Robust Options Valuation and Risk Management Workflows with Vola Dynamics Analytics

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Option valuation framework

- Discount rates
  - OMMs do not use the curve from your fixed income team
  - Can be name specific
- Dividends
  - Cash/proportional/continuous -> valuation for American options, risk of European
  - Dividend model: what’s the definition of volatility with cash dividends?
- Borrow
  - Market value changes intraday
  - Asynchronicity and varying liquidity make implication complicated
- Volatility curves
  - Bias-free, arb-free, stable, easy to define dynamic properties
- Volatility time
  - Affects early exercise, parameter term structure, and vol interpolation

Option valuation

What is the fair value of an option?

- Cost of replication
    - My rates, taxes etc
    - Gives the expected cost of holding a hedged position
- Equilibrium of supply and demand
    - Market implied rates, borrows, dividends etc
    - Fair value means the probability of execution of a bid or an offer is the same at this price level
    - Can use to determine where to place orders or estimate portfolio liquidation value

Should I use my rates or the market rates to price options?

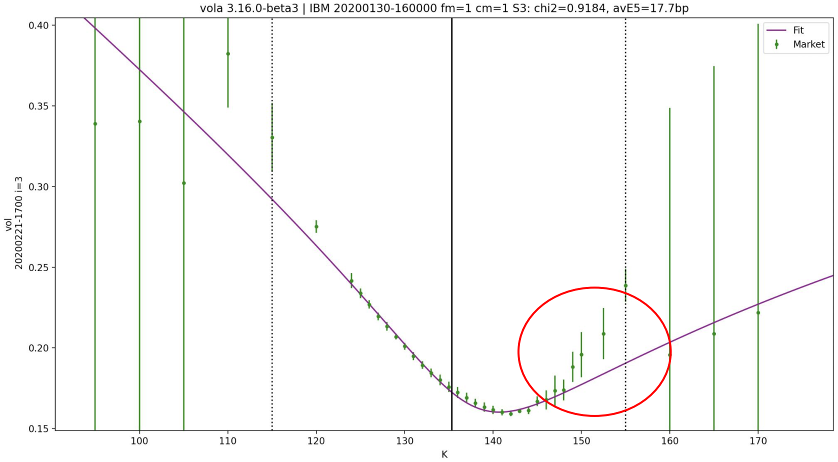
Option valuation: describing the option prices

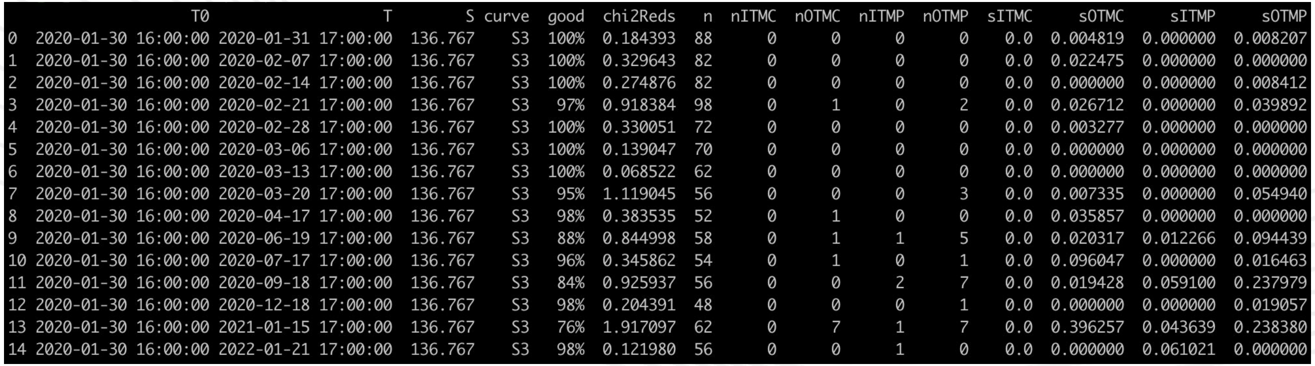
- What information can be extracted from listed option prices?
    - Discount rates
    - Borrow curves
    - Dividend amounts, dividend model
    - Volatility time
    - Events
    - Volatility surface (equivalent to the implied probability density)
- What happens if you disagree with the market?
- How can you tell what’s wrong and how to match the parameters that OMMs use in their valuations?

Example: incorrect curve type

Bad fit!

- chi^2>1
- Crossings/bias in OTM options





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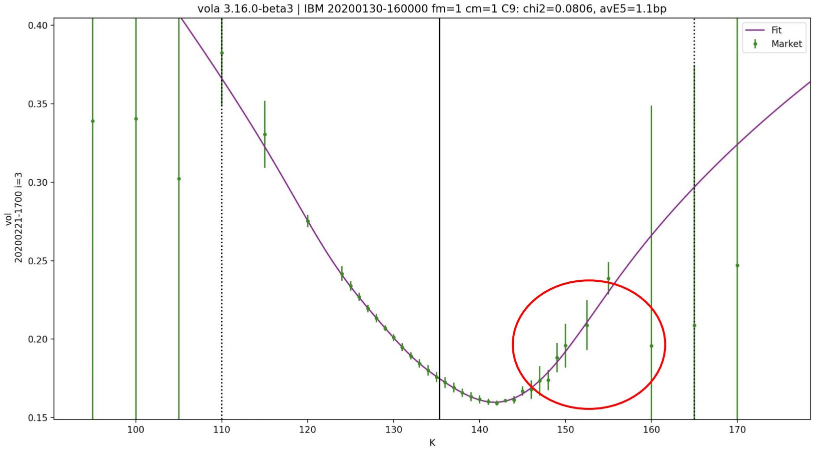
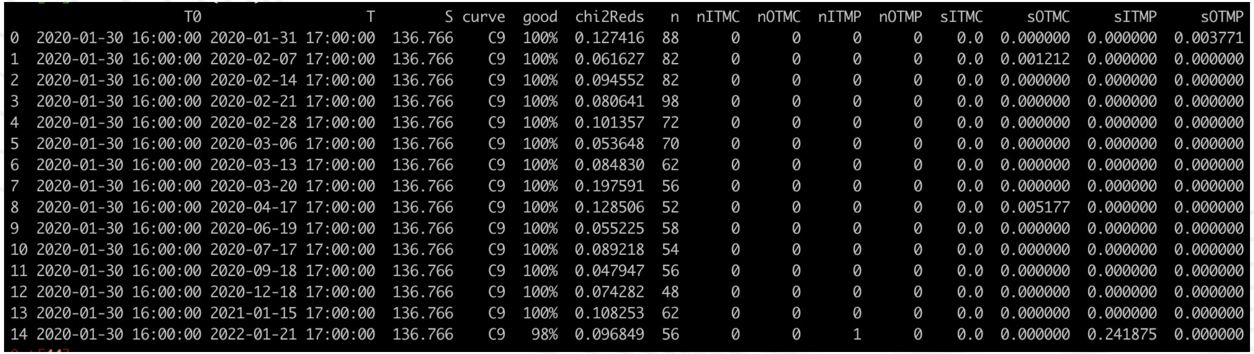
0  2020-01-30 16:00:00 2020-01-31 17:00:00  136.767    S3  100%  0.184393  88      0      0      0      0    0.0  0.004819  0.000000  0.008207
1  2020-01-30 16:00:00 2020-02-07 17:00:00  136.767    S3  100%  0.329643  82      0      0      0      0    0.0  0.022475  0.000000  0.000000
2  2020-01-30 16:00:00 2020-02-14 17:00:00  136.767    S3  100%  0.274876  82      0      0      0      0    0.0  0.000000  0.000000  0.008412
3  2020-01-30 16:00:00 2020-02-21 17:00:00  136.767    S3   97%  0.918384  98      0      1      0      2    0.0  0.026712  0.000000  0.039892
4  2020-01-30 16:00:00 2020-02-28 17:00:00  136.767    S3  100%  0.330051  72      0      0      0      0    0.0  0.003277  0.000000  0.000000
5  2020-01-30 16:00:00 2020-03-06 17:00:00  136.767    S3  100%  0.139047  70      0      0      0      0    0.0  0.000000  0.000000  0.000000
6  2020-01-30 16:00:00 2020-03-13 17:00:00  136.767    S3  100%  0.068522  62      0      0      0      0    0.0  0.000000  0.000000  0.000000
7  2020-01-30 16:00:00 2020-03-20 17:00:00  136.767    S3   95%  1.119045  56      0      0      0      3    0.0  0.007335  0.000000  0.054940
8  2020-01-30 16:00:00 2020-04-17 17:00:00  136.767    S3   98%  0.383535  52      0      1      0      0    0.0  0.035857  0.000000  0.000000
9  2020-01-30 16:00:00 2020-06-19 17:00:00  136.767    S3   88%  0.844998  58      0      1      1      5    0.0  0.020317  0.012266  0.094439
10 2020-01-30 16:00:00 2020-07-17 17:00:00  136.767    S3   96%  0.345862  54      0      1      0      1    0.0  0.096047  0.000000  0.016463
11 2020-01-30 16:00:00 2020-09-18 17:00:00  136.767    S3   84%  0.925937  56      0      0      2      7    0.0  0.019428  0.059100  0.237979
12 2020-01-30 16:00:00 2020-12-18 17:00:00  136.767    S3   98%  0.204391  48      0      0      0      1    0.0  0.000000  0.000000  0.019057
13 2020-01-30 16:00:00 2021-01-15 17:00:00  136.767    S3   76%  1.917097  62      0      7      1      7    0.0  0.396257  0.043639  0.238380
14 2020-01-30 16:00:00 2022-01-21 17:00:00  136.767    S3   98%  0.121980  56      0      0      1      0    0.0  0.000000  0.061021  0.000000
```

Example: incorrect curve type

Good fit!
- Low chi2
- No crossings





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1  2020-01-30 16:00:00 2020-02-07 17:00:00 136.766    C9  100%  0.061627  82      0      0      0      0    0.0  0.001212  0.000000  0.000000
2  2020-01-30 16:00:00 2020-02-14 17:00:00 136.766    C9  100%  0.094552  82      0      0      0      0    0.0  0.000000  0.000000  0.000000
3  2020-01-30 16:00:00 2020-02-21 17:00:00 136.766    C9  100%  0.080641  98      0      0      0      0    0.0  0.000000  0.000000  0.000000
4  2020-01-30 16:00:00 2020-02-28 17:00:00 136.766    C9  100%  0.101357  72      0      0      0      0    0.0  0.000000  0.000000  0.000000
5  2020-01-30 16:00:00 2020-03-06 17:00:00 136.766    C9  100%  0.053648  70      0      0      0      0    0.0  0.000000  0.000000  0.000000
6  2020-01-30 16:00:00 2020-03-13 17:00:00 136.766    C9  100%  0.084830  62      0      0      0      0    0.0  0.000000  0.000000  0.000000
7  2020-01-30 16:00:00 2020-03-20 17:00:00 136.766    C9  100%  0.197591  56      0      0      0      0    0.0  0.000000  0.000000  0.000000
8  2020-01-30 16:00:00 2020-04-17 17:00:00 136.766    C9  100%  0.128506  52      0      0      0      0    0.0  0.005177  0.000000  0.000000
9  2020-01-30 16:00:00 2020-06-19 17:00:00 136.766    C9  100%  0.055225  58      0      0      0      0    0.0  0.000000  0.000000  0.000000
10 2020-01-30 16:00:00 2020-07-17 17:00:00 136.766    C9  100%  0.089218  54      0      0      0      0    0.0  0.000000  0.000000  0.000000
11 2020-01-30 16:00:00 2020-09-18 17:00:00 136.766    C9  100%  0.047947  56      0      0      0      0    0.0  0.000000  0.000000  0.000000
12 2020-01-30 16:00:00 2020-12-18 17:00:00 136.766    C9  100%  0.074282  48      0      0      0      0    0.0  0.000000  0.000000  0.000000
13 2020-01-30 16:00:00 2021-01-15 17:00:00 136.766    C9  100%  0.108253  62      0      0      0      0    0.0  0.000000  0.000000  0.000000
14 2020-01-30 16:00:00 2022-01-21 17:00:00 136.766    C9   98%  0.096849  56      0      0      1      0    0.0  0.000000  0.241875  0.000000
```
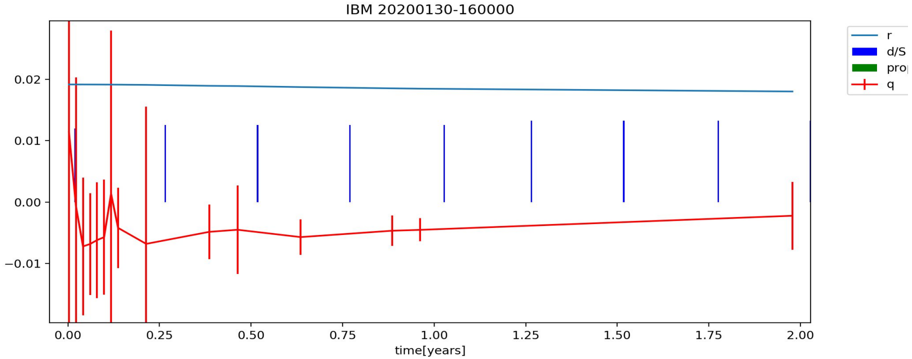
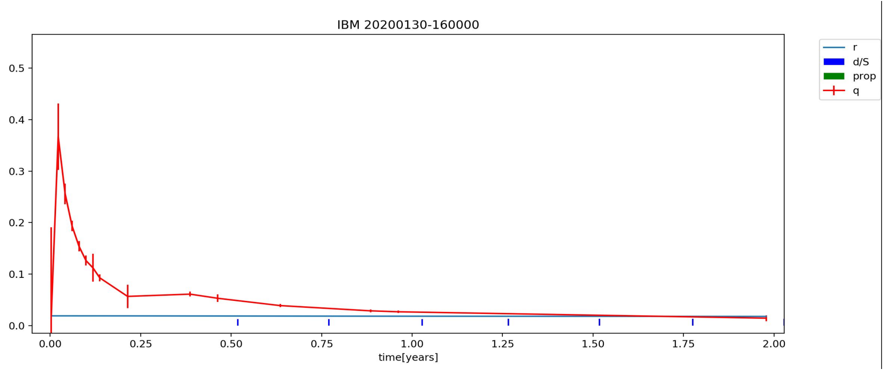
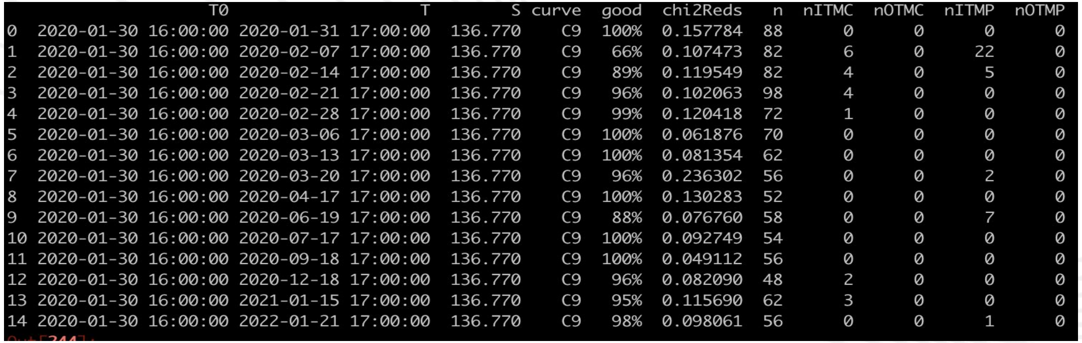

Example: missing dividend

Correct dividends

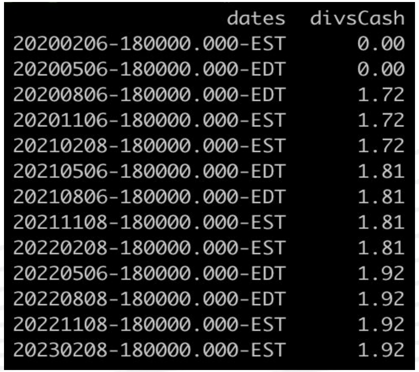


Missing dividends!





```
                    T0                   T        S curve  good  chi2Reds   n  nITMC  nOTMC  nITMP  nOTMP
0  2020-01-30 16:00:00 2020-01-31 17:00:00  136.770    C9  100%  0.157784  88      0      0      0      0
1  2020-01-30 16:00:00 2020-02-07 17:00:00  136.770    C9   66%  0.107473  82      6      0     22      0
2  2020-01-30 16:00:00 2020-02-14 17:00:00  136.770    C9   89%  0.119549  82      4      0      5      0
3  2020-01-30 16:00:00 2020-02-21 17:00:00  136.770    C9   96%  0.102063  98      4      0      0      0
4  2020-01-30 16:00:00 2020-02-28 17:00:00  136.770    C9   99%  0.120418  72      1      0      0      0
5  2020-01-30 16:00:00 2020-03-06 17:00:00  136.770    C9  100%  0.061876  70      0      0      0      0
6  2020-01-30 16:00:00 2020-03-13 17:00:00  136.770    C9  100%  0.081354  62      0      0      0      0
7  2020-01-30 16:00:00 2020-03-20 17:00:00  136.770    C9   96%  0.236302  56      0      0      2      0
8  2020-01-30 16:00:00 2020-04-17 17:00:00  136.770    C9  100%  0.130283  52      0      0      0      0
9  2020-01-30 16:00:00 2020-06-19 17:00:00  136.770    C9   88%  0.076760  58      0      0      7      0
10 2020-01-30 16:00:00 2020-07-17 17:00:00  136.770    C9  100%  0.092749  54      0      0      0      0
11 2020-01-30 16:00:00 2020-09-18 17:00:00  136.770    C9  100%  0.049112  56      0      0      0      0
12 2020-01-30 16:00:00 2020-12-18 17:00:00  136.770    C9   96%  0.082090  48      2      0      0      0
13 2020-01-30 16:00:00 2021-01-15 17:00:00  136.770    C9   95%  0.115690  62      3      0      0      0
14 2020-01-30 16:00:00 2022-01-21 17:00:00  136.770    C9   98%  0.098061  56      0      0      1      0
```



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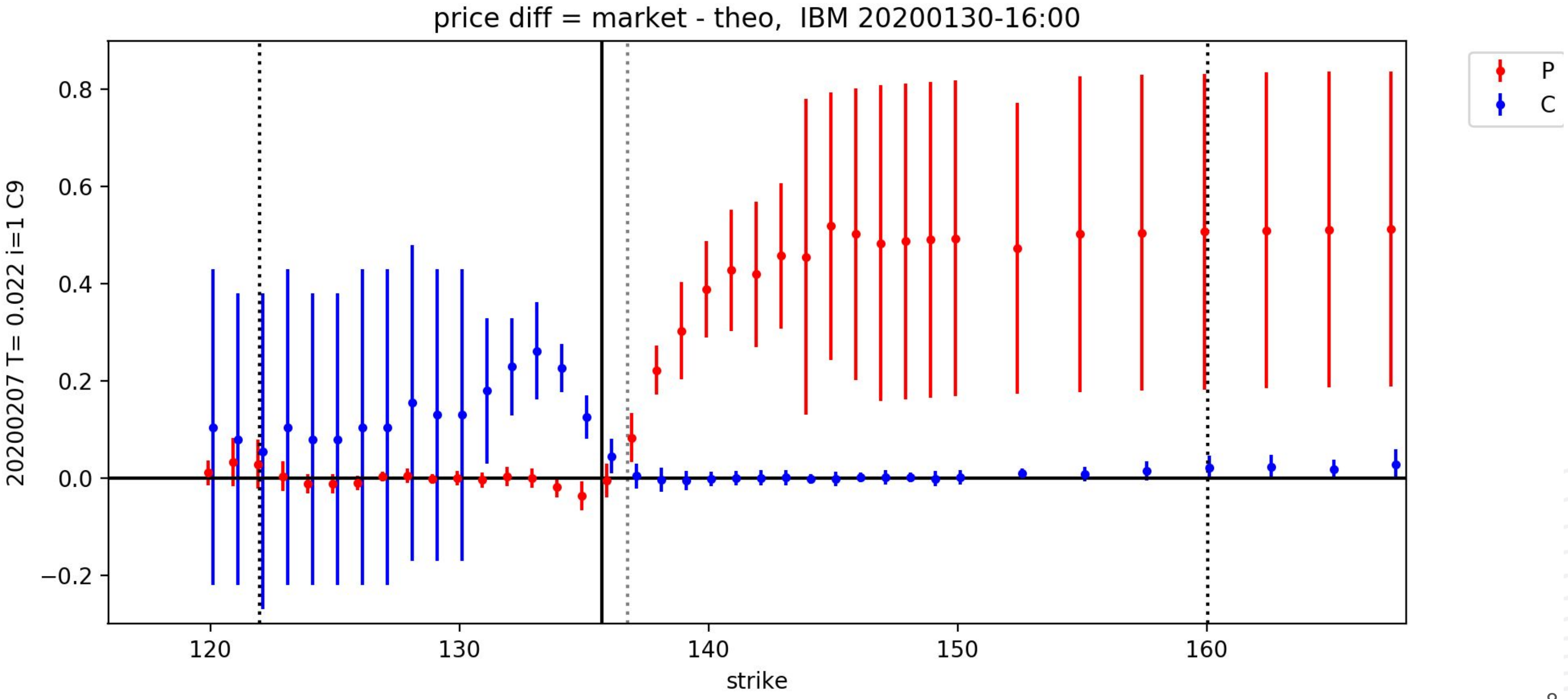
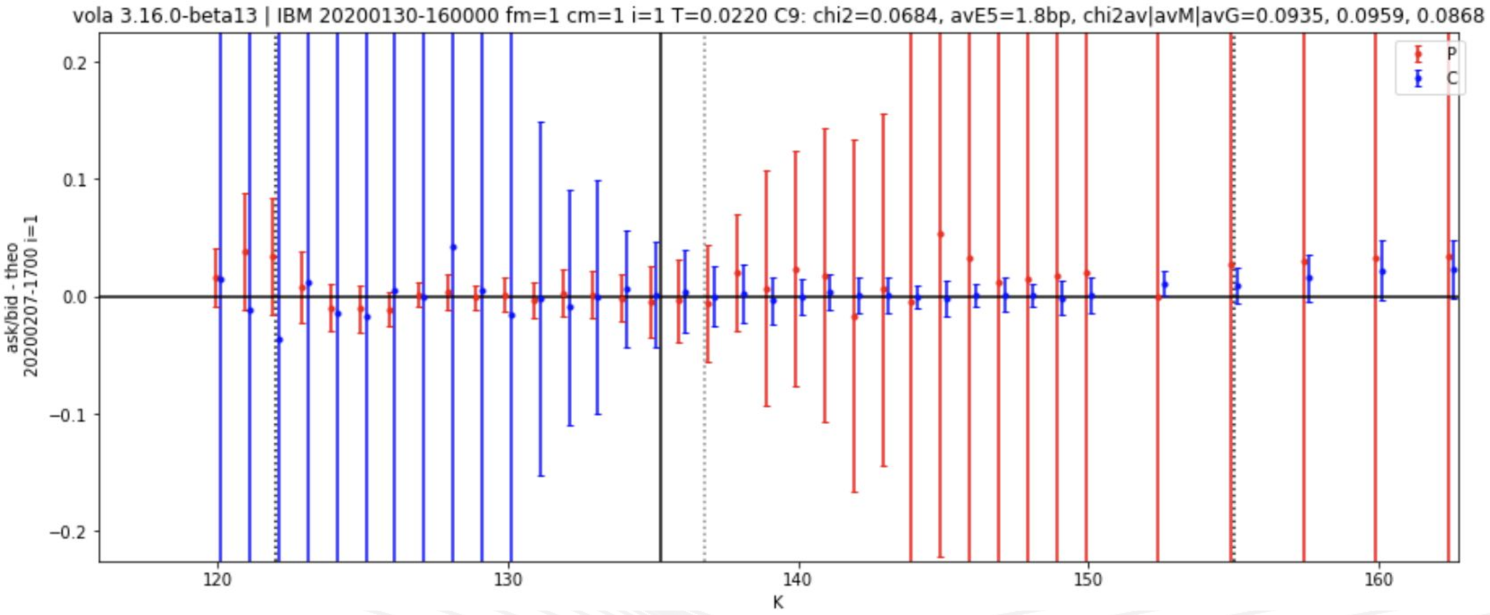
                       dates  divsCash
20200206-180000.000-EST           0.00
20200506-180000.000-EDT           0.00
20200806-180000.000-EDT           1.72
20201106-180000.000-EST           1.72
20210208-180000.000-EST           1.72
20210506-180000.000-EDT           1.81
20210806-180000.000-EDT           1.81
20211108-180000.000-EST           1.81
20220208-180000.000-EST           1.81
20220506-180000.000-EDT           1.92
20220808-180000.000-EDT           1.92
20221108-180000.000-EST           1.92
20230208-180000.000-EST           1.92
```

Example: missing dividend

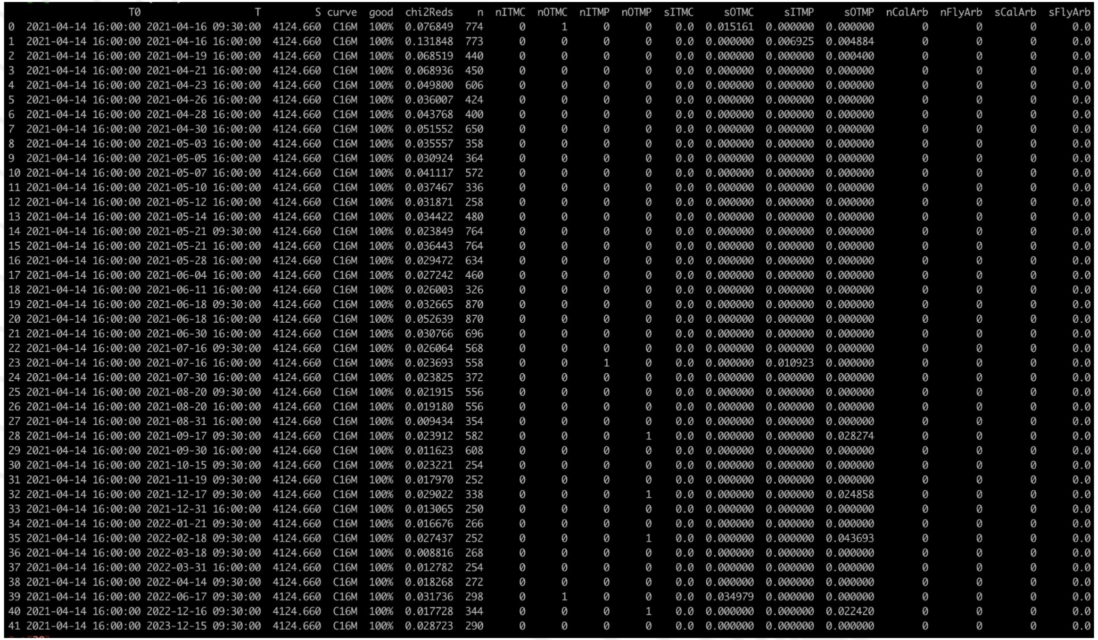


Example: correct dividend



vola 3.16.0-beta13 | IBM 20200130-160000 fm=1 cm=1 i=1 T=0.0220 C9: chi2=0.0684, avE5=1.8bp, chi2av|avM|avG=0.0935, 0.0959, 0.0868

Example: incorrect input spot



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0  2021-04-14 16:00:00 2021-04-16 09:30:00  4124.660  C16M  100%  0.076849  774      0      1      0      0    0.0  0.015161  0.000000  0.000000        0        0        0      0.0
1  2021-04-14 16:00:00 2021-04-16 16:00:00  4124.660  C16M  100%  0.131848  773      0      0      0      0    0.0  0.000000  0.006925  0.004884        0        0        0      0.0
2  2021-04-14 16:00:00 2021-04-19 16:00:00  4124.660  C16M  100%  0.068519  440      0      0      0      0    0.0  0.000000  0.000000  0.000400        0        0        0      0.0
3  2021-04-14 16:00:00 2021-04-21 16:00:00  4124.660  C16M  100%  0.068936  450      0      0      0      0    0.0  0.000000  0.000000  0.000000        0        0        0      0.0
4  2021-04-14 16:00:00 2021-04-23 16:00:00  4124.660  C16M  100%  0.049800  606      0      0      0      0    0.0  0.000000  0.000000  0.000000        0        0        0      0.0
5  2021-04-14 16:00:00 2021-04-26 16:00:00  4124.660  C16M  100%  0.036007  424      0      0      0      0    0.0  0.000000  0.000000  0.000000        0        0        0      0.0
6  2021-04-14 16:00:00 2021-04-28 16:00:00  4124.660  C16M  100%  0.043768  400      0      0      0      0    0.0  0.000000  0.000000  0.000000        0        0        0      0.0
7  2021-04-14 16:00:00 2021-04-30 16:00:00  4124.660  C16M  100%  0.051552  650      0      0      0      0    0.0  0.000000  0.000000  0.000000        0        0        0      0.0
8  2021-04-14 16:00:00 2021-05-03 16:00:00  4124.660  C16M  100%  0.035557  358      0      0      0      0    0.0  0.000000  0.000000  0.000000        0        0        0      0.0
9  2021-04-14 16:00:00 2021-05-05 16:00:00  4124.660  C16M  100%  0.030924  364      0      0      0      0    0.0  0.000000  0.000000  0.000000        0        0        0      0.0
10 2021-04-14 16:00:00 2021-05-07 16:00:00  4124.660  C16M  100%  0.041117  572      0      0      0      0    0.0  0.000000  0.000000  0.000000        0        0        0      0.0
11 2021-04-14 16:00:00 2021-05-10 16:00:00  4124.660  C16M  100%  0.037467  336      0      0      0      0    0.0  0.000000  0.000000  0.000000        0        0        0      0.0
12 2021-04-14 16:00:00 2021-05-12 16:00:00  4124.660  C16M  100%  0.031871  258      0      0      0      0    0.0  0.000000  0.000000  0.000000        0        0        0      0.0
13 2021-04-14 16:00:00 2021-05-14 16:00:00  4124.660  C16M  100%  0.034422  480      0      0      0      0    0.0  0.000000  0.000000  0.000000        0        0        0      0.0
14 2021-04-14 16:00:00 2021-05-21 09:30:00  4124.660  C16M  100%  0.023849  764      0      0      0      0    0.0  0.000000  0.000000  0.000000        0        0        0      0.0
15 2021-04-14 16:00:00 2021-05-21 16:00:00  4124.660  C16M  100%  0.036443  764      0      0      0      0    0.0  0.000000  0.000000  0.000000        0        0        0      0.0
16 2021-04-14 16:00:00 2021-05-28 16:00:00  4124.660  C16M  100%  0.029472  634      0      0      0      0    0.0  0.000000  0.000000  0.000000        0        0        0      0.0
17 2021-04-14 16:00:00 2021-06-04 16:00:00  4124.660  C16M  100%  0.027242  460      0      0      0      0    0.0  0.000000  0.000000  0.000000        0        0        0      0.0
18 2021-04-14 16:00:00 2021-06-11 16:00:00  4124.660  C16M  100%  0.026003  326      0      0      0      0    0.0  0.000000  0.000000  0.000000        0        0        0      0.0
19 2021-04-14 16:00:00 2021-06-18 09:30:00  4124.660  C16M  100%  0.032665  870      0      0      0      0    0.0  0.000000  0.000000  0.000000        0        0        0      0.0
20 2021-04-14 16:00:00 2021-06-18 16:00:00  4124.660  C16M  100%  0.052639  870      0      0      0      0    0.0  0.000000  0.000000  0.000000        0        0        0      0.0
21 2021-04-14 16:00:00 2021-06-30 16:00:00  4124.660  C16M  100%  0.030766  696      0      0      0      0    0.0  0.000000  0.000000  0.000000        0        0        0      0.0
22 2021-04-14 16:00:00 2021-07-16 09:30:00  4124.660  C16M  100%  0.026064  568      0      0      0      0    0.0  0.000000  0.000000  0.000000        0        0        0      0.0
23 2021-04-14 16:00:00 2021-07-16 16:00:00  4124.660  C16M  100%  0.023693  558      0      0      1      0    0.0  0.000000  0.010923  0.000000        0        0        0      0.0
24 2021-04-14 16:00:00 2021-07-30 16:00:00  4124.660  C16M  100%  0.023825  372      0      0      0      0    0.0  0.000000  0.000000  0.000000        0        0        0      0.0
25 2021-04-14 16:00:00 2021-08-20 09:30:00  4124.660  C16M  100%  0.021915  556      0      0      0      0    0.0  0.000000  0.000000  0.000000        0        0        0      0.0
26 2021-04-14 16:00:00 2021-08-20 16:00:00  4124.660  C16M  100%  0.019180  556      0      0      0      0    0.0  0.000000  0.000000  0.000000        0        0        0      0.0
27 2021-04-14 16:00:00 2021-08-31 16:00:00  4124.660  C16M  100%  0.009434  354      0      0      0      0    0.0  0.000000  0.000000  0.000000        0        0        0      0.0
28 2021-04-14 16:00:00 2021-09-17 09:30:00  4124.660  C16M  100%  0.023912  582      0      0      0      1    0.0  0.000000  0.000000  0.028274        0        0        0      0.0
29 2021-04-14 16:00:00 2021-09-30 16:00:00  4124.660  C16M  100%  0.011623  608      0      0      0      0    0.0  0.000000  0.000000  0.000000        0        0        0      0.0
30 2021-04-14 16:00:00 2021-10-15 09:30:00  4124.660  C16M  100%  0.023221  254      0      0      0      0    0.0  0.000000  0.000000  0.000000        0        0        0      0.0
31 2021-04-14 16:00:00 2021-11-19 09:30:00  4124.660  C16M  100%  0.017970  252      0      0      0      0    0.0  0.000000  0.000000  0.000000        0        0        0      0.0
32 2021-04-14 16:00:00 2021-12-17 09:30:00  4124.660  C16M  100%  0.029022  338      0      0      0      1    0.0  0.000000  0.000000  0.024858        0        0        0      0.0
33 2021-04-14 16:00:00 2021-12-31 16:00:00  4124.660  C16M  100%  0.013065  250      0      0      0      0    0.0  0.000000  0.000000  0.000000        0        0        0      0.0
34 2021-04-14 16:00:00 2022-01-21 09:30:00  4124.660  C16M  100%  0.016676  266      0      0      0      0    0.0  0.000000  0.000000  0.000000        0        0        0      0.0
35 2021-04-14 16:00:00 2022-02-18 09:30:00  4124.660  C16M  100%  0.027437  252      0      0      0      1    0.0  0.000000  0.000000  0.043693        0        0        0      0.0
36 2021-04-14 16:00:00 2022-03-18 09:30:00  4124.660  C16M  100%  0.008816  268      0      0      0      0    0.0  0.000000  0.000000  0.000000        0        0        0      0.0
37 2021-04-14 16:00:00 2022-03-31 16:00:00  4124.660  C16M  100%  0.012782  254      0      0      0      0    0.0  0.000000  0.000000  0.000000        0        0        0      0.0
38 2021-04-14 16:00:00 2022-04-14 09:30:00  4124.660  C16M  100%  0.018268  272      0      0      0      0    0.0  0.000000  0.000000  0.000000        0        0        0      0.0
39 2021-04-14 16:00:00 2022-06-17 09:30:00  4124.660  C16M  100%  0.031736  298      0      1      0      0    0.0  0.034979  0.000000  0.000000        0        0        0      0.0
40 2021-04-14 16:00:00 2022-12-16 09:30:00  4124.660  C16M  100%  0.017728  344      0      0      0      1    0.0  0.000000  0.000000  0.022420        0        0        0      0.0
41 2021-04-14 16:00:00 2023-12-15 09:30:00  4124.660  C16M  100%  0.028723  290      0      0      0      0    0.0  0.000000  0.000000  0.000000        0        0        0      0.0
```
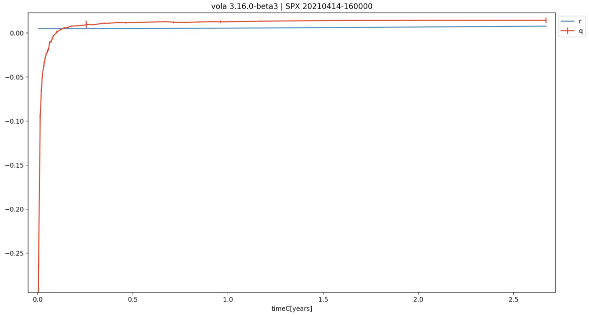
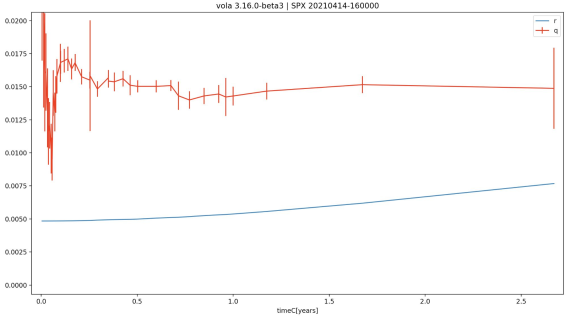
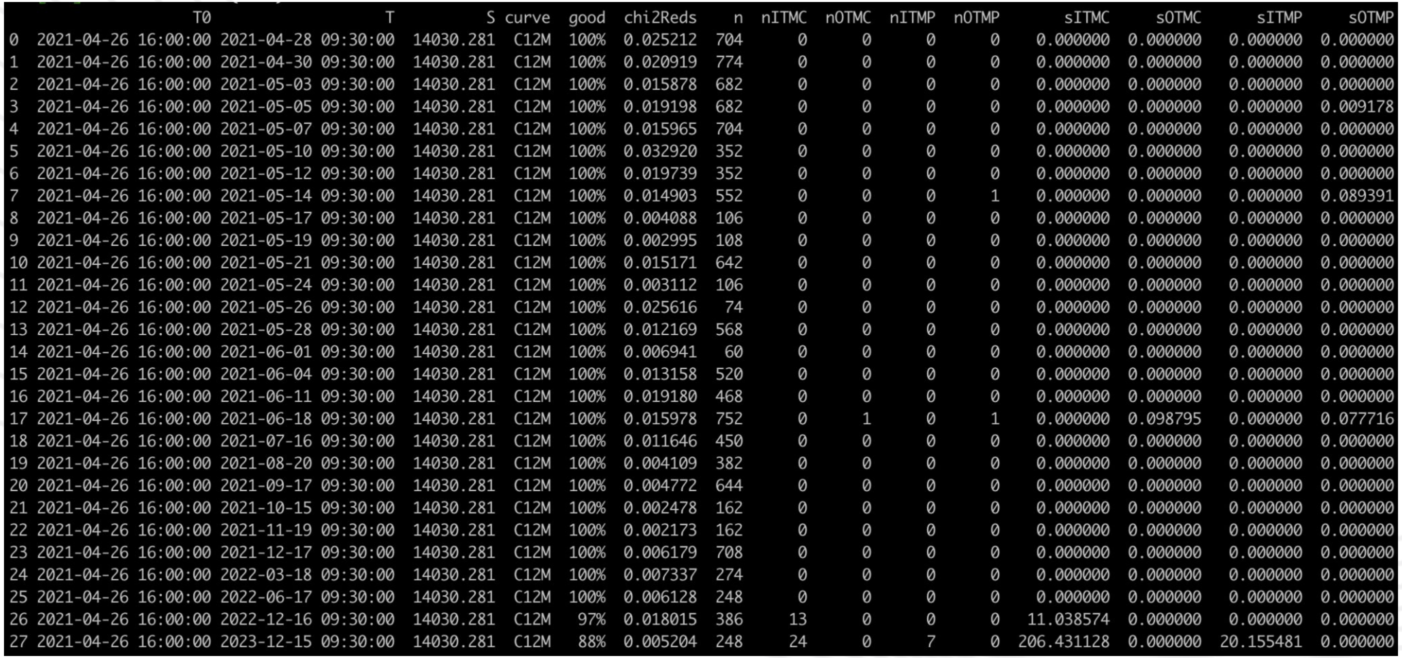

Input spot: 4124.66



Implied spot: 4131.3246



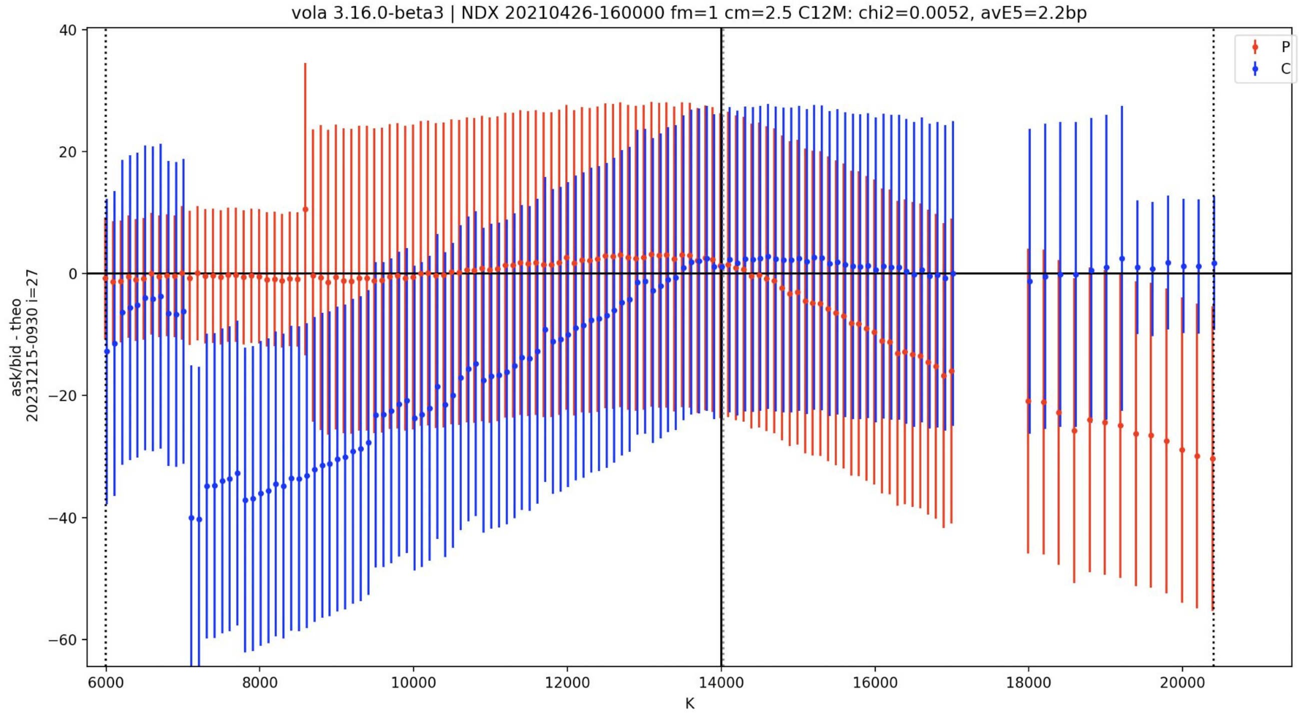
Example: discount rates (NDX)



```
                    T0                   T          S curve  good  chi2Reds    n   nITMC  nOTMC  nITMP  nOTMP       sITMC     sOTMC      sITMP     sOTMP
0  2021-04-26 16:00:00 2021-04-28 09:30:00  14030.281  C12M  100%  0.025212  704       0      0      0      0    0.000000  0.000000   0.000000  0.000000
1  2021-04-26 16:00:00 2021-04-30 09:30:00  14030.281  C12M  100%  0.020919  774       0      0      0      0    0.000000  0.000000   0.000000  0.000000
2  2021-04-26 16:00:00 2021-05-03 09:30:00  14030.281  C12M  100%  0.015878  682       0      0      0      0    0.000000  0.000000   0.000000  0.000000
3  2021-04-26 16:00:00 2021-05-05 09:30:00  14030.281  C12M  100%  0.019198  682       0      0      0      0    0.000000  0.000000   0.000000  0.009178
4  2021-04-26 16:00:00 2021-05-07 09:30:00  14030.281  C12M  100%  0.015965  704       0      0      0      0    0.000000  0.000000   0.000000  0.000000
5  2021-04-26 16:00:00 2021-05-10 09:30:00  14030.281  C12M  100%  0.032920  352       0      0      0      0    0.000000  0.000000   0.000000  0.000000
6  2021-04-26 16:00:00 2021-05-12 09:30:00  14030.281  C12M  100%  0.019739  352       0      0      0      0    0.000000  0.000000   0.000000  0.000000
7  2021-04-26 16:00:00 2021-05-14 09:30:00  14030.281  C12M  100%  0.014903  552       0      0      0      1    0.000000  0.000000   0.000000  0.089391
8  2021-04-26 16:00:00 2021-05-17 09:30:00  14030.281  C12M  100%  0.004088  106       0      0      0      0    0.000000  0.000000   0.000000  0.000000
9  2021-04-26 16:00:00 2021-05-19 09:30:00  14030.281  C12M  100%  0.002995  108       0      0      0      0    0.000000  0.000000   0.000000  0.000000
10 2021-04-26 16:00:00 2021-05-21 09:30:00  14030.281  C12M  100%  0.015171  642       0      0      0      0    0.000000  0.000000   0.000000  0.000000
11 2021-04-26 16:00:00 2021-05-24 09:30:00  14030.281  C12M  100%  0.003112  106       0      0      0      0    0.000000  0.000000   0.000000  0.000000
12 2021-04-26 16:00:00 2021-05-26 09:30:00  14030.281  C12M  100%  0.025616   74       0      0      0      0    0.000000  0.000000   0.000000  0.000000
13 2021-04-26 16:00:00 2021-05-28 09:30:00  14030.281  C12M  100%  0.012169  568       0      0      0      0    0.000000  0.000000   0.000000  0.000000
14 2021-04-26 16:00:00 2021-06-01 09:30:00  14030.281  C12M  100%  0.006941   60       0      0      0      0    0.000000  0.000000   0.000000  0.000000
15 2021-04-26 16:00:00 2021-06-04 09:30:00  14030.281  C12M  100%  0.013158  520       0      0      0      0    0.000000  0.000000   0.000000  0.000000
16 2021-04-26 16:00:00 2021-06-11 09:30:00  14030.281  C12M  100%  0.019180  468       0      0      0      0    0.000000  0.000000   0.000000  0.000000
17 2021-04-26 16:00:00 2021-06-18 09:30:00  14030.281  C12M  100%  0.015978  752       0      1      0      1    0.000000  0.098795   0.000000  0.077716
18 2021-04-26 16:00:00 2021-07-16 09:30:00  14030.281  C12M  100%  0.011646  450       0      0      0      0    0.000000  0.000000   0.000000  0.000000
19 2021-04-26 16:00:00 2021-08-20 09:30:00  14030.281  C12M  100%  0.004109  382       0      0      0      0    0.000000  0.000000   0.000000  0.000000
20 2021-04-26 16:00:00 2021-09-17 09:30:00  14030.281  C12M  100%  0.004772  644       0      0      0      0    0.000000  0.000000   0.000000  0.000000
21 2021-04-26 16:00:00 2021-10-15 09:30:00  14030.281  C12M  100%  0.002478  162       0      0      0      0    0.000000  0.000000   0.000000  0.000000
22 2021-04-26 16:00:00 2021-11-19 09:30:00  14030.281  C12M  100%  0.002173  162       0      0      0      0    0.000000  0.000000   0.000000  0.000000
23 2021-04-26 16:00:00 2021-12-17 09:30:00  14030.281  C12M  100%  0.006179  708       0      0      0      0    0.000000  0.000000   0.000000  0.000000
24 2021-04-26 16:00:00 2022-03-18 09:30:00  14030.281  C12M  100%  0.007337  274       0      0      0      0    0.000000  0.000000   0.000000  0.000000
25 2021-04-26 16:00:00 2022-06-17 09:30:00  14030.281  C12M  100%  0.006128  248       0      0      0      0    0.000000  0.000000   0.000000  0.000000
26 2021-04-26 16:00:00 2022-12-16 09:30:00  14030.281  C12M   97%  0.018015  386      13      0      0      0   11.038574  0.000000   0.000000  0.000000
27 2021-04-26 16:00:00 2023-12-15 09:30:00  14030.281  C12M   88%  0.005204  248      24      0      7      0  206.431128  0.000000  20.155481  0.000000
```

Note the bias in
in-the-money options
in Dec 22 and Dec 23!

Example: discount rates (NDX)

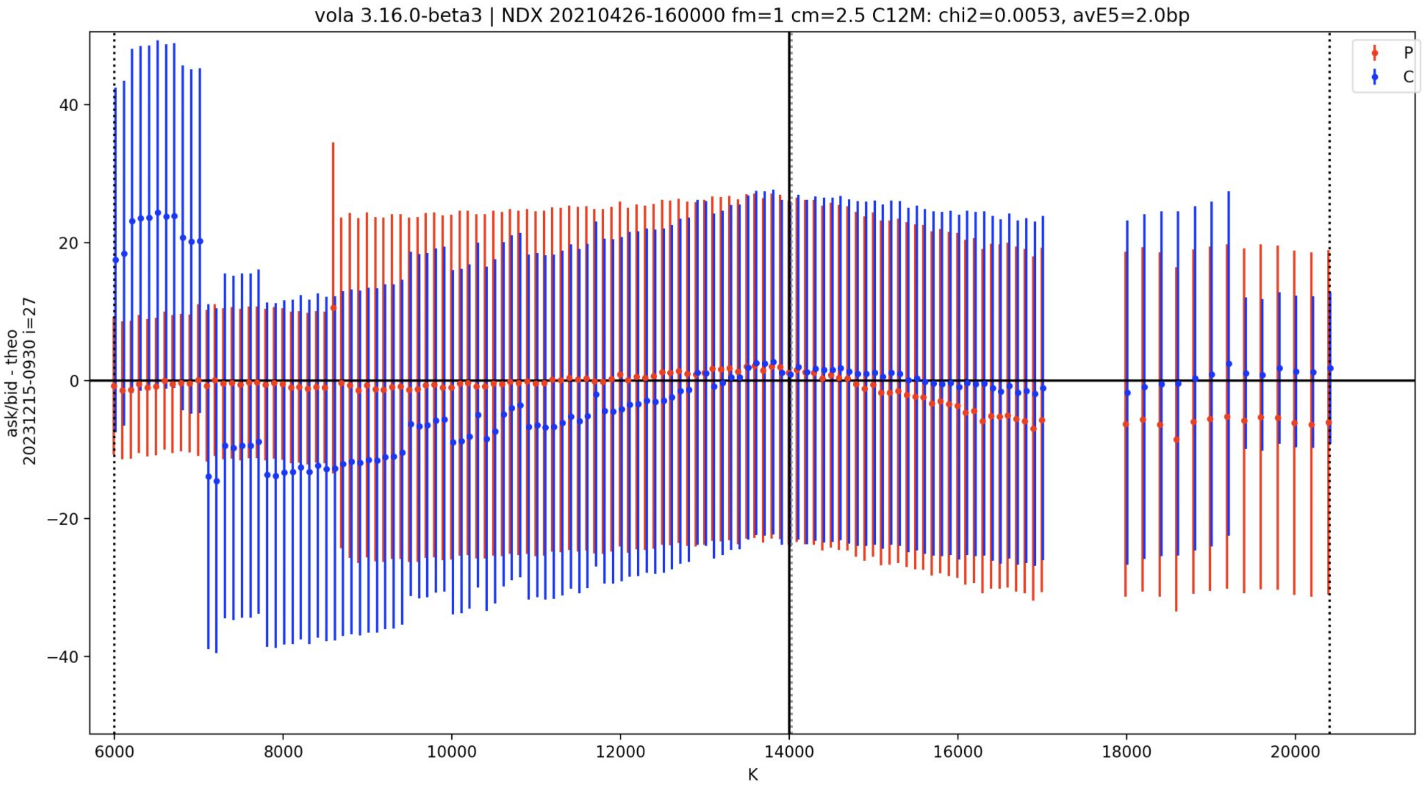


Graph shows the market bid/ask minus fitted theos (calls are blue, puts are red)… we see large fitting errors for ITM options

NDX is fit with discount rates implied from SPX options.

Such bias in long-dated options is typical for wrong discount rates.

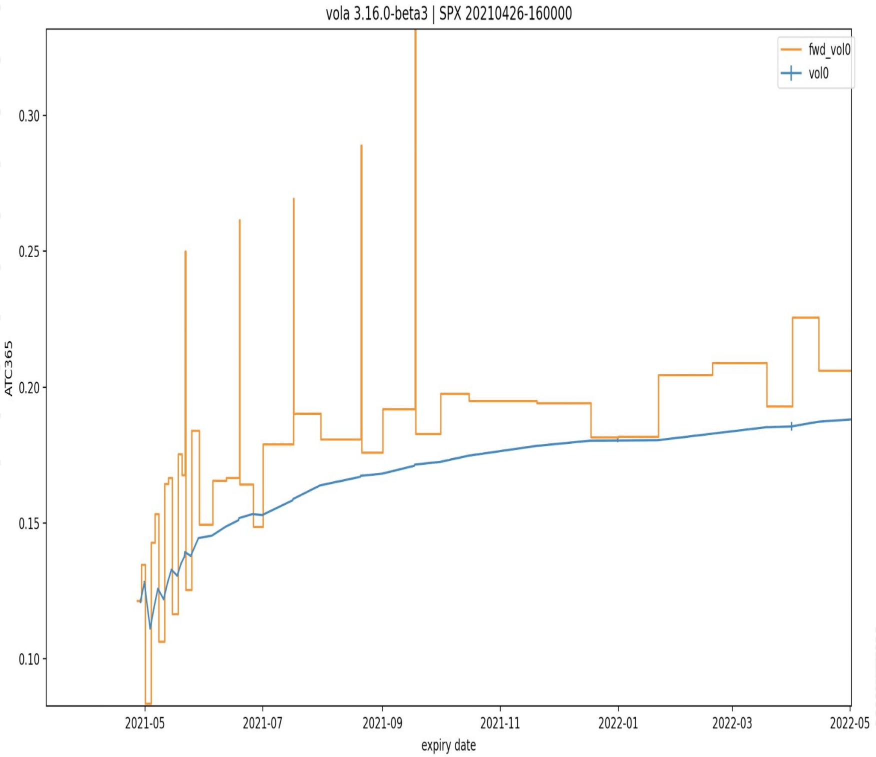
Example: discount rates (NDX)



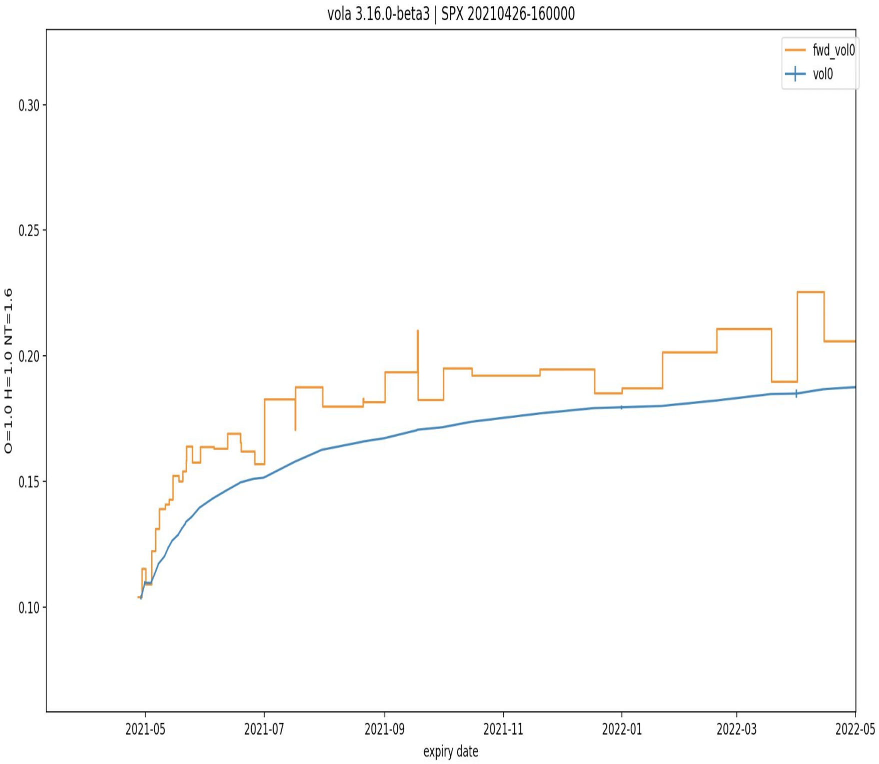
Discount rate changed from 78bps to 92bps mostly removes the bias and make all valuations within BBO.

Volatility time and term structure of forward starting SPX vol

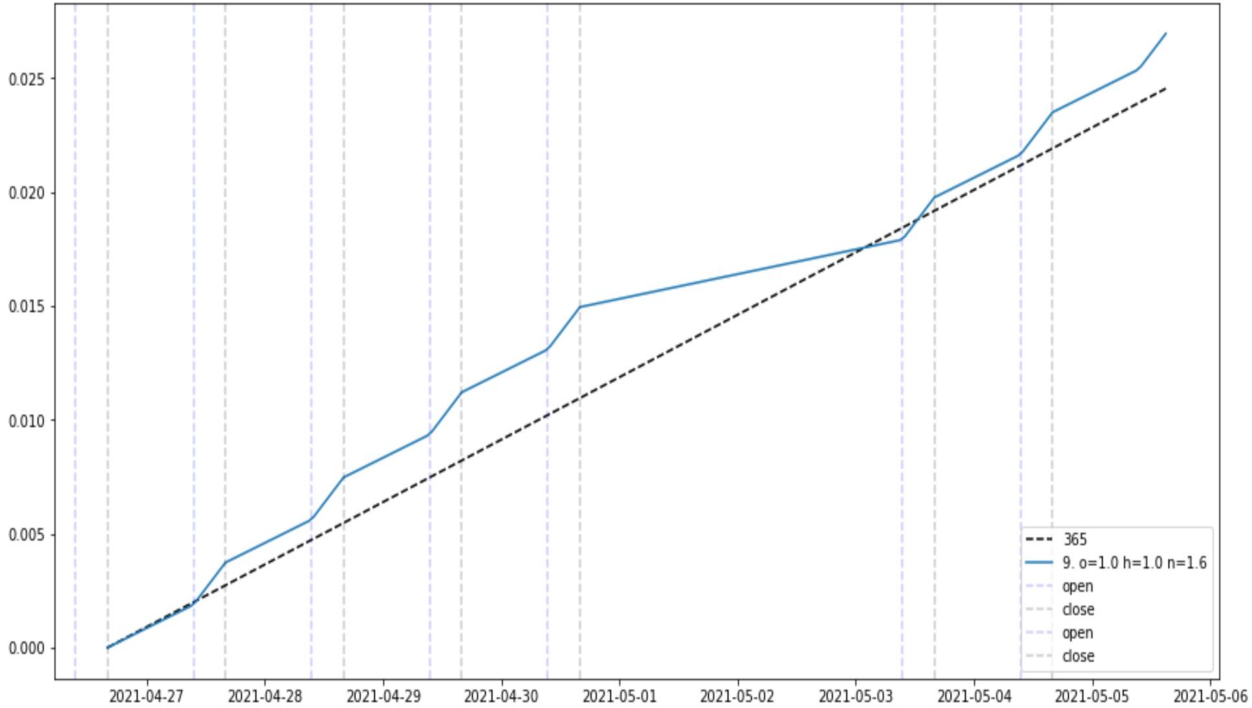
Clock time



Calibrated volatility time



Time converter: time in years between two datetimes

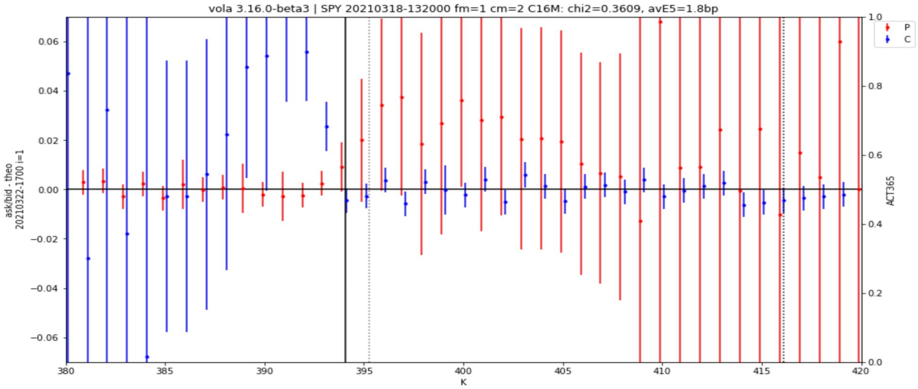


In volatility time variance accrues at different rates

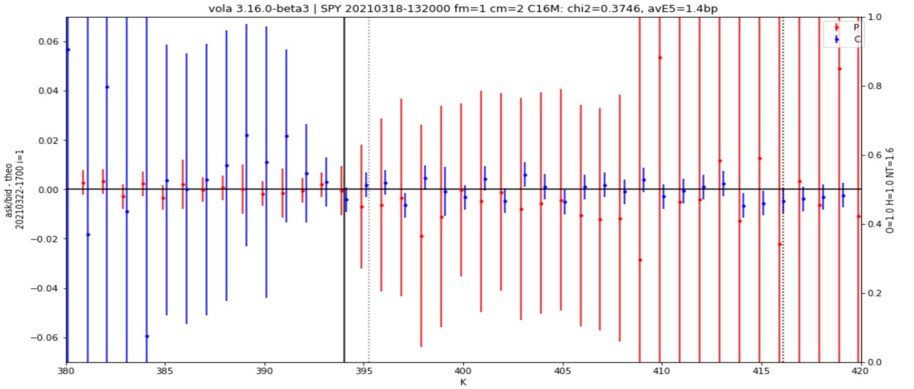
- Intraday
- Overnight
- Non-trading

Volatility time affects SPY early exercise premium

Clock time

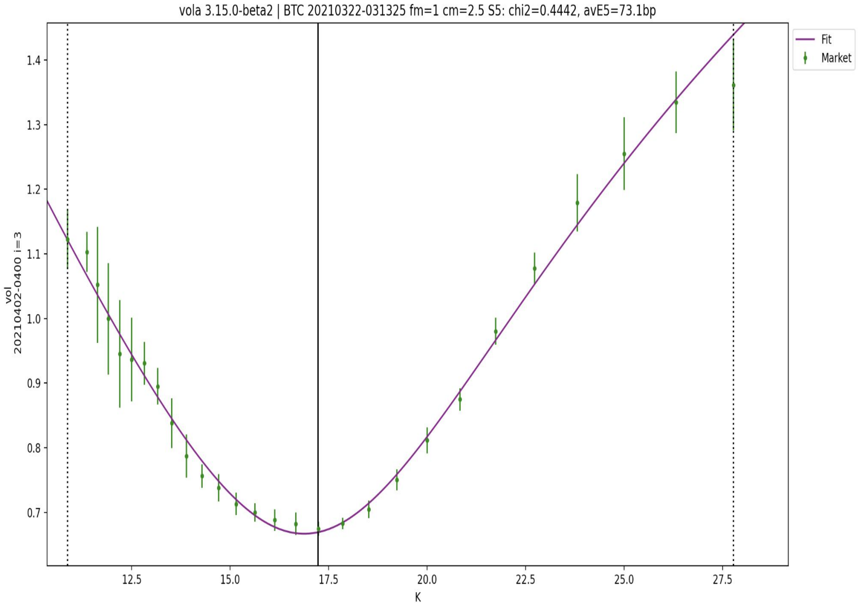


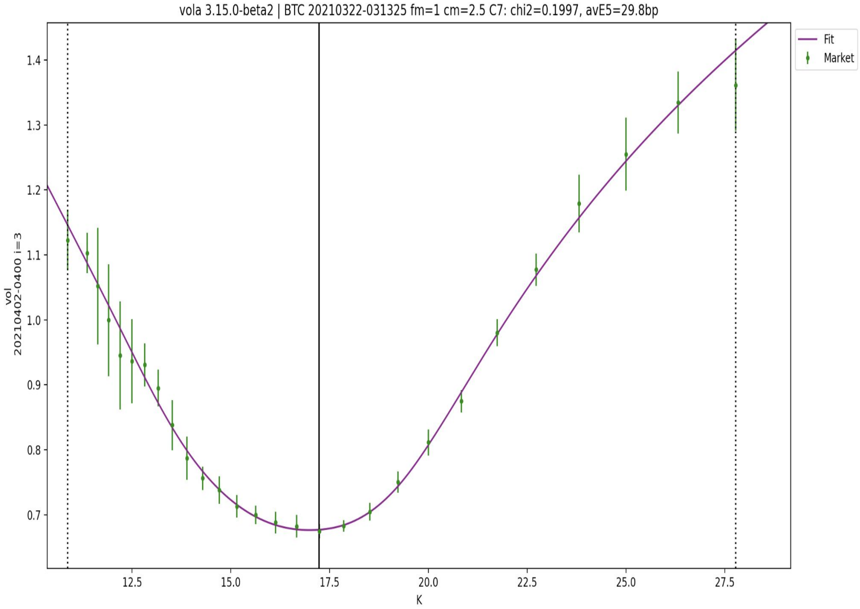
Calibrated vol time



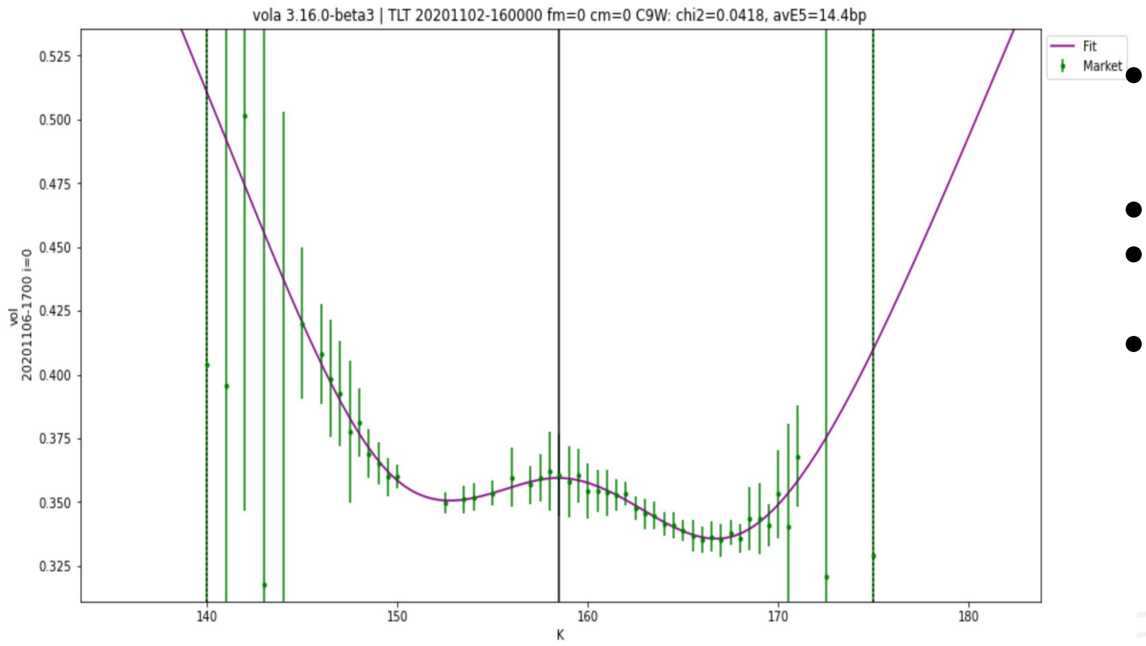
- SPY goes ex-div on Friday, hence need to early exercise calls on Thursday night to get the div
- Early exercise premium depends on how much variance accrues from Thursday afternoon to the close.
- Simple clock time does not take into account that variance accrues faster during trading hours, therefore, ITM calls are underpriced

Crypto vol fit example: SVI cannot fit BTC


vola 3.15.0-beta2 | BTC 20210322-031325 fm=1 cm=2.5 S5: chi2=0.4442, avE5=73.1bp


vola 3.15.0-beta2 | BTC 20210322-031325 fm=1 cm=2.5 C7: chi2=0.1997, avE5=29.8bp

Example: events, TLT before the US elections



- Negative curvatures first appeared ~2005 in tech (GOOG) & autos (GM, F)
- Cannot fit with SABR, SVI, SSVI
- Now present in nearly every geography and asset class
- Markets which relied on vols sampled at 5 deltas will likely need to adopt equity framework to describe event-driven return distributions

Summary

- Options fitting is a complex engineering problem
- Key ingredients:
    - Fast option pricer with cash dividends
    - Flexible yet sensible vol curves that can match any market including event
    - Robust vol fitter
    - Vol dynamics
- Valuations depend on many parameters from dividends and rates to time convention
- With robust infrastructure (such as provided by Vola Dynamics) thousands of underliers can be reliably fit with small teams.