Deutsche Boerse A7 usage example for equity options

Canari.dev (www.canari.dev), Feb-2021

Identifying clusters of trades with similar characteristics in order to detect trades dynamics

Abstract :

It is easy to miss price-relevant information when trading Equity Options. Trade patterns can alert traders that market assumptions are shifting. They can also inform on the arrival of large orders in an illiquid market. This project aims to detect trading patterns.

One important aspect of a trade analysis is to spot the "interest" side of the trade. Whether the aggressor was the buyer or the seller, it doesn't tell us who was actually crossing the spread to make the trade happen. To figure that out, we will first calibrate a volatility surface in order to get a theoretical bid and ask price, undisturbed by local (ie. strike specific) microstructure action.

We will then calculate an "aggressivity" indicator, defined as follows :

aggressivity = min(1, max(-1, (traded_price - mid_theo_price) / half_theo_spread))

NB : The aggressivity is negative for selling interest and positive for buying ones.

This indicator will then be used in conjunction with the vega of the trade to determine the "intensity" of each trade. It is defined as :

intensity = vega * aggressivity

Indeed, interesting trades are the ones with a large vega and a clear interest side.

This metric, among others, will then be used to identify clusters of similar trades. These clusters will in turn be sorted by intensity in order to show the most remarkable trade actions in the period.

```
# Indicate here the folders where you have saved the quotes and trades data (folder1)
# and the calibration result (folder 2) in the calibration git (see readme file)
folder1 = 'D:/Users/GitHub/TradesDynamics/processed'
folder2 = 'D:/Users/GitHub/TradesDynamics/parameters'

import os
os.makedirs(folder1, exist_ok=True)
```

```
os.makedirs(folder1 + '/raw', exist_ok=True)
os.makedirs(folder2, exist_ok=True)
```

```
# We are now importing public libraries
import numpy as np
import pandas as pd
import QuantLib as ql # options pricing librairy
import math
import datetime
import matplotlib.pyplot as plt
import requests
import warnings

pd.set_option('display.width', 200)
pd.set_option('display.max_columns', 30)
```

```
# ...and specific libraries available in this git

from DateAndTime import DateAndTime
# uses QuantLib to calculate numbers of business day between dates and generate a list expiration dat

from PricingAndCalibration import Pricing
# uses Quantlib to price European and American options with continuous dividend yield and the associa

from TradeFlesh import TradeFlesh
# enrich trades description with "aggressivity" and "intensity" indicators + shows graphic representa

from Clustering import Clustering
# uses sklearn-AgglomerativeClustering in order to identify clusters of similar trades, potentially s
```

```
#choose a date and underlying for analysis :
reference_date = '20210105'
udl = 'DAI'
# These should match the underlying and date chosen in the preliminary calibration git
```

The following program will use calibration file geenrated by the preliminary git to enrich the description of the trades (aggressivity indicator) then use this indicator to analyse trades dynamics

```
# Let's use the calibration to determine the aggressivity factor for each trade :
TF = TradeFlesh(udl, DT, folder1, folder2)
TF.pct_aggressivity()

# The result is saved in the FleshedTrades.pkl file in folder2

print(TF.df_trades[['PutOrCall', 'StrikePrice', 'qty', 'px', 'bid', 'ask', 'theo_bid', 'theo_ask', 'a
```

```
                           PutOrCall  StrikePrice qty    px   bid   ask  theo_bid  theo_ask  aggres
time
```

```
2021-01-05 08:03:36.895110484         0         46.0  25  0.43  0.43  0.49       NaN       NaN
2021-01-05 08:09:40.750130535         1         56.0   3  3.96  3.92  3.96  3.944440  4.061759      -0
2021-01-05 08:09:40.750418800         1         56.0   7  3.96  3.92  3.96  3.944440  4.061759      -0
2021-01-05 08:12:00.246509944         1         61.0   1  1.85  1.82  1.85  1.823174  1.929556      -0
2021-01-05 08:12:56.256645008         1         56.0   2  3.50  3.50  3.51  3.405229  3.505455       0
```

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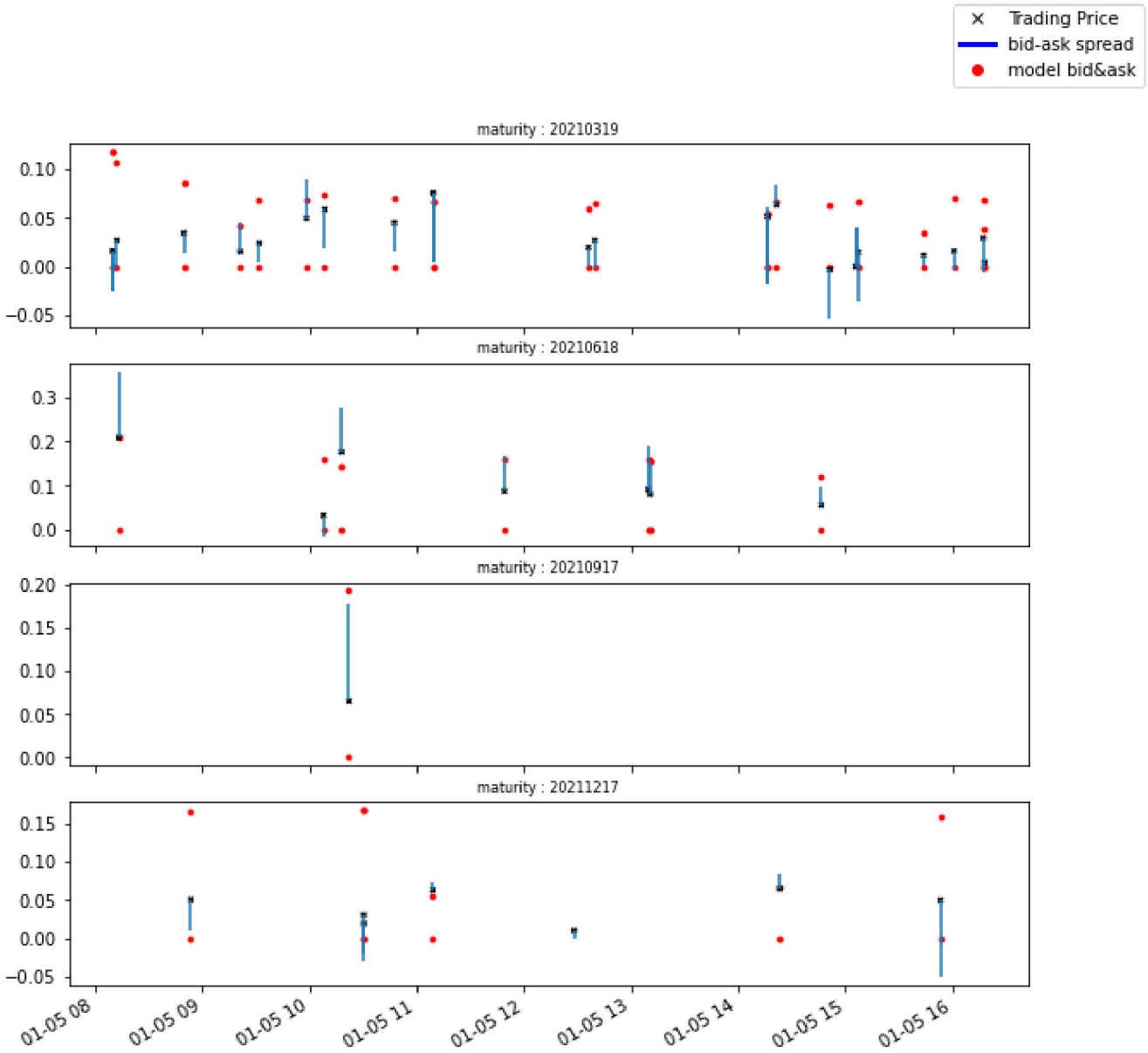
```
# ...and get a view of the trades too
TF.graph_aggressivity(reference_date)

# This Graph shows each trade, irrespective of quantity as a blue bar going from screen bid to screen
# Each subgraph corresponds to a different maturity
# The model bid and ask prices are indicated as red points
# The trade price is marked with a cross
# The X axis is the time of the day (date selected as parameter)
# The Y axis is in currency
# Since we are representing on the same graph options with different strikes, the points are rebased
# so that the model bid is at 0, allowing for a more compact graph
# This graph illustrates how the aggressivity indicator is computed, measuring how close the cross is
```



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```
# We will now calculate the intensity of the trades
from TradeFlesh import TradeFlesh
TF.get_intensity()

print(TF.df_trades[['PutOrCall', 'StrikePrice', 'qty', 'px', 'bid', 'ask', 'vega', 'aggressivity', 'v
```

time	PutOrCall	StrikePrice	qty	px	bid	ask	vega	aggressivity	ve
2021-01-05 08:03:36.895110484	0	46.0	25	0.43	0.43	0.49	NaN	NaN	
2021-01-05 08:09:40.750130535	1	56.0	3	3.96	3.92	3.96	0.099930	-0.734737	
2021-01-05 08:09:40.750418800	1	56.0	7	3.96	3.92	3.96	0.099930	-0.734737	
2021-01-05 08:12:00.246509944	1	61.0	1	1.85	1.82	1.85	0.096053	-0.495667	
2021-01-05 08:12:56.256645008	1	56.0	2	3.50	3.50	3.51	0.078181	0.891155	

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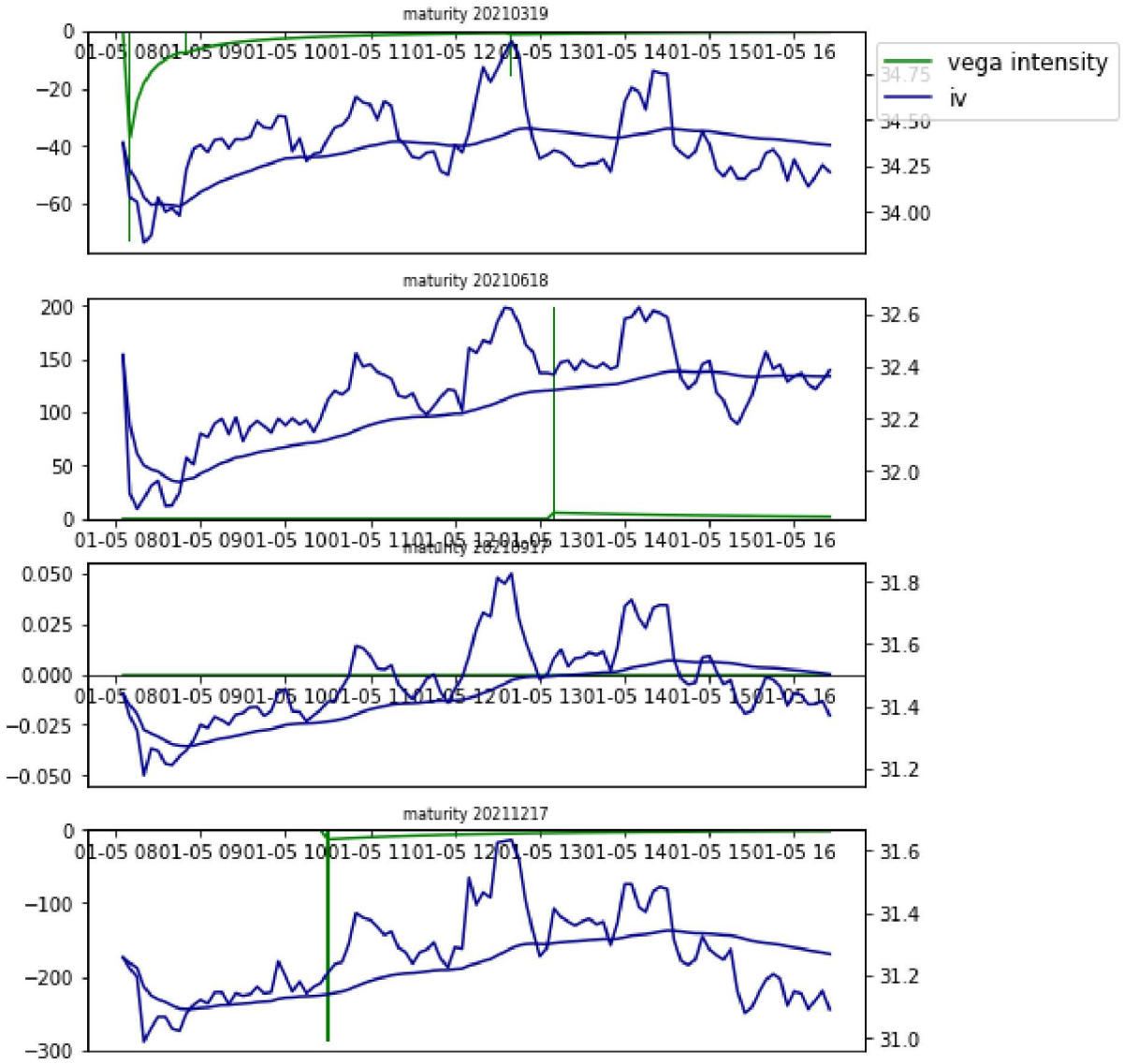
```
# We will now  aggregate trades over 5 minutes intervals.
# We then graph the vega intensity as green bars and it's exponentially weighted moving average as a
# The long green bars indicate "meaningful trades with both large quantities and clear interest side
# In blue is the ATM (fixed strike) volatility and it's moving average.

TF.graph_sensitivity('vega', reference_date)
```



Finally, we will group trades into clusters in order to identify those which may stem from a market moving agent

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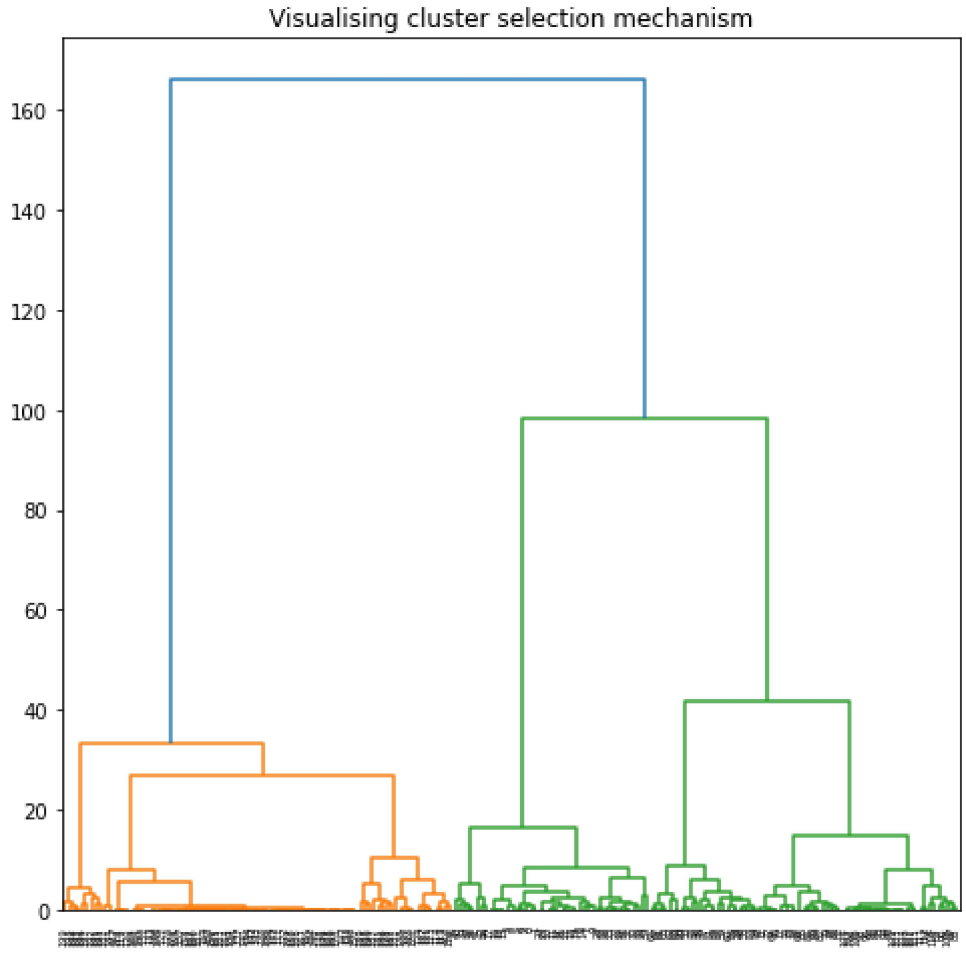
```
# A high intensity trade may be meaningful but a bunch of similar ones with similar characteritics ar
# They may point to an agent who is either informed or with a large size to trade, and help anticipat
```

```
C = Clustering(udl, DT, folder2)
C.prepare_data(with_graph = True)

# The graph below shows the hierarchical clustering process :
# We define a cluster as a set whose max distance is less than 4 times it's distance to to next clust
# The distance refered to here is a calculated on 4 dimensions :
# ['tscale', 'interest_aggressivity', 'moneyness', 'T']
# where tscale is the duration bewteen first and last trade of the cluster and T is time to maturity.

# Each column is centered and its standard deviation is set accoring to the importance we want to giv
# In this case :
# {'tscale': 10, 'interest_aggressivity': 1, 'moneyness': 0.2, 'T': 2}
```



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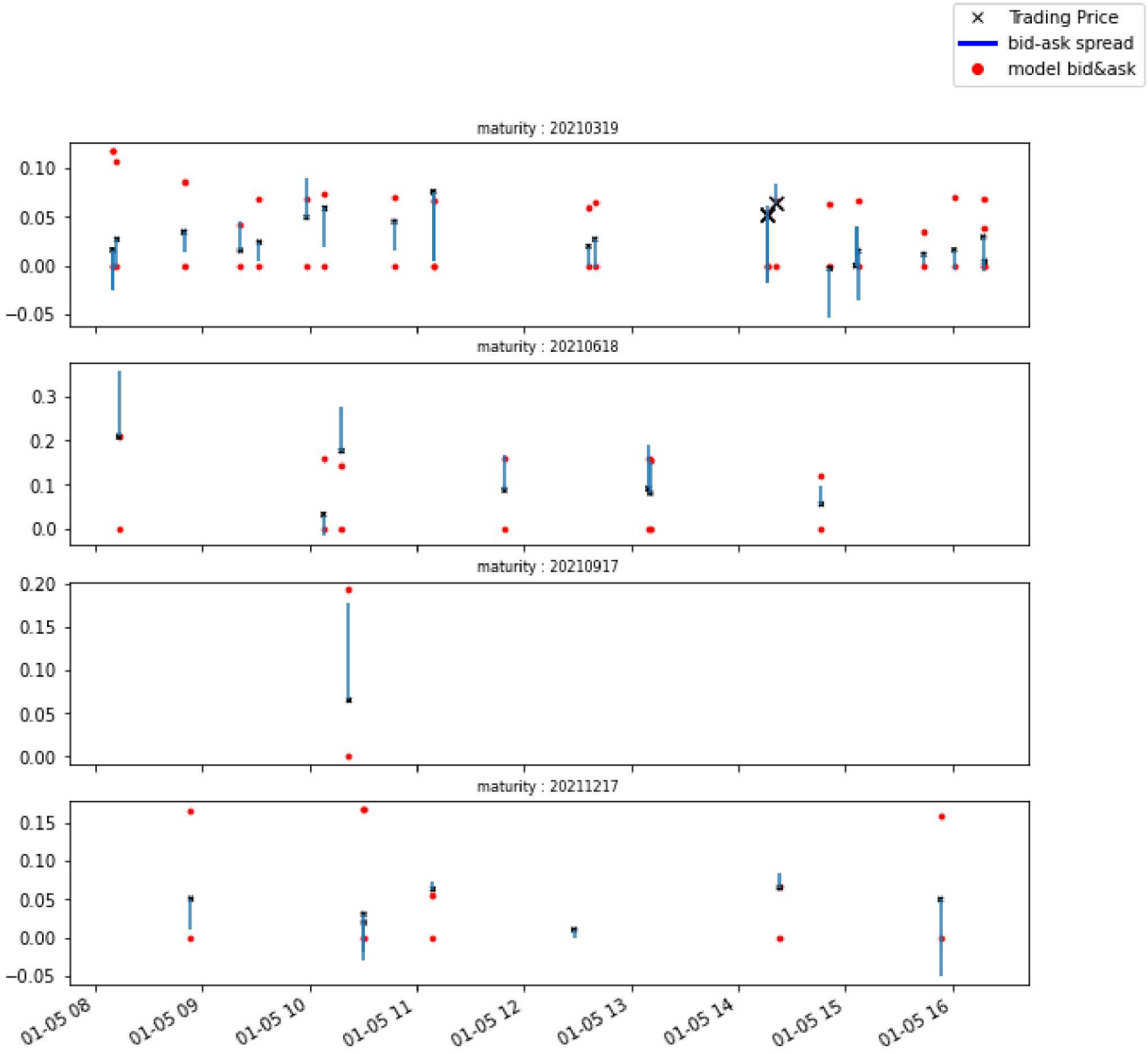
```
#The main clusters (measured in total vega intensity) are shown here :
C.display_clusters(5)
```

```
Here are the most important clusters sorted by vega intensity

       timespan  vega_intensity  delta_intensity
0  6.599088e-03     4520.826704     9.897469e+05
1  8.640000e-08     4255.745070     9.098750e+05
2  0.000000e+00     2953.487078     6.314532e+05
3  8.986890e-02    -1637.512840    -4.769985e+05
4  2.288513e-01     1488.096149     1.137690e+06

And here are the trades forming each of these clusters
cluster number :0

                            time      matu  qty PutOrCall  StrikePrice  side    px   bid   ask  aggre
140 2021-01-05 14:21:35.142957952  20210319   30         1         56.0     1  3.60  3.60  3.62      6
129 2021-01-05 14:16:38.187898865  20210319  153         1         60.0     1  1.92  1.92  1.93      6
127 2021-01-05 14:16:38.184010361  20210319   50         1         60.0     2  1.92  1.85  1.92      6
```

```
128 2021-01-05 14:16:38.184010361  20210319  297         1         60.0     2  1.92  1.85  1.92      0

cluster number :1

                            time      matu  qty PutOrCall  StrikePrice  side    px   bid   ask  aggre
129 2021-01-05 14:16:38.187898865  20210319  153         1         60.0     1  1.92  1.92  1.93      0
127 2021-01-05 14:16:38.184010361  20210319   50         1         60.0     2  1.92  1.85  1.92      0
128 2021-01-05 14:16:38.184010361  20210319  297         1         60.0     2  1.92  1.85  1.92      0

cluster number :2

                            time      matu  qty PutOrCall  StrikePrice  side    px   bid   ask  aggre
127 2021-01-05 14:16:38.184010361  20210319   50         1         60.0     2  1.92  1.85  1.92      0
128 2021-01-05 14:16:38.184010361  20210319  297         1         60.0     2  1.92  1.85  1.92      0

cluster number :3

                           time      matu  qty PutOrCall  StrikePrice  side    px   bid   ask  aggres
67 2021-01-05 11:14:57.334338882  20210219   53         1         63.0     2  0.70  0.69  0.70     -0
68 2021-01-05 11:15:09.907708706  20210219  247         1         63.0     2  0.70  0.69  0.70     -0
62 2021-01-05 11:09:02.406007643  20210115    1         0         58.0     2  2.19  2.17  2.19     -0
66 2021-01-05 11:13:38.109937266  20210219  380         1         62.0     2  0.90  0.88  0.90     -0
63 2021-01-05 11:09:03.127313288  20211217  100         1         80.0     1  0.90  0.90  0.91      1
64 2021-01-05 11:09:16.158839138  20210319    1         1         62.0     2  1.49  1.42  1.49      1
65 2021-01-05 11:09:16.158839138  20210319    1         1         62.0     2  1.49  1.42  1.49      1
50 2021-01-05 10:30:14.983411272  20211217   17         1         59.0     2  5.40  5.35  5.40     -0
51 2021-01-05 10:30:20.026171024  20211217    3         1         59.0     2  5.40  5.35  5.40     -0
44 2021-01-05 10:07:45.807240600  20210618    3         1         60.0     2  3.32  3.27  3.32     -0
47 2021-01-05 10:21:45.301277882  20210917    1         1         60.0     1  4.27  4.27  4.38     -0
46 2021-01-05 10:17:51.568985723  20210618   20         1         52.0     1  7.70  7.70  7.80      1
48 2021-01-05 10:29:05.913858716  20210115    5         0         56.0     2  1.00  0.98  1.00     -0
52 2021-01-05 10:31:05.059237750  20210115    8         0         60.0     2  3.39  3.31  3.39      1
53 2021-01-05 10:31:05.059237750  20210115    2         0         60.0     2  3.39  3.31  3.39      1
58 2021-01-05 10:46:07.061715760  20210115    1         0         54.0     2  0.56  0.54  0.56     -0
60 2021-01-05 10:47:28.416270881  20210319    1         0         56.0     2  3.20  3.17  3.20      0
61 2021-01-05 10:49:06.863207914  20210115    1         0         58.0     2  2.17  2.14  2.17     -0
57 2021-01-05 10:45:48.564425961  20210115    1         0         58.0     2  2.06  2.04  2.06     -0
59 2021-01-05 10:46:58.367613847  20210115    1         0         58.0     2  2.12  2.10  2.12     -0
49 2021-01-05 10:29:06.655669140  20210115    1         0         60.0     2  3.33  3.30  3.33     -0
56 2021-01-05 10:34:23.292330511  20210115    3         1         57.0     1  1.43  1.43  1.48     -0
54 2021-01-05 10:34:19.177967099  20210219    1         0         47.0     2  0.50  0.49  0.50     -0
55 2021-01-05 10:34:19.188419719  20210115    1         1         55.0     1  2.74  2.74  2.78      0

cluster number :4

                           time      matu qty PutOrCall  StrikePrice  side    px   bid   ask  aggres
203 2021-01-05 16:26:47.162316980  20210115   1         1         56.0     2  1.80  1.78  1.80     -1
202 2021-01-05 16:17:57.704603677  20210319   7         0         46.0     2  0.73  0.72  0.73     -0
198 2021-01-05 16:09:34.208142202  20210219   1         1         58.0     2  2.12  2.10  2.12     -0
199 2021-01-05 16:11:34.628657851  20210115   1         0         57.0     2  1.57  1.55  1.57     -0
200 2021-01-05 16:13:02.629347140  20210115  53         0         53.0     1  0.38  0.38  0.41      0
..                            ...       ...  ..       ...          ...   ...   ...   ...   ...
125 2021-01-05 14:00:22.842469991  20210115   1         0         57.0     2  1.88  1.86  1.88     -0
116 2021-01-05 13:38:20.717486722  20210115  11         0         52.0     2  0.30  0.28  0.30      0
117 2021-01-05 13:39:16.118855620  20210219  11         0         52.0     1  1.25  1.25  1.27      0
115 2021-01-05 13:35:08.854952447  20210115   1         1         56.0     2  1.70  1.67  1.70     -0
118 2021-01-05 13:42:22.869186930  20210115   1         0         56.0     2  1.20  1.18  1.20     -0

[87 rows x 11 columns]



# We can now pick one cluster and look into it in details :

TF.graph_aggressivity(reference_date, C.trades(0))

# Trades belonging for the cluster (whose number was passed as argument in graph_aggressivity) get a
```


Trading Price
bid-ask spread
model bid&ask
maturity : 20210319
maturity : 20210618
maturity : 20210917
maturity : 20211217
01-05 08
01-05 09
01-05 10
01-05 11
01-05 12
01-05 13
01-05 14
01-05 15
01-05 16