Rates_2_2014_to_2016_in_sample

November 12, 2018

1 Exchange Rate Futures

1.1 In-sample: 2014-2016 validation: 2017

1.2 Pair Trading:

1.2.1 This project is to extract potential opportunities of pair trading for varies futures.

1.2.2 Data is based on minute prices from Quantopian. This Python code is for Quantopian.

1.2.3 Steps:

1. Compute sample correlation of in-sample future returns.

2. Compute and plot simple price spreads of any two futures for further observations. For example, for futures X and Y, if series of (X's returns - Y's retuns) looks like a stable series, then this implies that it is possible for us to generate stable returns by going long a share of X and going short a share of Y.

3. Compute and plot division price spreads of any two futures for further observations.

4. Find pairs with significant (p-value < 0.05) co-integration.

5. If future X and future Y has a significant in-sample co-integration, apply OLS regression model to get coefficients between X's returns and Y's returns during in-sample periods. For example, in-sample period is 2014-2015. Then, get coefficient and intercept between X's returns and Y's returns in 2014-2016, such as (Y'sreturn = 0.1 + 0.5 * X's return).

6. Compute, plot and check residules in validation period. For example, for future X and future Y, compute residules as (Y's return - 0.1 - 0.5 * X's return) in validation period, 2017.

If the residules look like stable series, this further confirms that we may make use of the pair relationships to form a pair trading strategy.

```
In [2]: import pandas as pd
        import numpy as np
        import matplotlib.pyplot as plt
        import statsmodels.api as sm
        from quantopian.research.experimental import continuous_future, history
```

```
import statsmodels.tsa.stattools as ts
from statsmodels.tsa.stattools import adfuller
import seaborn as sns
```

In [3]:
```
Rates = {
    'rates': {
        'us_2y': continuous_future('TU'),
        'us_30y': continuous_future('US'),
        'deliverable_interest_rate_swap_5y': continuous_future('FI'),
        'deliverable_interest_rate_swap_10y': continuous_future('TN'),
        'utra_tbond': continuous_future('UB'),
        'fed30day': continuous_future('FF'),
        'eur': continuous_future('ED'),
        'eurodollar_nyse_liffe': continuous_future('EL'),
    }}
```

In [4]:
```
# Get data of different futures
def get_data(future_dic,start_date, end_date,fields_type='price',frequency_type='minute
    df = pd.DataFrame()
    future_list = future_dic.values()[0]
    for future_name, future_data in future_list.items():

        data = history(future_data, start = start_date, end = end_date, fields = fields
        data = pd.DataFrame(data)
        data.columns=[future_name+'_'+'_'+frequency_type]
        df = pd.concat([df,data],axis=1)
    return df

# Calculate simple price spread
def spread_subtraction(df,times=1):
    future_name = df.columns

    delta_df = pd.DataFrame()

    for i in range(len(future_name)):
        for j in range(i+1,len(future_name)):
            y_future = future_name[i]
            x_future = future_name[j]

            delta_df[y_future+' - '+x_future] = df[y_future] - times*df[x_future]

    return delta_df


# Calculate price division
def spread_division(df):
    future_name = df.columns
    delta_df = pd.DataFrame()
```

```
    for i in range(len(future_name)):
        for j in range(i+1,len(future_name)):
            y_future = future_name[i]
            x_future = future_name[j]

            delta_df[y_future+' / '+x_future] = df[y_future] / df[x_future]

    return delta_df


# Plot time series
def plotting(df):
    future_name = df.columns
    num = len(future_name)

    for i in future_name:
        plt.figure(figsize=(10,3))
        plt.plot(df[i])
        plt.title(i)
        plt.show()

# Get adf test results to determine whether time series is stationary
def adf_test(df):
    future_name = df.columns
    adf_df = pd.DataFrame()

    for i in future_name:
        adftest = adfuller(df[i])
        adf_df.ix[i,'Test Statistic'] = adf_test[0]
        adf_df.ix[i,'p-value'] = adf_test[1]
        adf_df.ix[i,'Test Statistic'] = adf_test[0]

        for key, value in adftest[4].items():
            adf_df[i,'Critical Value (%s)'% key] = value

    return adf_test


# Find paris with significant cointegration
def find_cointegrated_paris(df,pvalue_level=0.05):
    future_name = df.columns
    n = len(future_name)
    pvalue_matrix = np.ones((n,n))

    pairs = []

    for i in range(len(future_name)):
```

```
            for j in range(i+1,len(future_name)):
                y_future = future_name[i]
                x_future = future_name[j]

                result = ts.coint(df[y_future],df[x_future])

                pvalue = result[1]
                pvalue_matrix[i,j] = pvalue

                if pvalue < pvalue_level:
                    pairs.append((y_future,x_future))
    return pvalue_matrix, pairs

# Get ols parameters
def ols_in_sample(df,pairs):
    future_name = df.columns
    ols_df = pd.DataFrame()

    for i in range(len(future_name)):
        for j in range(i+1,len(future_name)):
            y_future = future_name[i]
            x_future = future_name[j]

            if (y_future,x_future) in pairs:
                reg = sm.add_constant(df[x_future])
                results = sm.OLS(df[y_future], reg).fit()

                name = str(y_future+' vs '+x_future)

                ols_df.loc[name,'cons'] = results.params[0]
                ols_df.loc[name,'coef'] = results.params[1]

    return ols_df

# Get residules of validation data based on in-sample ols parameters
def ols_validation(df, ols_df,pairs):
    future_name = df.columns
    ols_validation_df = pd.DataFrame()
    for i in range(len(future_name)):
        for j in range(i+1,len(future_name)):
            y_future = future_name[i]
            x_future = future_name[j]

            if (y_future,x_future) in pairs:
                name = str(y_future+' vs '+x_future)

                cons = ols_df.loc[name,'cons']
                coef = ols_df.loc[name,'coef']
```

```
                ols_validation_df[y_future+' vs '+x_future+' _residules'] = df[y_future

        return ols_validation_df
```

2 2. In-sample Period: 2014-2016 Validation Period: 2017

```
In [5]: future_list = Rates.values()[0].keys()
```

```
In [6]: data = get_data(Rates,'2014-01-01','2016-12-31')
```

2.0.1 2.1 Correlation: 2014-01-01 to 2016-12-31

```
In [6]: correlation =data.corr()
        correlation
```

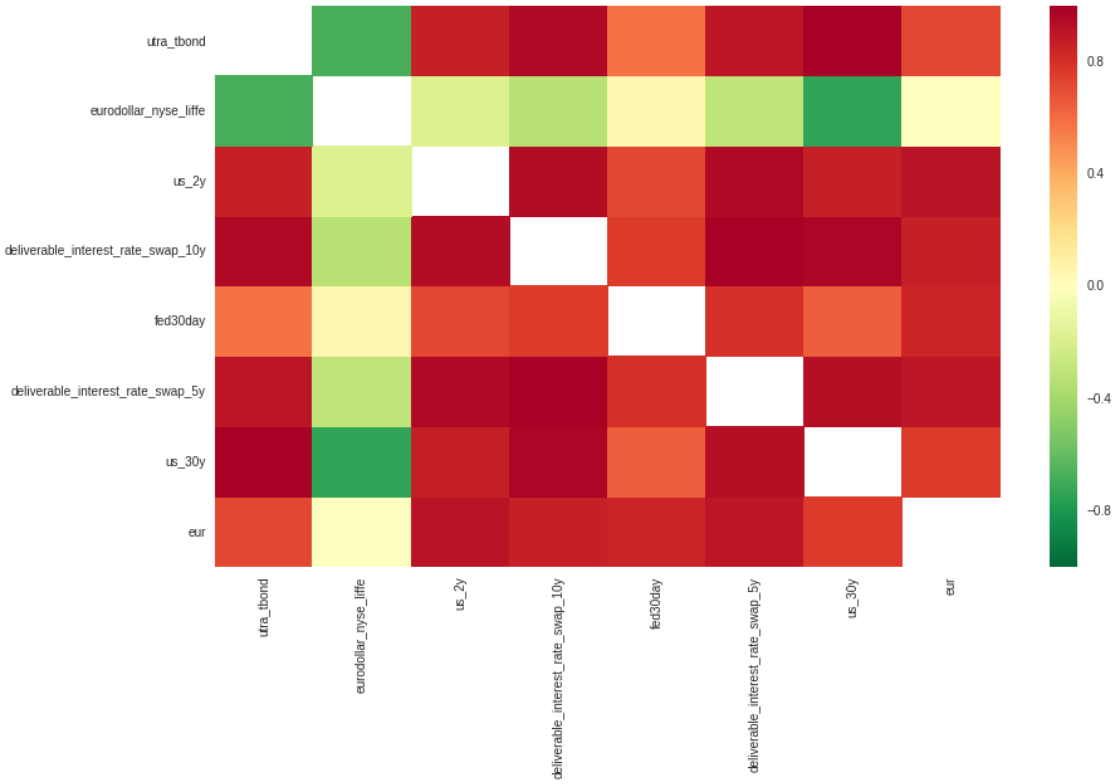
```
Out[6]:                                             utra_tbond__minute  \
        utra_tbond__minute                                    1.000000
        eurodollar_nyse_liffe__minute                        -0.676610
        us_2y__minute                                         0.864758
        deliverable_interest_rate_swap_10y__minute            0.955583
        fed30day__minute                                      0.581291
        deliverable_interest_rate_swap_5y__minute             0.912840
        us_30y__minute                                        0.990004
        eur__minute                                           0.725030

                                                    eurodollar_nyse_liffe__minute  \
        utra_tbond__minute                                              -0.676610
        eurodollar_nyse_liffe__minute                                    1.000000
        us_2y__minute                                                   -0.177020
        deliverable_interest_rate_swap_10y__minute                      -0.333847
        fed30day__minute                                                 0.061464
        deliverable_interest_rate_swap_5y__minute                       -0.302470
        us_30y__minute                                                  -0.736797
        eur__minute                                                     -0.006890

                                                    us_2y__minute  \
        utra_tbond__minute                               0.864758
        eurodollar_nyse_liffe__minute                   -0.177020
        us_2y__minute                                    1.000000
        deliverable_interest_rate_swap_10y__minute       0.937689
        fed30day__minute                                 0.724263
        deliverable_interest_rate_swap_5y__minute        0.954603
        us_30y__minute                                   0.866327
        eur__minute                                      0.916891

                                                    deliverable_interest_rate_swap_10y__minute
        utra_tbond__minute                                                            0.955583
        eurodollar_nyse_liffe__minute                                                -0.333847
```

```
us_2y__minute                                                    0.937689
deliverable_interest_rate_swap_10y__minute                       1.000000
fed30day__minute                                                 0.762283
deliverable_interest_rate_swap_5y__minute                        0.989380
us_30y__minute                                                   0.970003
eur__minute                                                      0.864614

                                                 fed30day__minute  \
utra_tbond__minute                                       0.581291
eurodollar_nyse_liffe__minute                            0.061464
us_2y__minute                                            0.724263
deliverable_interest_rate_swap_10y__minute               0.762283
fed30day__minute                                         1.000000
deliverable_interest_rate_swap_5y__minute                0.801550
us_30y__minute                                           0.647710
eur__minute                                              0.848326

                                                 deliverable_interest_rate_swap_5y__minute
utra_tbond__minute                                                               0.912840
eurodollar_nyse_liffe__minute                                                   -0.302470
us_2y__minute                                                                    0.954603
deliverable_interest_rate_swap_10y__minute                                       0.989380
fed30day__minute                                                                 0.801550
deliverable_interest_rate_swap_5y__minute                                        1.000000
us_30y__minute                                                                   0.937466
eur__minute                                                                      0.911112

                                                 us_30y__minute  eur__minute
utra_tbond__minute                                     0.990004     0.725030
eurodollar_nyse_liffe__minute                         -0.736797    -0.006890
us_2y__minute                                          0.866327     0.916891
deliverable_interest_rate_swap_10y__minute             0.970003     0.864614
fed30day__minute                                       0.647710     0.848326
deliverable_interest_rate_swap_5y__minute              0.937466     0.911112
us_30y__minute                                         1.000000     0.765449
eur__minute                                            0.765449     1.000000
```

2.0.2 Heatmap of correlation: Red High correlation

```
In [7]: sns.heatmap(correlation,xticklabels=future_list, yticklabels=future_list,cmap = 'RdYlGr
```

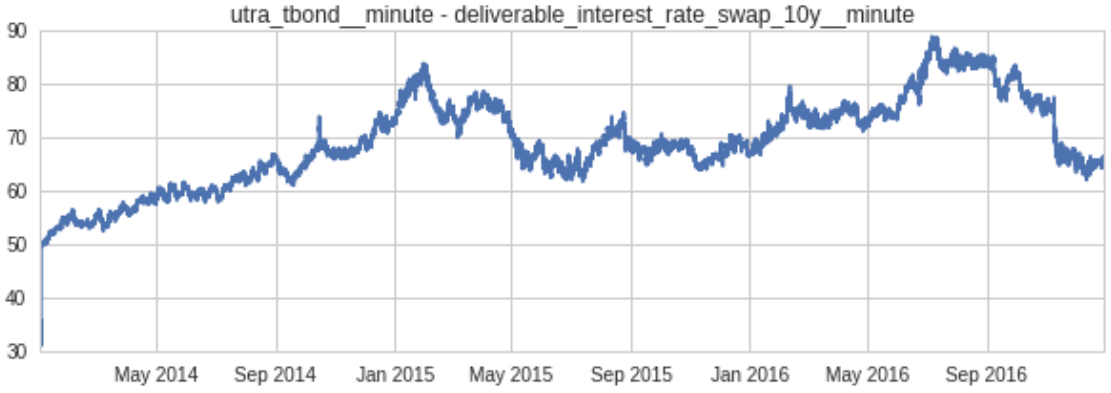
```
Out[7]: <matplotlib.axes._subplots.AxesSubplot at 0x7fa7347732d0>
```

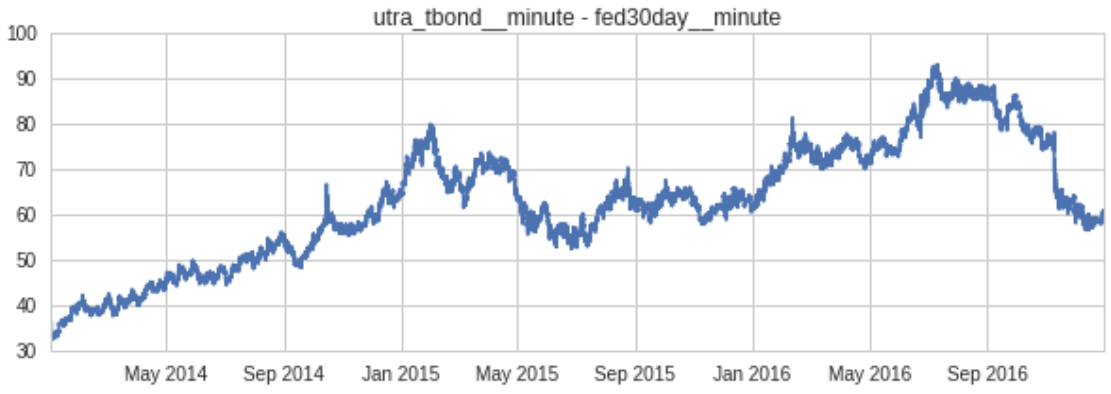


2.0.3 2.2 Price Speard

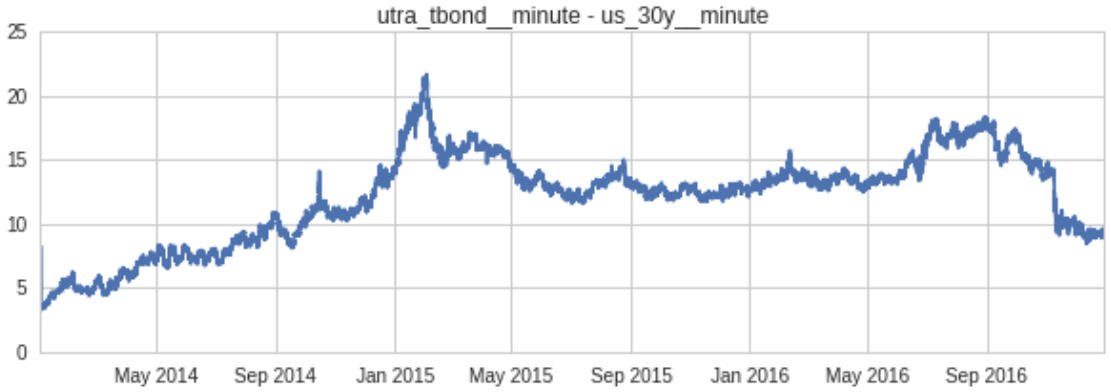
```
In [ ]: a = spread_subtraction(data)
        plotting(a)
```


utra_tbond__minute - us_2y__minute
90
80
70
60
50
40
30
20
May 2014
Sep 2014
Jan 2015
May 2015
Sep 2015
Jan 2016
May 2016
Sep 2016

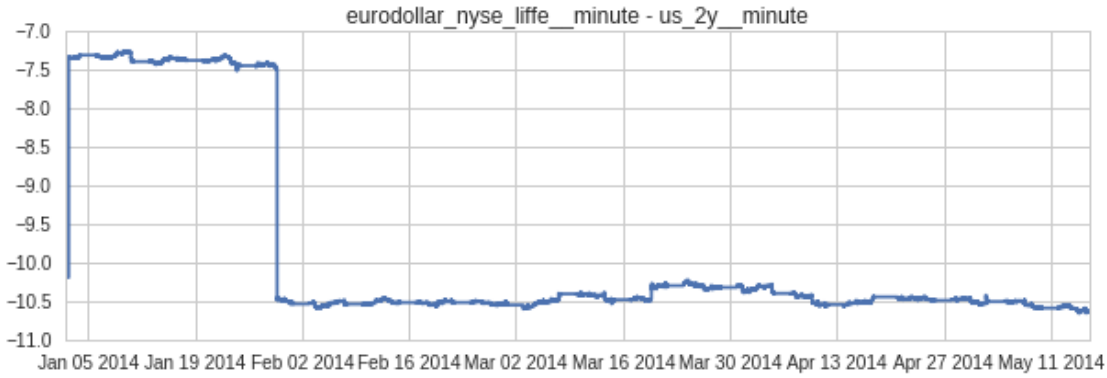

utra_tbond__minute - deliverable_interest_rate_swap_10y__minute
90
80
70
60
50
40
30
May 2014
Sep 2014
Jan 2015
May 2015
Sep 2015
Jan 2016
May 2016
Sep 2016

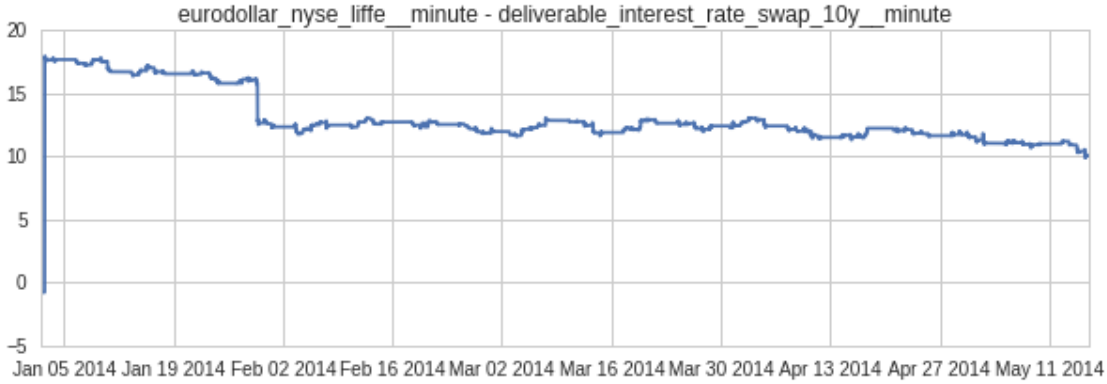

utra_tbond__minute - fed30day__minute
100
90
80
70
60
50
40
30
May 2014
Sep 2014
Jan 2015
May 2015
Sep 2015
Jan 2016
May 2016
Sep 2016

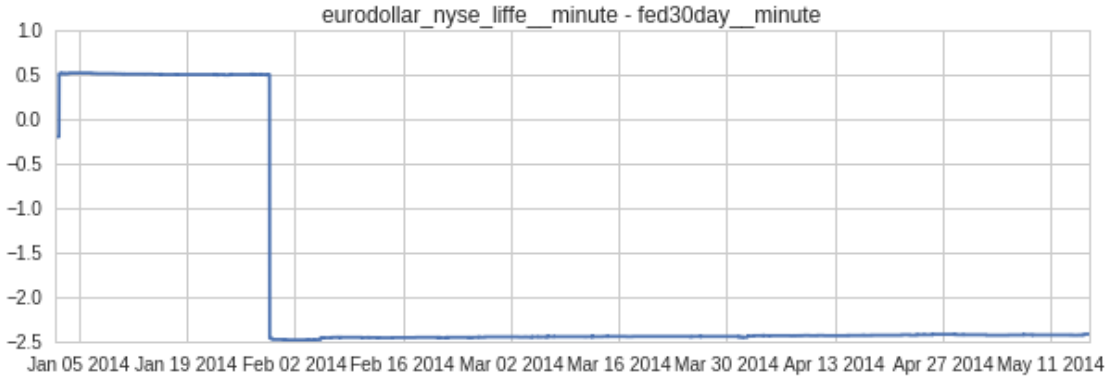

utra_tbond__minute - deliverable_interest_rate_swap_5y__minute
100
90
80
70
60
50
40
30
May 2014
Sep 2014
Jan 2015
May 2015
Sep 2015
Jan 2016
May 2016
Sep 2016

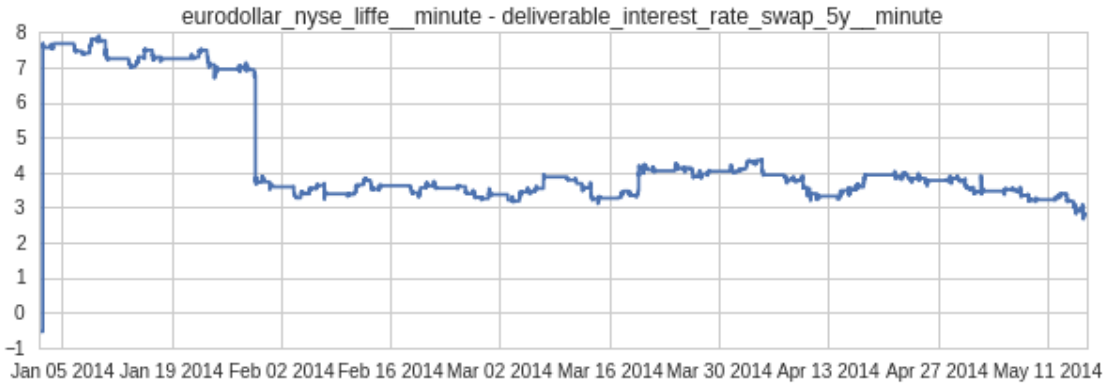

utra_tbond__minute - us_30y__minute
25
20
15
10
5
0
May 2014
Sep 2014
Jan 2015
May 2015
Sep 2015
Jan 2016
May 2016
Sep 2016


utra_tbond__minute - eur__minute
100
90
80
70
60
50
40
30
May 2014
Sep 2014
Jan 2015
May 2015
Sep 2015
Jan 2016
May 2016
Sep 2016

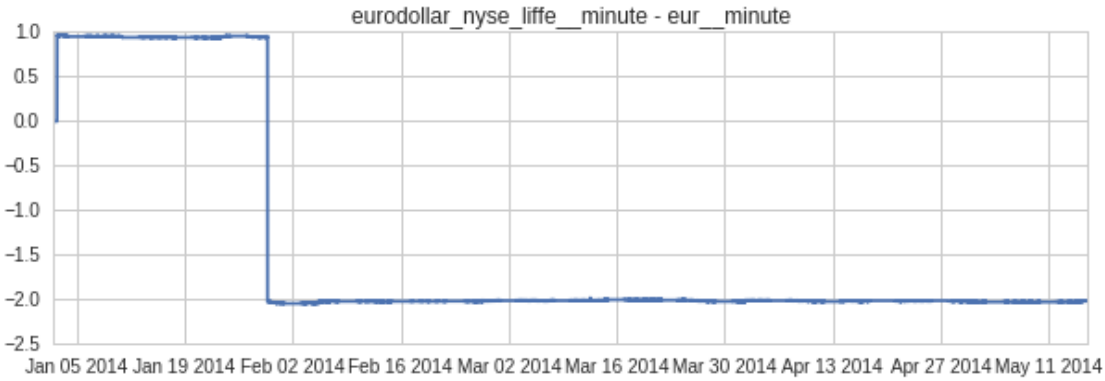

eurodollar_nyse_liffe__minute - us_2y__minute
−7.0
−7.5
−8.0
−8.5
−9.0
−9.5
−10.0
−10.5
−11.0
Jan 05 2014
Jan 19 2014
Feb 02 2014
Feb 16 2014
Mar 02 2014
Mar 16 2014
Mar 30 2014
Apr 13 2014
Apr 27 2014
May 11 2014


eurodollar_nyse_liffe__minute - deliverable_interest_rate_swap_10y__minute
20
15
10
5
0
−5
Jan 05 2014
Jan 19 2014
Feb 02 2014
Feb 16 2014
Mar 02 2014
Mar 16 2014
Mar 30 2014
Apr 13 2014
Apr 27 2014
May 11 2014


eurodollar_nyse_liffe__minute - fed30day__minute
1.0
0.5
0.0
−0.5
−1.0
−1.5
−2.0
−2.5
Jan 05 2014
Jan 19 2014
Feb 02 2014
Feb 16 2014
Mar 02 2014
Mar 16 2014
Mar 30 2014
Apr 13 2014
Apr 27 2014
May 11 2014


eurodollar_nyse_liffe__minute - deliverable_interest_rate_swap_5y__minute
8
7
6
5
4
3
2
1
0
−1
Jan 05 2014
Jan 19 2014
Feb 02 2014
Feb 16 2014
Mar 02 2014
Mar 16 2014
Mar 30 2014
Apr 13 2014
Apr 27 2014
May 11 2014


eurodollar_nyse_liffe__minute - us_30y__minute
−28
−30
−32
−34
−36
−38
−40
−42
−44
Jan 05 2014
Jan 19 2014
Feb 02 2014
Feb 16 2014
Mar 02 2014
Mar 16 2014
Mar 30 2014
Apr 13 2014
Apr 27 2014
May 11 2014


eurodollar_nyse_liffe__minute - eur__minute
1.0
0.5
0.0
−0.5
−1.0
−1.5
−2.0
−2.5
Jan 05 2014
Jan 19 2014
Feb 02 2014
Feb 16 2014
Mar 02 2014
Mar 16 2014
Mar 30 2014
Apr 13 2014
Apr 27 2014
May 11 2014


us_2y__minute - deliverable_interest_rate_swap_10y__minute
30
25
20
15
10
5
May 2014
Sep 2014
Jan 2015
May 2015
Sep 2015
Jan 2016
May 2016
Sep 2016

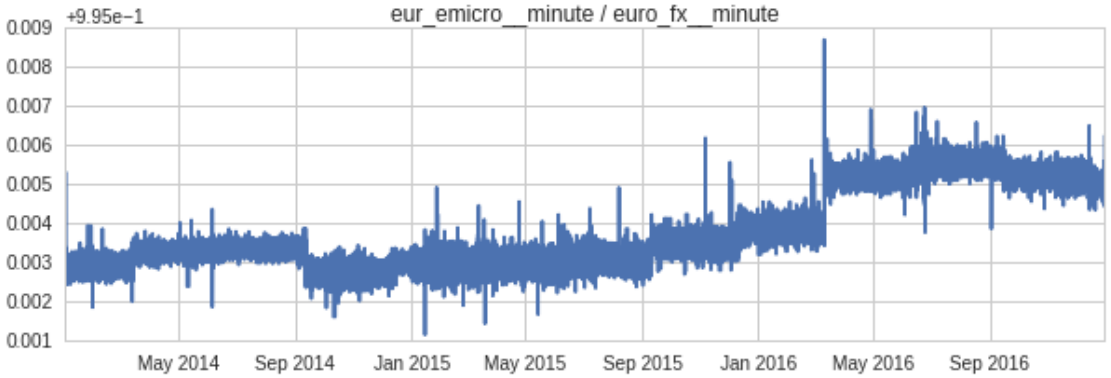

us_2y__minute - fed30day__minute
10.5
10.0
9.5
9.0
8.5
8.0
7.5
May 2014
Sep 2014
Jan 2015
May 2015
Sep 2015
Jan 2016
May 2016
Sep 2016


us_2y__minute - deliverable_interest_rate_swap_5y__minute
16
14
12
10
8
6
May 2014
Sep 2014
Jan 2015
May 2015
Sep 2015
Jan 2016
May 2016
Sep 2016

2.0.4 2.3 Price Division

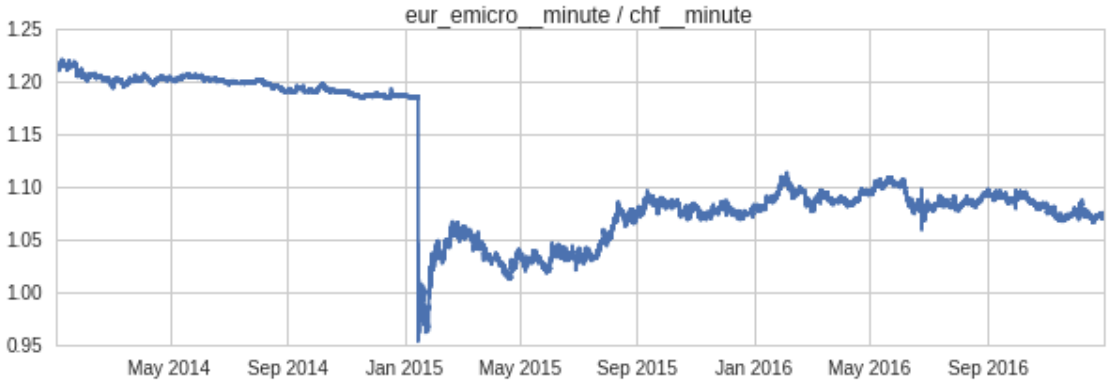
```
In [ ]: b = spread_division(data)
        plotting(b)
```

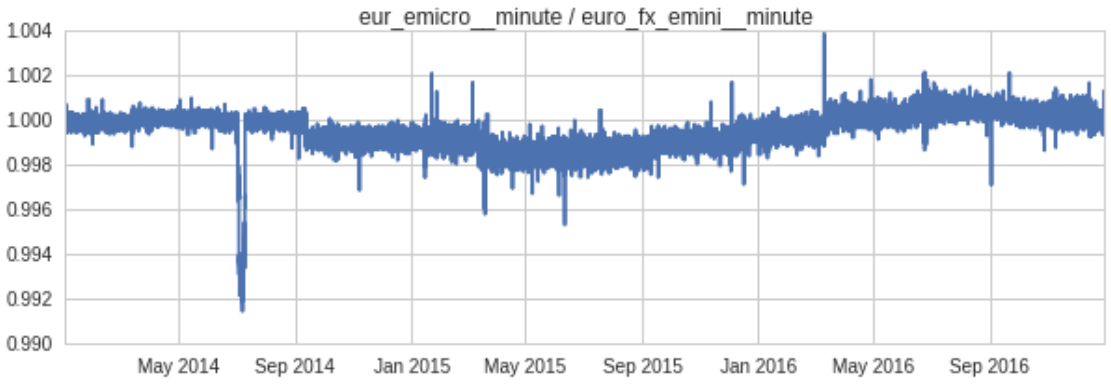

eur_emicro__minute / jpy__minute
150
145
140
135
130
125
120
115
110
105
May 2014
Sep 2014
Jan 2015
May 2015
Sep 2015
Jan 2016
May 2016
Sep 2016


eur_emicro__minute / euro_fx__minute
+9.95e−1
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
May 2014
Sep 2014
Jan 2015
May 2015
Sep 2015
Jan 2016
May 2016
Sep 2016


eur_emicro__minute / mxn__minute
24
23
22
21
20
19
18
17
May 2014
Sep 2014
Jan 2015
May 2015
Sep 2015
Jan 2016
May 2016
Sep 2016

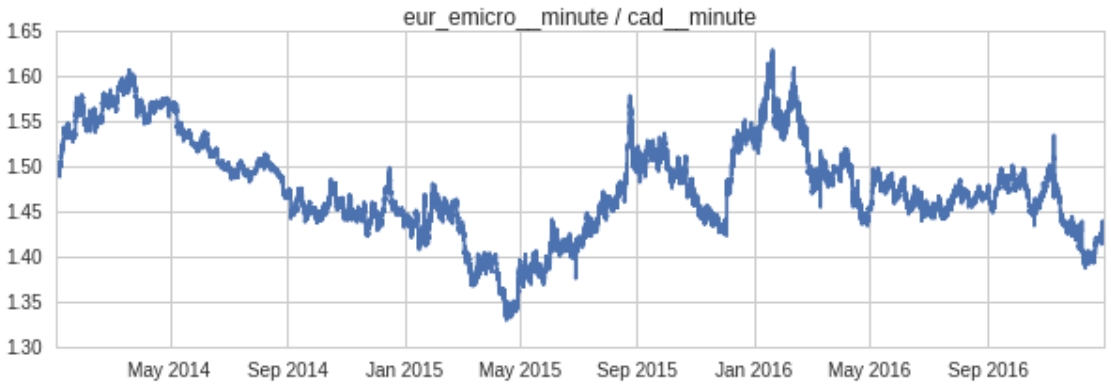

eur_emicro__minute / aud__minute
1.75
1.70
1.65
1.60
1.55
1.50
1.45
1.40
May 2014
Sep 2014
Jan 2015
May 2015
Sep 2015
Jan 2016
May 2016
Sep 2016

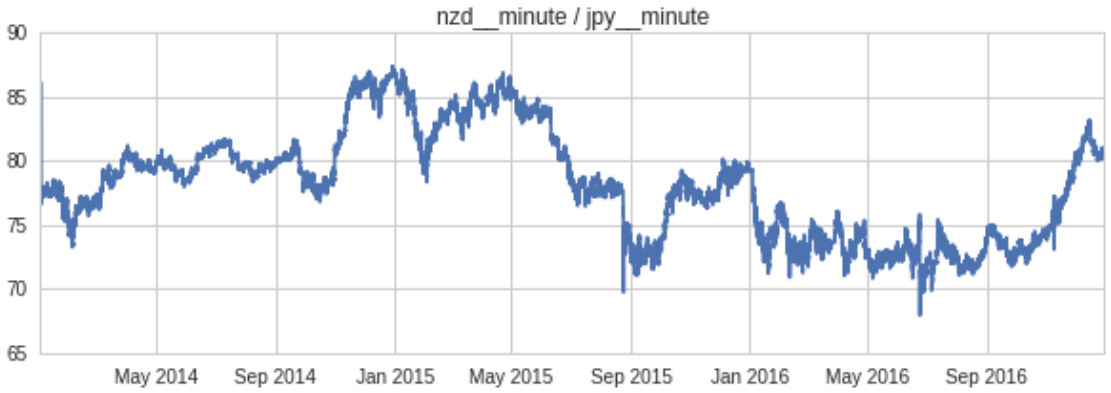

eur_emicro__minute / chf__minute
1.25
1.20
1.15
1.10
1.05
1.00
0.95
May 2014
Sep 2014
Jan 2015
May 2015
Sep 2015
Jan 2016
May 2016
Sep 2016


eur_emicro__minute / euro_fx_emini__minute
1.004
1.002
1.000
0.998
0.996
0.994
0.992
0.990
May 2014
Sep 2014
Jan 2015
May 2015
Sep 2015
Jan 2016
May 2016
Sep 2016


eur_emicro__minute / gbp__minute
0.95
0.90
0.85
0.80
0.75
0.70
May 2014
Sep 2014
Jan 2015
May 2015
Sep 2015
Jan 2016
May 2016
Sep 2016

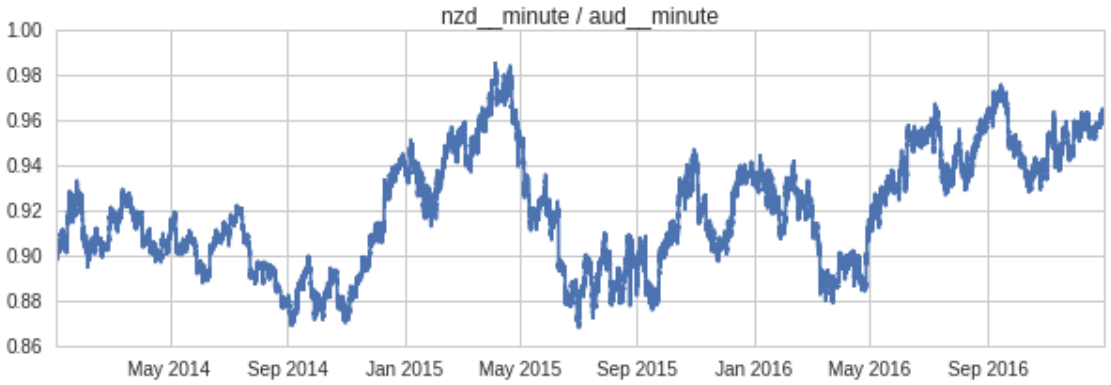

eur_emicro__minute / jpy_emini__minute
150
145
140
135
130
125
120
115
110
105
May 2014
Sep 2014
Jan 2015
May 2015
Sep 2015
Jan 2016
May 2016
Sep 2016


eur_emicro__minute / cad__minute
1.65
1.60
1.55
1.50
1.45
1.40
1.35
1.30
May 2014
Sep 2014
Jan 2015
May 2015
Sep 2015
Jan 2016
May 2016
Sep 2016


nzd__minute / jpy__minute
90
85
80
75
70
65
May 2014
Sep 2014
Jan 2015
May 2015
Sep 2015
Jan 2016
May 2016
Sep 2016


nzd__minute / euro_fx__minute
0.65
0.60
0.55
0.50
May 2014
Sep 2014
Jan 2015
May 2015
Sep 2015
Jan 2016
May 2016
Sep 2016

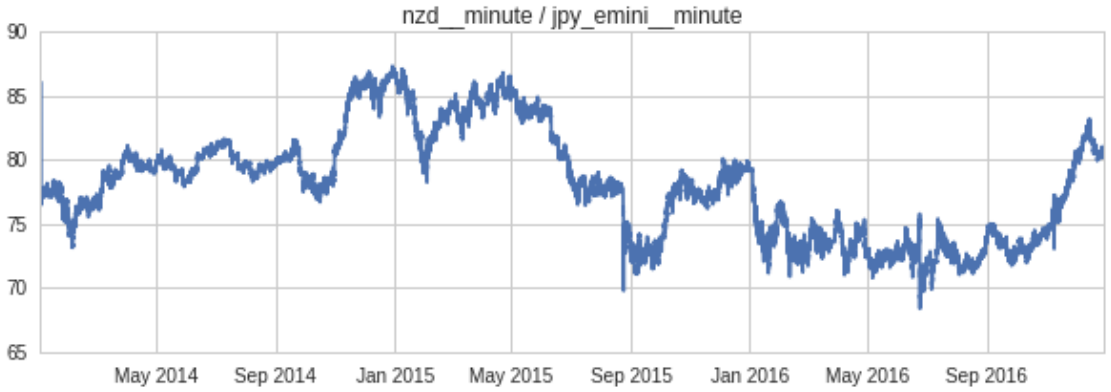

nzd__minute / mxn__minute
16
15
14
13
12
11
10
May 2014
Sep 2014
Jan 2015
May 2015
Sep 2015
Jan 2016
May 2016
Sep 2016


nzd__minute / aud__minute
1.00
0.98
0.96
0.94
0.92
0.90
0.88
0.86
May 2014
Sep 2014
Jan 2015
May 2015
Sep 2015
Jan 2016
May 2016
Sep 2016


nzd__minute / chf__minute
0.75
0.70
0.65
0.60
0.55
May 2014
Sep 2014
Jan 2015
May 2015
Sep 2015
Jan 2016
May 2016
Sep 2016


nzd__minute / euro_fx_emini__minute
0.65
0.60
0.55
0.50
May 2014
Sep 2014
Jan 2015
May 2015
Sep 2015
Jan 2016
May 2016
Sep 2016


nzd__minute / gbp__minute
0.60
0.55
0.50
0.45
0.40
0.35
May 2014
Sep 2014
Jan 2015
May 2015
Sep 2015
Jan 2016
May 2016
Sep 2016


nzd__minute / jpy_emini__minute
90
85
80
75
70
65
May 2014
Sep 2014
Jan 2015
May 2015
Sep 2015
Jan 2016
May 2016
Sep 2016


nzd__minute / cad__minute
1.00
0.95
0.90
0.85
0.80
May 2014
Sep 2014
Jan 2015
May 2015
Sep 2015
Jan 2016
May 2016
Sep 2016

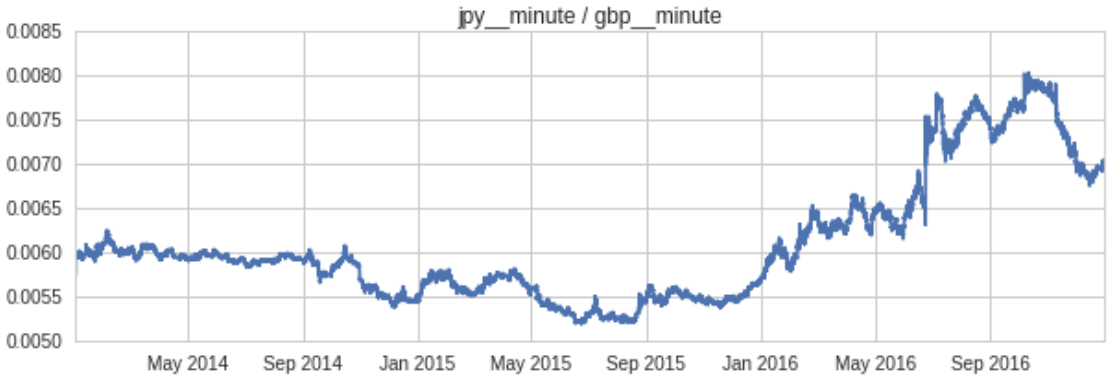

jpy__minute / euro_fx__minute
0.0095
0.0090
0.0085
0.0080
0.0075
0.0070
0.0065
May 2014
Sep 2014
Jan 2015
May 2015
Sep 2015
Jan 2016
May 2016
Sep 2016

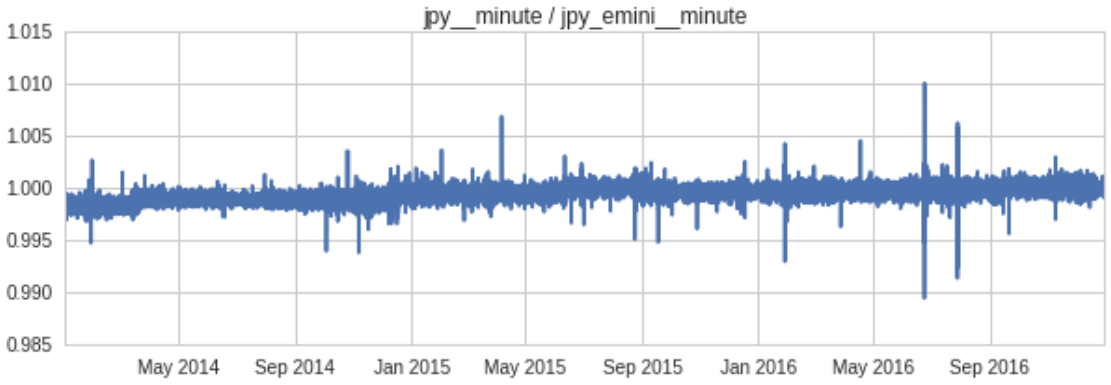

jpy__minute / mxn__minute
0.20
0.18
0.16
0.14
0.12
May 2014
Sep 2014
Jan 2015
May 2015
Sep 2015
Jan 2016
May 2016
Sep 2016

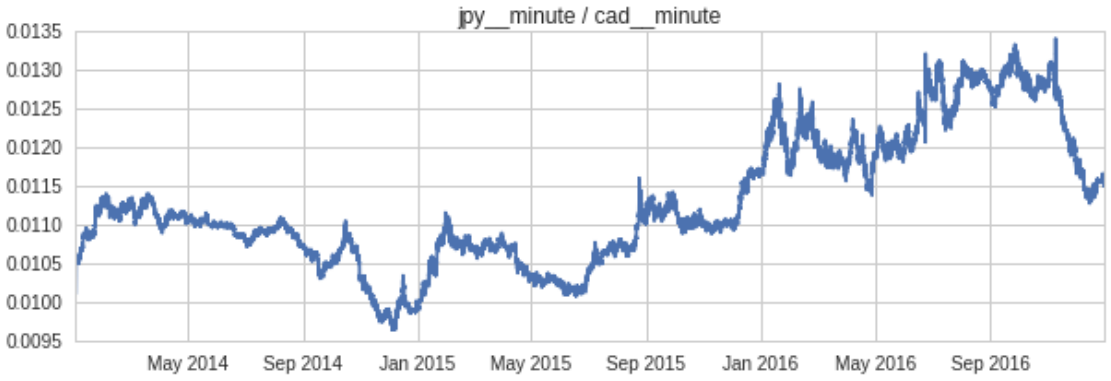

jpy__minute / aud__minute
0.0145
0.0140
0.0135
0.0130
0.0125
0.0120
0.0115
0.0110
0.0105
0.0100
May 2014
Sep 2014
Jan 2015
May 2015
Sep 2015
Jan 2016
May 2016
Sep 2016


jpy__minute / chf__minute
0.0100
0.0095
0.0090
0.0085
0.0080
0.0075
0.0070
0.0065
May 2014
Sep 2014
Jan 2015
May 2015
Sep 2015
Jan 2016
May 2016
Sep 2016


jpy__minute / euro_fx_emini__minute
0.0095
0.0090
0.0085
0.0080
0.0075
0.0070
0.0065
May 2014
Sep 2014
Jan 2015
May 2015
Sep 2015
Jan 2016
May 2016
Sep 2016


jpy__minute / gbp__minute
0.0085
0.0080
0.0075
0.0070
0.0065
0.0060
0.0055
0.0050
May 2014
Sep 2014
Jan 2015
May 2015
Sep 2015
Jan 2016
May 2016
Sep 2016


jpy__minute / jpy_emini__minute
1.015
1.010
1.005
1.000
0.995
0.990
0.985
May 2014
Sep 2014
Jan 2015
May 2015
Sep 2015
Jan 2016
May 2016
Sep 2016


jpy__minute / cad__minute
0.0135
0.0130
0.0125
0.0120
0.0115
0.0110
0.0105
0.0100
0.0095
May 2014
Sep 2014
Jan 2015
May 2015
Sep 2015
Jan 2016
May 2016
Sep 2016


euro_fx__minute / mxn__minute
24
23
22
21
20
19
18
17
May 2014
Sep 2014
Jan 2015
May 2015
Sep 2015
Jan 2016
May 2016
Sep 2016

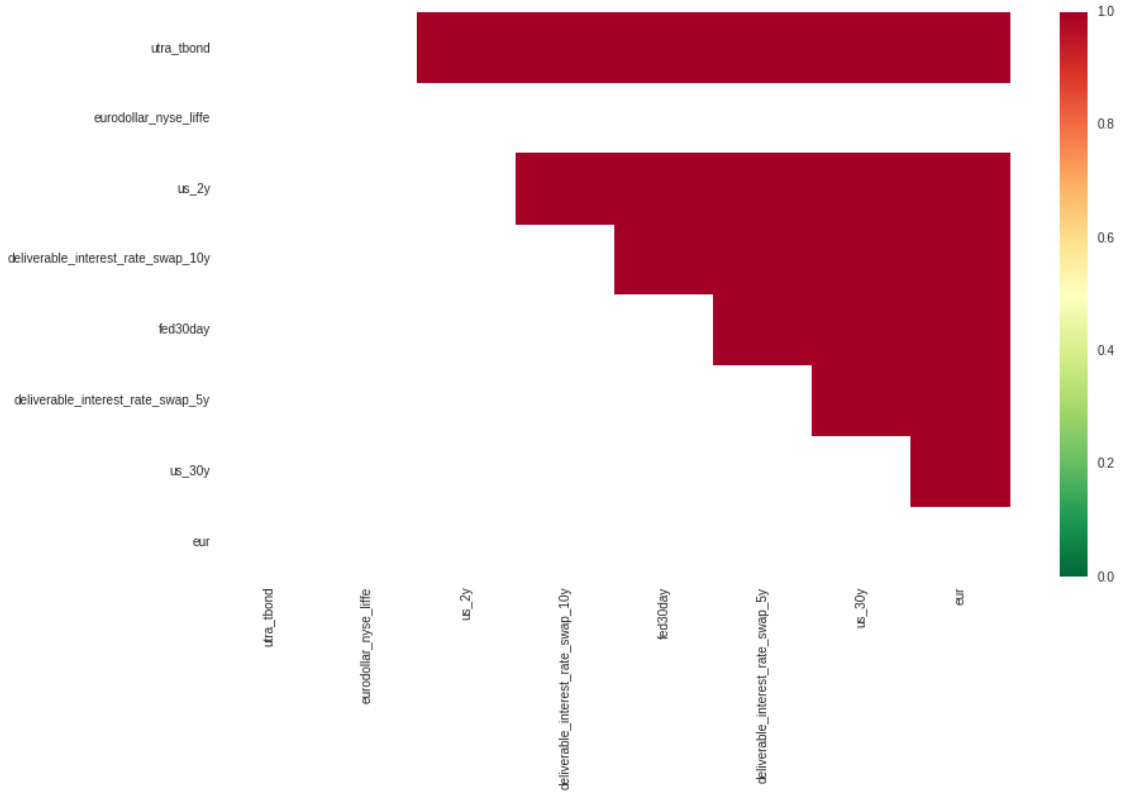
2.0.5 2.4 Cointegration (Green color squares imply lowest p-value and significant cointegration)

```
In [7]: pvalues, pairs =  find_cointegrated_paris(data)
```

2.0.6 Heatmap of cointegration: Green Significant cointegration

```
In [8]: sns.heatmap(1-pvalues,xticklabels=future_list, yticklabels=future_list,cmap = 'RdYlGn_
```

```
Out[8]: <matplotlib.axes._subplots.AxesSubplot at 0x7ff64d5b3790>
```



2.0.7 2.5 Pairs with significant cointegration

```
In [9]: pd.DataFrame(pairs)
```

```
Out[9]:                                                 0  \
        0                              utra_tbond__minute
        1                              utra_tbond__minute
        2                              utra_tbond__minute
        3                              utra_tbond__minute
        4                              utra_tbond__minute
        5                              utra_tbond__minute
        6                                   us_2y__minute
        7                                   us_2y__minute
        8                                   us_2y__minute
        9                                   us_2y__minute
        10                                  us_2y__minute
        11  deliverable_interest_rate_swap_10y__minute
        12  deliverable_interest_rate_swap_10y__minute
        13  deliverable_interest_rate_swap_10y__minute
        14  deliverable_interest_rate_swap_10y__minute
        15                               fed30day__minute
        16                               fed30day__minute
```

```
17                              fed30day__minute
18   deliverable_interest_rate_swap_5y__minute
19   deliverable_interest_rate_swap_5y__minute
20                                us_30y__minute

                                              1
0                                  us_2y__minute
1   deliverable_interest_rate_swap_10y__minute
2                               fed30day__minute
3    deliverable_interest_rate_swap_5y__minute
4                                 us_30y__minute
5                                    eur__minute
6   deliverable_interest_rate_swap_10y__minute
7                               fed30day__minute
8    deliverable_interest_rate_swap_5y__minute
9                                 us_30y__minute
10                                   eur__minute
11                              fed30day__minute
12   deliverable_interest_rate_swap_5y__minute
13                                us_30y__minute
14                                   eur__minute
15   deliverable_interest_rate_swap_5y__minute
16                                us_30y__minute
17                                   eur__minute
18                                us_30y__minute
19                                   eur__minute
20                                   eur__minute
```

2.0.8 2.6 OLS In-sample: 2014-2016, Validation:2017

2.0.9 (Only pairs with significant cointegration are included)

In [11]:
```
# Get ols parameters using in-sample data
ols_result = ols_in_sample(data,pairs)

# Get residules using validation data based on in-sample ols parameters
validation_data = get_data(Rates,start_date='2017-01-01', end_date='2017-12-31')
n=ols_validation(validation_data, ols_result,pairs)
plotting(n)
```


utra_tbond__minute vs us_2y__minute _residules
25
20
15
10
5
0
−5
Feb 2017 Mar 2017 Apr 2017 May 2017 Jun 2017 Jul 2017 Aug 2017 Sep 2017 Oct 2017 Nov 2017 Dec 2017

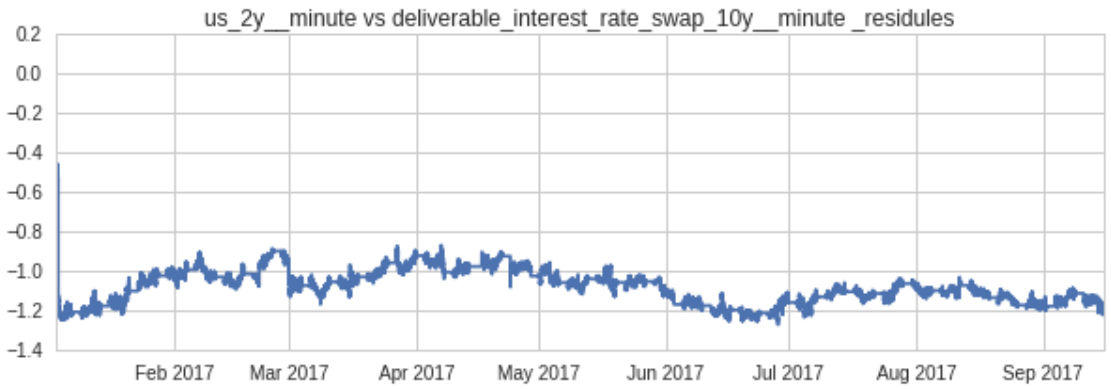

utra_tbond__minute vs deliverable_interest_rate_swap_10y__minute _residules
0
−5
−10
−15
−20
−25
Feb 2017 Mar 2017 Apr 2017 May 2017 Jun 2017 Jul 2017 Aug 2017 Sep 2017

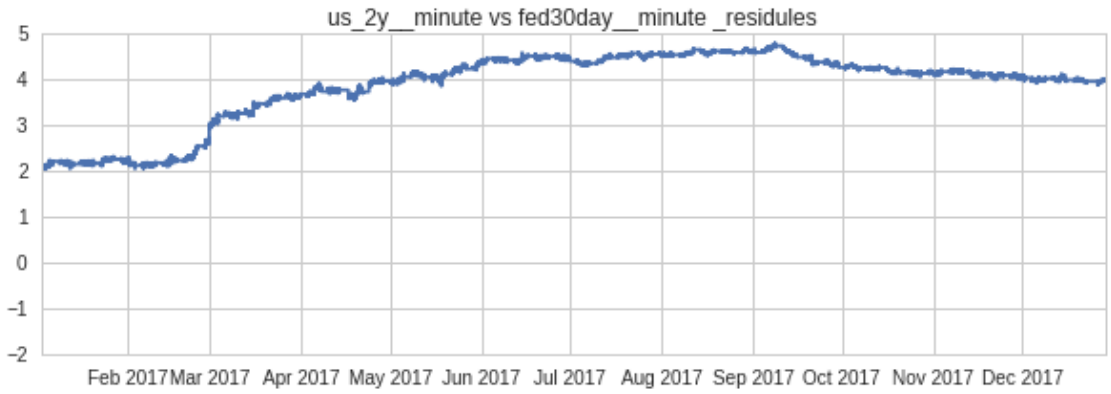

utra_tbond__minute vs fed30day__minute _residules
100
80
60
40
20
0
−20
Feb 2017 Mar 2017 Apr 2017 May 2017 Jun 2017 Jul 2017 Aug 2017 Sep 2017 Oct 2017 Nov 2017 Dec 2017

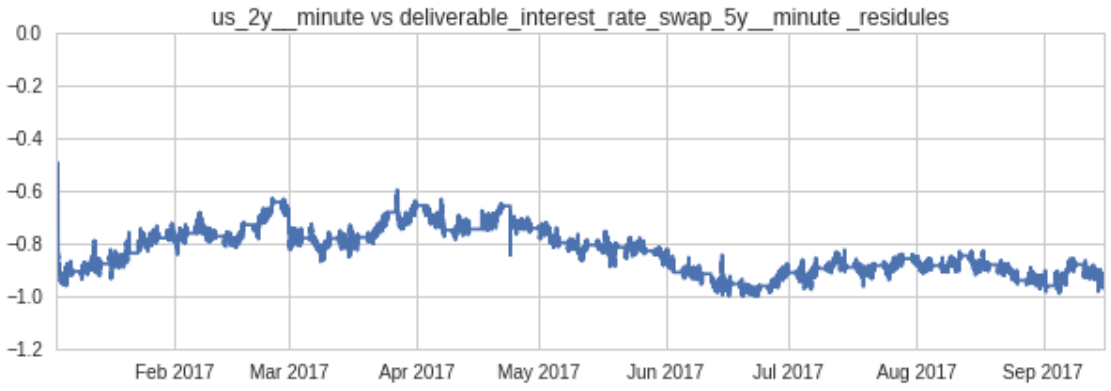

utra_tbond__minute vs deliverable_interest_rate_swap_5y__minute _residules
−4
−6
−8
−10
−12
−14
−16
−18
Feb 2017
Mar 2017
Apr 2017
May 2017
Jun 2017
Jul 2017
Aug 2017
Sep 2017


utra_tbond__minute vs us_30y__minute _residules
3
2
1
0
−1
−2
−3
Feb 2017
Mar 2017
Apr 2017
May 2017
Jun 2017
Jul 2017
Aug 2017
Sep 2017
Oct 2017
Nov 2017
Dec 2017

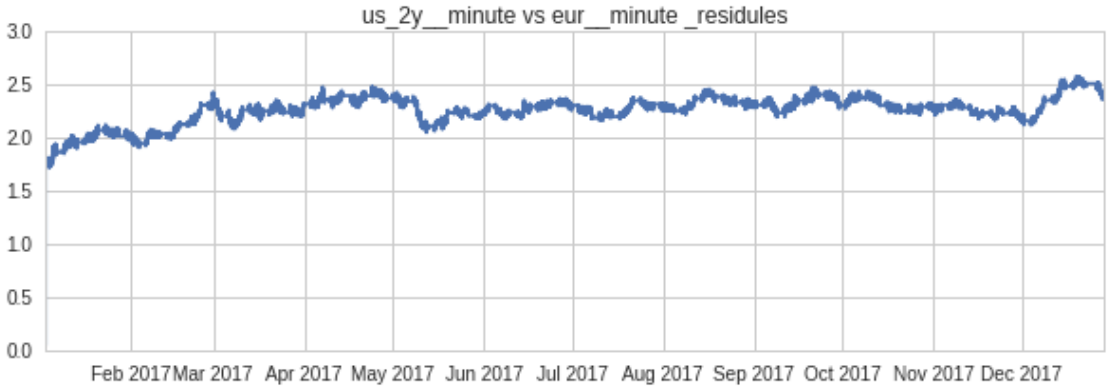

utra_tbond__minute vs eur__minute _residules
70
60
50
40
30
20
10
0
−10
Feb 2017
Mar 2017
Apr 2017
May 2017
Jun 2017
Jul 2017
Aug 2017
Sep 2017
Oct 2017
Nov 2017
Dec 2017

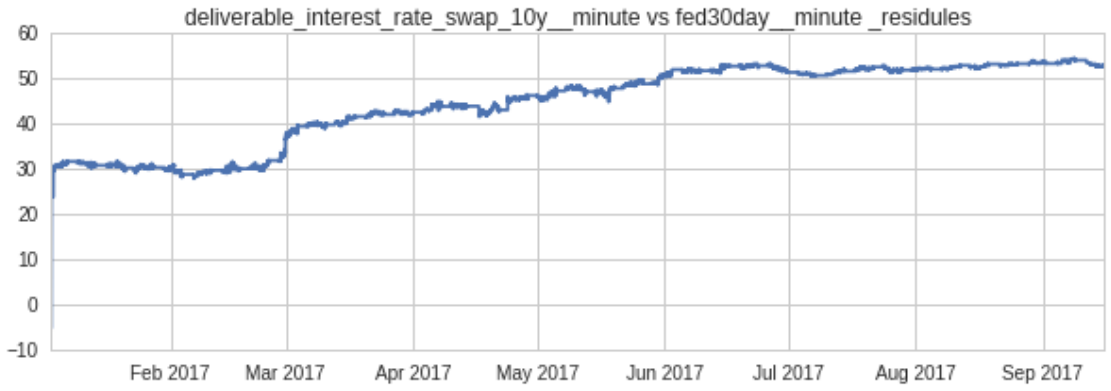

us_2y__minute vs deliverable_interest_rate_swap_10y__minute _residules
0.2
0.0
−0.2
−0.4
−0.6
−0.8
−1.0
−1.2
−1.4
Feb 2017
Mar 2017
Apr 2017
May 2017
Jun 2017
Jul 2017
Aug 2017
Sep 2017

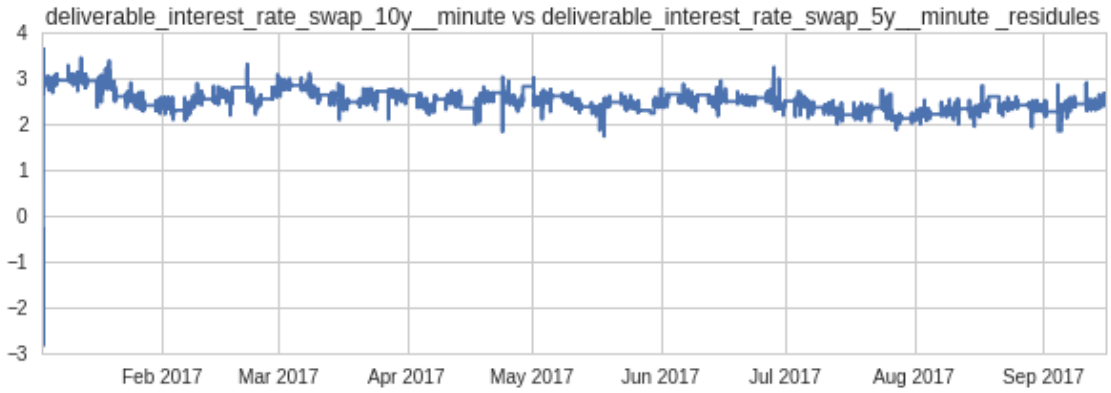

us_2y__minute vs fed30day__minute _residules
5
4
3
2
1
0
−1
−2
Feb 2017
Mar 2017
Apr 2017
May 2017
Jun 2017
Jul 2017
Aug 2017
Sep 2017
Oct 2017
Nov 2017
Dec 2017

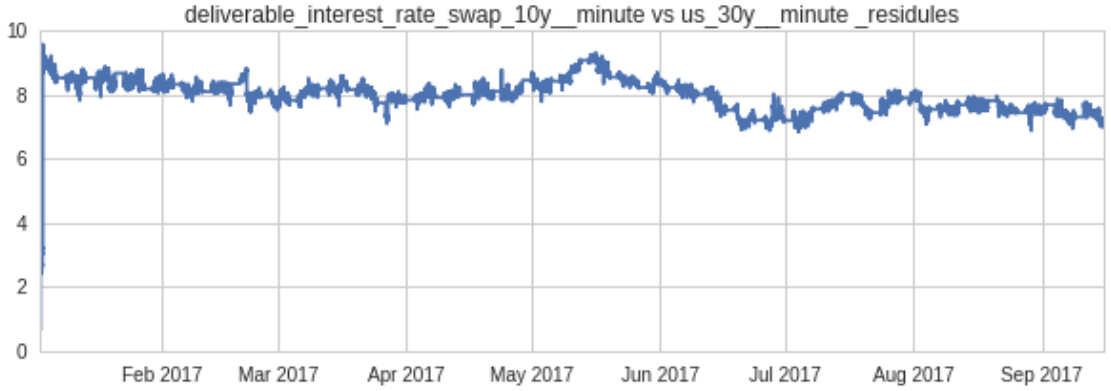

us_2y__minute vs deliverable_interest_rate_swap_5y__minute _residules
0.0
−0.2
−0.4
−0.6
−0.8
−1.0
−1.2
Feb 2017
Mar 2017
Apr 2017
May 2017
Jun 2017
Jul 2017
Aug 2017
Sep 2017


us_2y__minute vs us_30y__minute _residules
0.2
0.0
−0.2
−0.4
−0.6
−0.8
−1.0
−1.2
−1.4
Feb 2017 Mar 2017 Apr 2017 May 2017 Jun 2017 Jul 2017 Aug 2017 Sep 2017 Oct 2017 Nov 2017 Dec 2017


us_2y__minute vs eur__minute _residules
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Feb 2017 Mar 2017 Apr 2017 May 2017 Jun 2017 Jul 2017 Aug 2017 Sep 2017 Oct 2017 Nov 2017 Dec 2017


deliverable_interest_rate_swap_10y__minute vs fed30day__minute _residules
60
50
40
30
20
10
0
−10
Feb 2017 Mar 2017 Apr 2017 May 2017 Jun 2017 Jul 2017 Aug 2017 Sep 2017


deliverable_interest_rate_swap_10y__minute vs deliverable_interest_rate_swap_5y__minute _residules
4
3
2
1
0
−1
−2
−3
Feb 2017
Mar 2017
Apr 2017
May 2017
Jun 2017
Jul 2017
Aug 2017
Sep 2017


deliverable_interest_rate_swap_10y__minute vs us_30y__minute _residules
10
8
6
4
2
0
Feb 2017
Mar 2017
Apr 2017
May 2017
Jun 2017
Jul 2017
Aug 2017
Sep 2017


deliverable_interest_rate_swap_10y__minute vs eur__minute _residules
35
30
25
20
15
10
5
0
Feb 2017
Mar 2017
Apr 2017
May 2017
Jun 2017
Jul 2017
Aug 2017
Sep 2017


fed30day__minute vs deliverable_interest_rate_swap_5y__minute _residules
0.1
0.0
−0.1
−0.2
−0.3
−0.4
−0.5
−0.6
−0.7
−0.8
Feb 2017
Mar 2017
Apr 2017
May 2017
Jun 2017
Jul 2017
Aug 2017
Sep 2017


fed30day__minute vs us_30y__minute _residules
0.2
0.0
−0.2
−0.4
−0.6
−0.8
Feb 2017 Mar 2017 Apr 2017 May 2017 Jun 2017 Jul 2017 Aug 2017 Sep 2017 Oct 2017 Nov 2017 Dec 2017


fed30day__minute vs eur__minute _residules
0.3
0.2
0.1
0.0
−0.1
−0.2
−0.3
−0.4
−0.5
Feb 2017Mar 2017 Apr 2017 May 2017 Jun 2017 Jul 2017 Aug 2017 Sep 2017 Oct 2017 Nov 2017 Dec 2017


deliverable_interest_rate_swap_5y__minute vs us_30y__minute _residules
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Feb 2017
Mar 2017
Apr 2017
May 2017
Jun 2017
Jul 2017
Aug 2017
Sep 2017


deliverable_interest_rate_swap_5y__minute vs eur__minute _residules
16
14
12
10
8
6
4
2
0
Feb 2017
Mar 2017
Apr 2017
May 2017
Jun 2017
Jul 2017
Aug 2017
Sep 2017


us_30y__minute vs eur__minute _residules
60
50
40
30
20
10
0
−10
Feb 2017
Mar 2017
Apr 2017
May 2017
Jun 2017
Jul 2017
Aug 2017
Sep 2017
Oct 2017
Nov 2017
Dec 2017