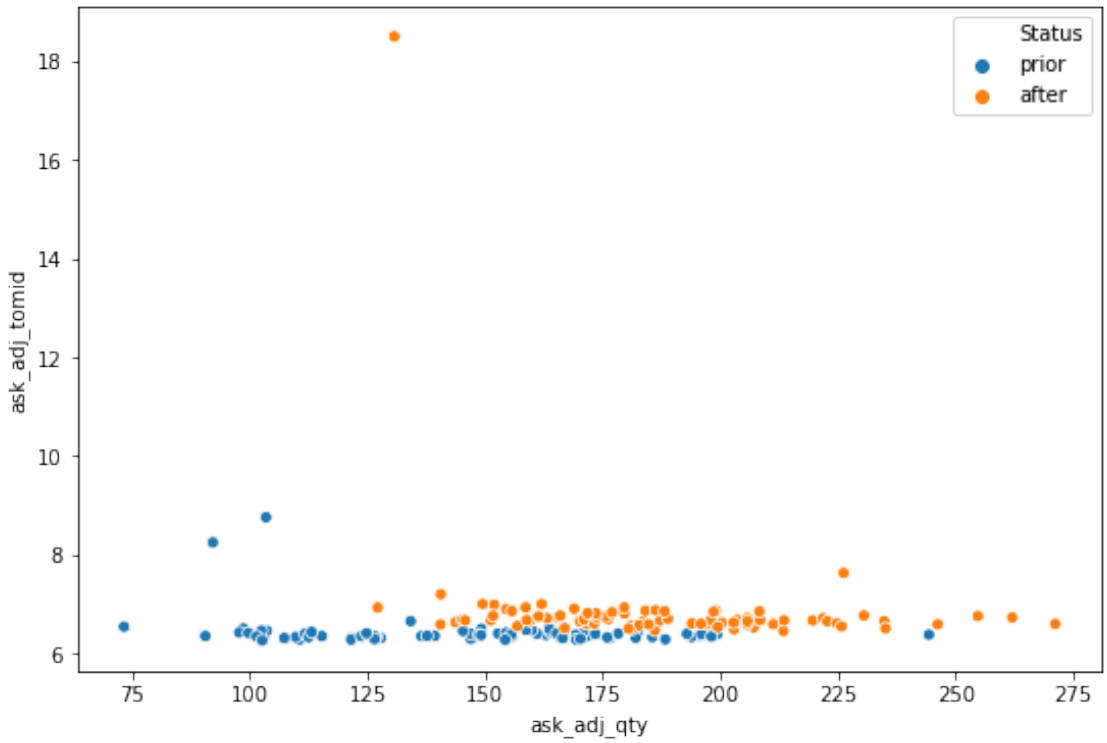
[140]:
```
OB_UZ_STATS_SPREADS[['bid_adj_tomid', 'ask_adj_tomid']].plot(figsize=(9,6),\
    title='Adjusted distances between mid and best level(s) expressed in USD :␣
↪'+CURR);
```



[141]:
```
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);
```



[142]:
```
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

[143]:
```
PRIOR_MEAN_COST = cme.cost_mean(PRIOR_COST_STATS, 100)
```

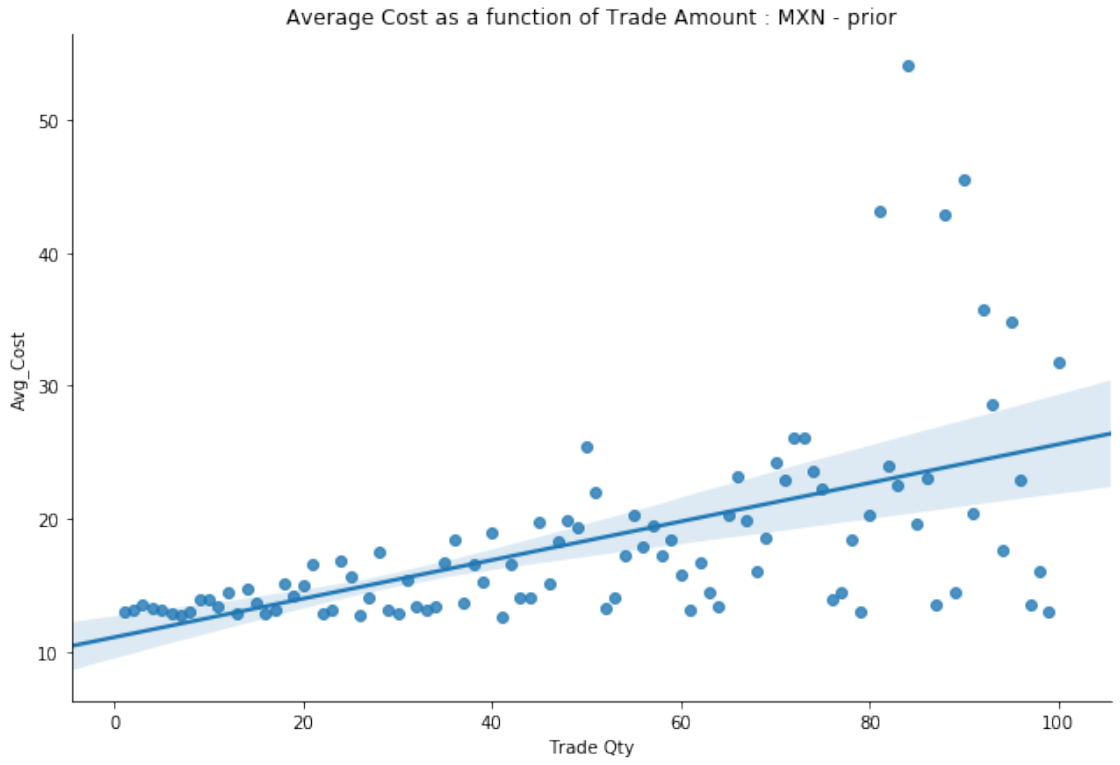
[144]:
```
PRIOR_MEAN_COST['Status'] = 'prior'
```

[145]:
```
AFTER_MEAN_COST = cme.cost_mean(AFTER_COST_STATS, 100)
```

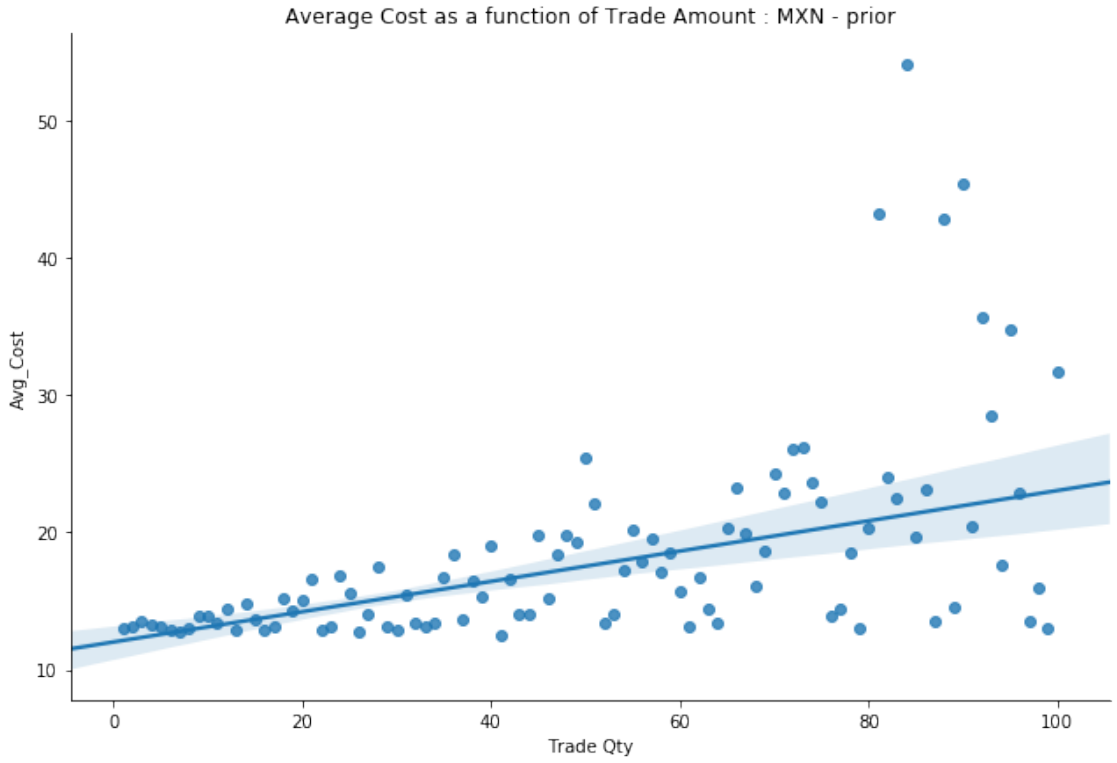
[146]:
```
AFTER_MEAN_COST['Status'] = 'after'
```

[147]:
```
MEAN_COST_STATS = pd.concat([PRIOR_MEAN_COST, AFTER_MEAN_COST], sort=False)
```

[148]:
```
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');
```



[149]:
```
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');
```



[150]:
```
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:	0.382
Model:	OLS	Adj. R-squared:	0.369
Method:	Least Squares	F-statistic:	29.67
Date:	Wed, 09 Oct 2019	Prob (F-statistic):	1.73e-06
Time:	17:07:42	Log-Likelihood:	-105.47
No. Observations:	50	AIC:	214.9
Df Residuals:	48	BIC:	218.8
Df Model:	1		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	12.1806	0.585	20.837	0.000	11.005	13.356
Trade Qty	0.1087	0.020	5.447	0.000	0.069	0.149

Omnibus:	14.107	Durbin-Watson:	1.624
Prob(Omnibus):	0.001	Jarque-Bera (JB):	21.705
Skew:	0.857	Prob(JB):	1.94e-05

```
Kurtosis:                       5.735   Cond. No.                         59.5
==============================================================================

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

[151]:
```
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:                        17:07:42
No. Iterations:                    27
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
const         12.4666      0.636     19.616      0.000      11.221      13.712
Trade Qty      0.0912      0.022      4.206      0.000       0.049       0.134
==============================================================================

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 .
```

[152]:
```
cme.lin_reg(cme.cost_mean(PRIOR_COST_STATS, 100).reset_index(), 'Trade Qty',␣
↪'Avg_Cost')
```

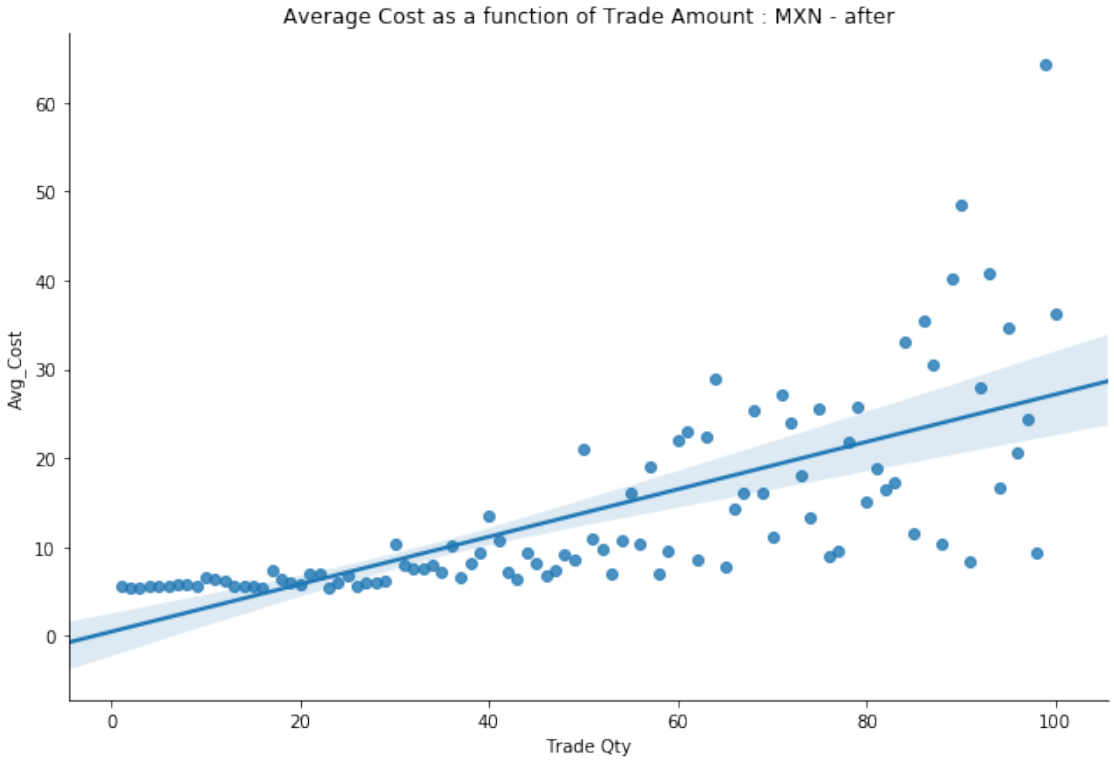
```
                            OLS Regression Results
==============================================================================
Dep. Variable:               Avg_Cost   R-squared:                       0.310
Model:                            OLS   Adj. R-squared:                  0.303
Method:                 Least Squares   F-statistic:                     44.11
Date:                Wed, 09 Oct 2019   Prob (F-statistic):           1.74e-09
Time:                        17:07:42   Log-Likelihood:                -324.97
No. Observations:                 100   AIC:                             653.9
Df Residuals:                      98   BIC:                             659.1
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
```

```
const          11.0990      1.270      8.740      0.000       8.579      13.619
Trade Qty       0.1450      0.022      6.642      0.000       0.102       0.188
==============================================================================
Omnibus:                       59.941   Durbin-Watson:                   2.186
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              279.178
Skew:                           1.958   Prob(JB):                     2.38e-61
Kurtosis:                      10.188   Cond. No.                         117.
==============================================================================

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

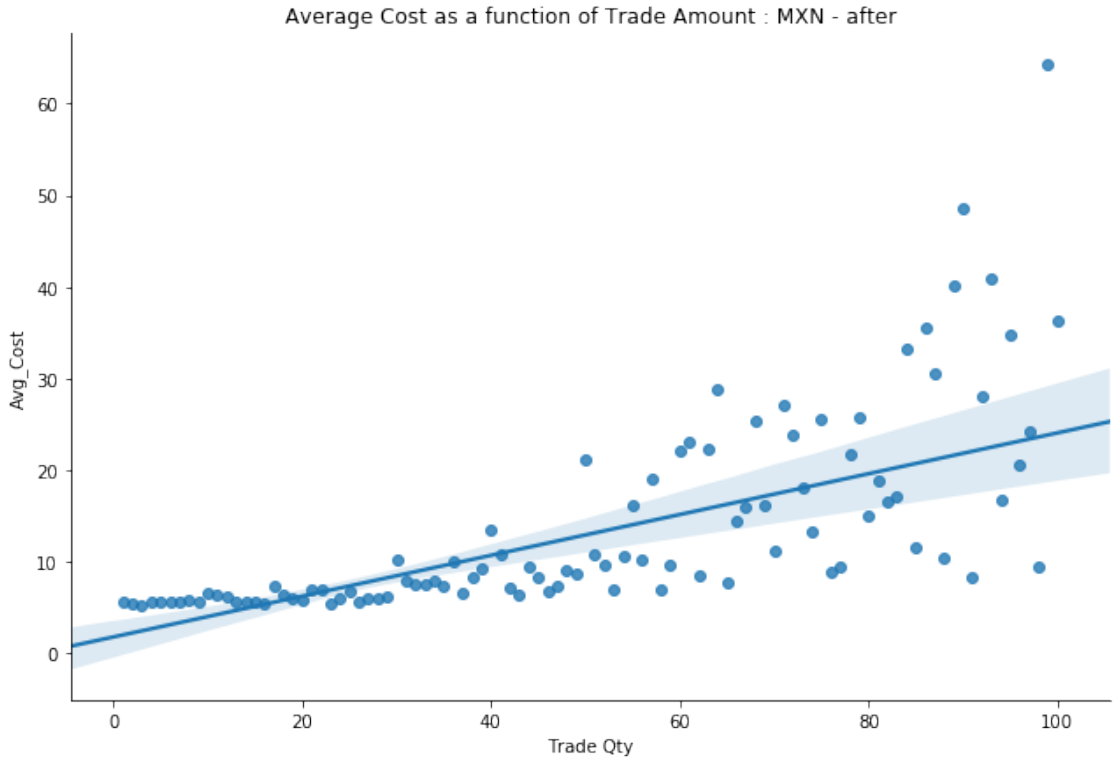
[153]:
```
cme.lin_reg_rob(cme.cost_mean(PRIOR_COST_STATS, 100).reset_index(), 'Trade␣
↪Qty', 'Avg_Cost')
```

```
                    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:                        17:07:42
No. Iterations:                    24
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
const         12.0217      0.748     16.079      0.000      10.556      13.487
Trade Qty      0.1103      0.013      8.580      0.000       0.085       0.135
==============================================================================

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 .
```

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



[155]:
```
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');
```



[156]:
```
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:	0.364
Model:	OLS	Adj. R-squared:	0.351
Method:	Least Squares	F-statistic:	27.47
Date:	Wed, 09 Oct 2019	Prob (F-statistic):	3.53e-06
Time:	17:07:51	Log-Likelihood:	-107.16
No. Observations:	50	AIC:	218.3
Df Residuals:	48	BIC:	222.1
Df Model:	1		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	4.5525	0.605	7.530	0.000	3.337	5.768
Trade Qty	0.1081	0.021	5.241	0.000	0.067	0.150

Omnibus:	63.690	Durbin-Watson:	1.253
Prob(Omnibus):	0.000	Jarque-Bera (JB):	553.849
Skew:	3.247	Prob(JB):	5.41e-121

```
Kurtosis:                       17.956   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(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:                        17:07:51
No. Iterations:                    16
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
const          5.0797      0.287     17.727      0.000       4.518       5.641
Trade Qty      0.0720      0.010      7.364      0.000       0.053       0.091
==============================================================================

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(AFTER_COST_STATS, 100).reset_index(), 'Trade Qty',␣
↪'Avg_Cost')
```

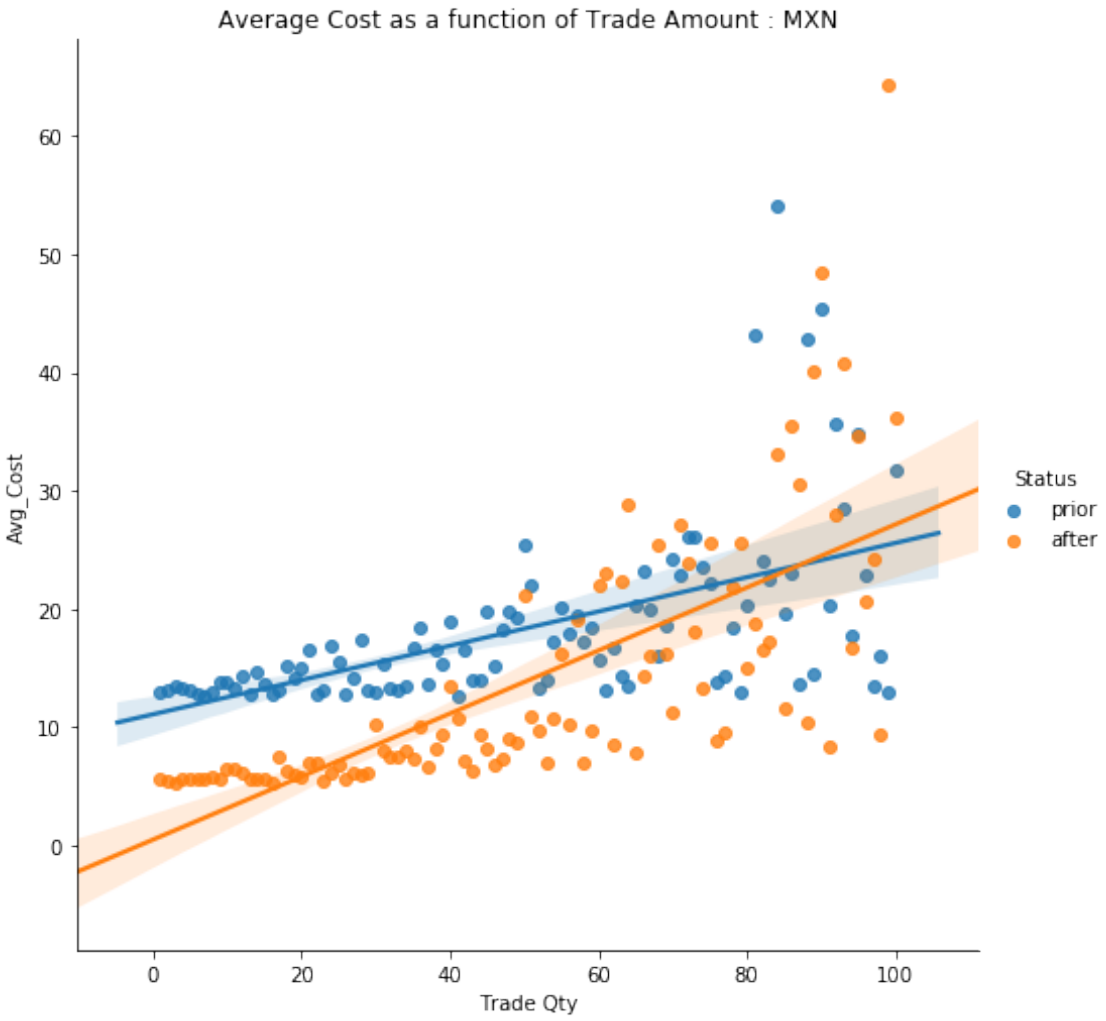
```
                            OLS Regression Results
==============================================================================
Dep. Variable:               Avg_Cost   R-squared:                       0.506
Model:                            OLS   Adj. R-squared:                  0.501
Method:                 Least Squares   F-statistic:                     100.6
Date:                Wed, 09 Oct 2019   Prob (F-statistic):           1.05e-16
Time:                        17:07:51   Log-Likelihood:                -344.74
No. Observations:                 100   AIC:                             693.5
Df Residuals:                      98   BIC:                             698.7
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
```

```
const          0.4940      1.548      0.319      0.750      -2.577       3.565
Trade Qty      0.2668      0.027     10.028      0.000       0.214       0.320
==============================================================================
Omnibus:                       41.734   Durbin-Watson:                   2.250
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              151.495
Skew:                           1.345   Prob(JB):                     1.27e-33
Kurtosis:                       8.396   Cond. No.                         117.
==============================================================================

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

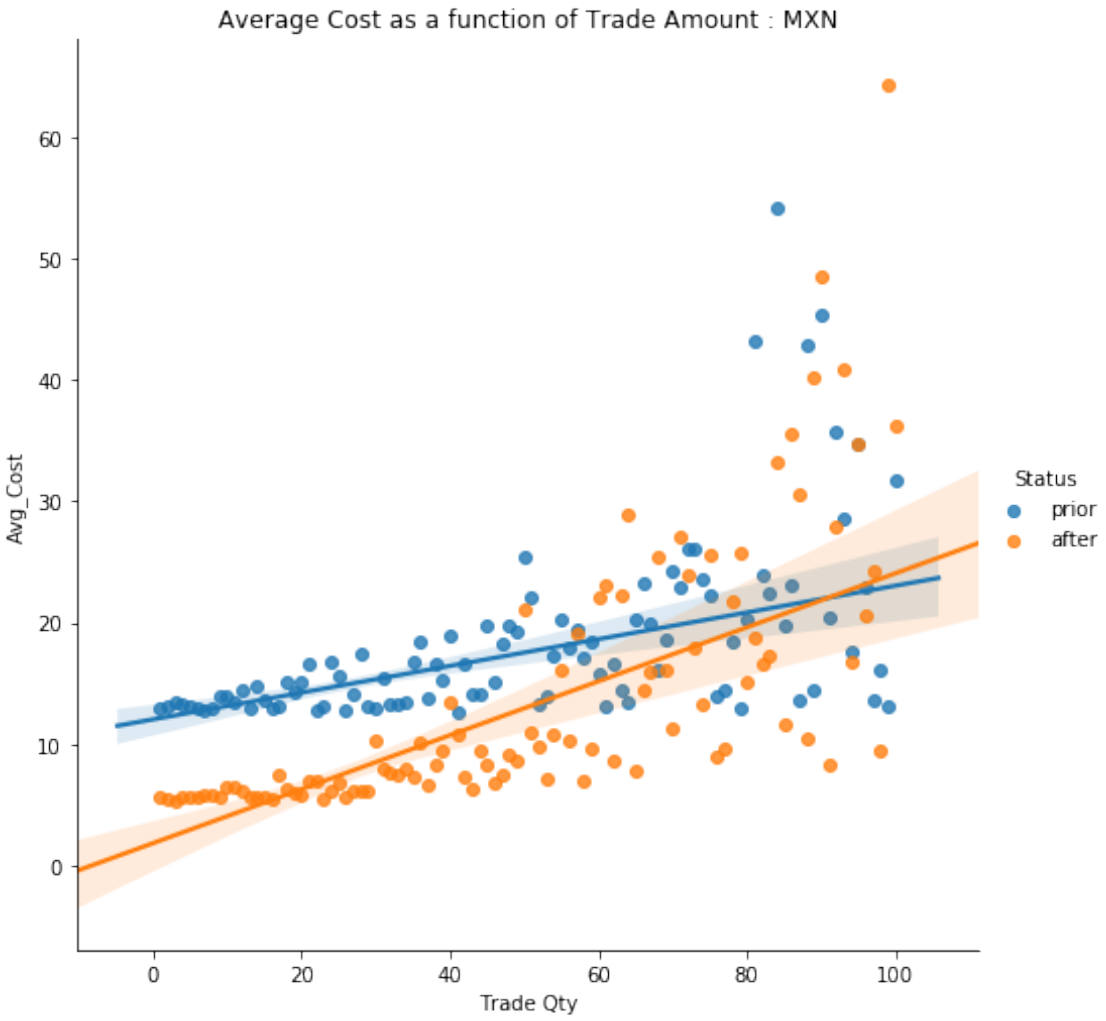
[159]:
```
cme.lin_reg_rob(cme.cost_mean(AFTER_COST_STATS, 100).reset_index(), 'Trade␣
↪Qty', 'Avg_Cost')
```

```
                    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:                        17:07:51
No. Iterations:                    50
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
const          1.8125      1.186      1.528      0.126      -0.512       4.137
Trade Qty      0.2226      0.020     10.918      0.000       0.183       0.263
==============================================================================

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

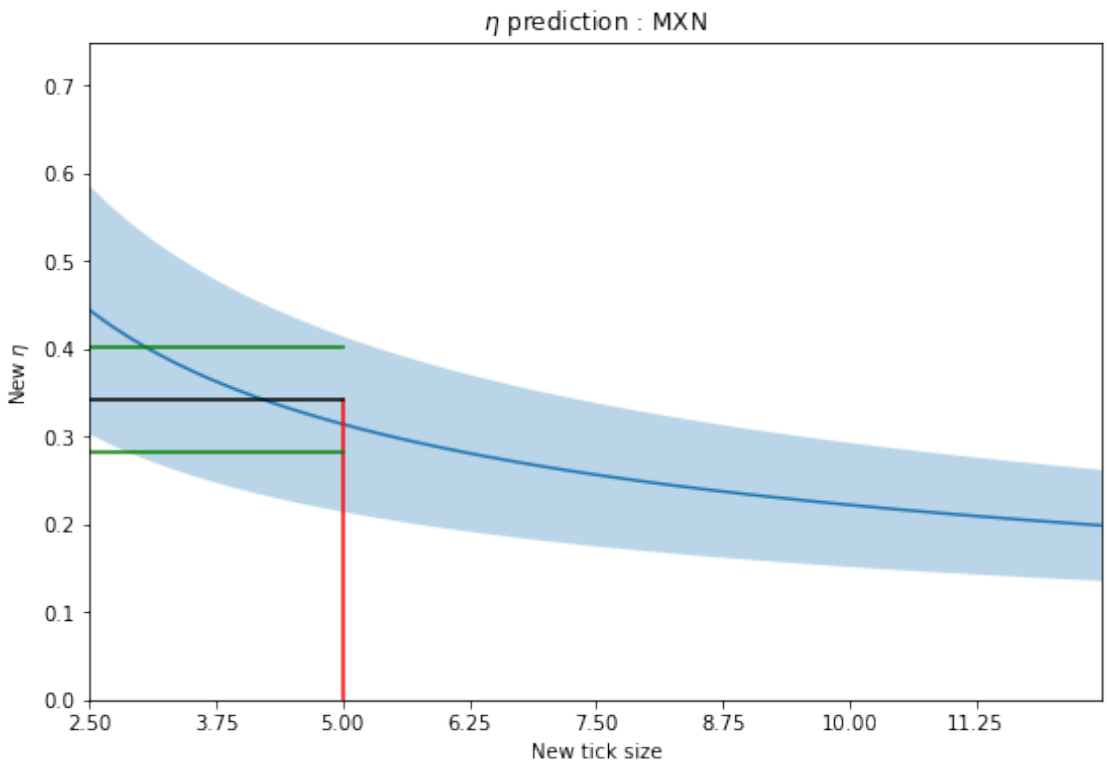


[161]:
```
cme.regr_plot(MEAN_COST_STATS.reset_index(), 'Trade Qty', 'Avg_Cost',\
    'Average Cost as a function of Trade Amount : '+CURR, True)
```



2.9 Eta prediction

[162]:
```
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 : MXN
New η
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
2.50
3.75
5.00
6.25
7.50
8.75
10.00
11.25
New tick size

[ ]: