In [178]:

```
import pandas as pd
import numpy as np
from pandas_datareader import DataReader
from datetime import datetime
```

In [179]:

```
#Import data
VIX = DataReader("^VIX",  "yahoo", datetime(2016,1,1), datetime(2016,4,1))
VIX
```

Out[179]:

Date	High	Low	Open	Close	Volume	Adj Close
2016-01-04	23.360001	20.670000	22.480000	20.700001	0	20.700001
2016-01-05	21.059999	19.250000	20.750000	19.340000	0	19.340000
2016-01-06	21.860001	19.799999	21.670000	20.590000	0	20.590000
2016-01-07	25.860001	22.400000	23.219999	24.990000	0	24.990000
2016-01-08	27.080000	22.480000	22.959999	27.010000	0	27.010000
2016-01-11	27.389999	23.830000	25.580000	24.299999	0	24.299999
2016-01-12	23.930000	21.910000	22.969999	22.469999	0	22.469999
2016-01-13	26.110001	21.440001	21.719999	25.219999	0	25.219999
2016-01-14	26.280001	23.070000	24.750000	23.950001	0	23.950001
2016-01-15	30.950001	26.670000	28.959999	27.020000	0	27.020000
2016-01-19	27.590000	25.209999	25.400000	26.049999	0	26.049999
2016-01-20	32.090000	26.590000	27.780001	27.590000	0	27.590000
2016-01-21	28.430000	25.010000	27.790001	26.690001	0	26.690001
2016-01-22	24.549999	22.219999	24.209999	22.340000	0	22.340000
2016-01-25	24.309999	22.379999	23.299999	24.150000	0	24.150000
2016-01-26	24.020000	22.330000	23.750000	22.500000	0	22.500000
2016-01-27	27.219999	20.420000	22.879999	23.110001	0	23.110001
2016-01-28	23.809999	21.900000	22.150000	22.420000	0	22.420000
2016-01-29	21.740000	19.500000	21.590000	20.200001	0	20.200001
2016-02-01	23.660000	19.610001	21.320000	19.980000	0	19.980000
2016-02-02	22.420000	21.059999	21.340000	21.980000	0	21.980000
2016-02-03	27.700001	21.420000	21.490000	21.650000	0	21.650000
2016-02-04	23.139999	21.240000	22.290001	21.840000	0	21.840000
2016-02-05	24.110001	21.910000	22.090000	23.379999	0	23.379999
2016-02-08	27.719999	25.559999	25.889999	26.000000	0	26.000000
2016-02-09	28.309999	25.990000	28.299999	26.540001	0	26.540001
2016-02-10	26.600000	24.469999	25.750000	26.290001	0	26.290001
2016-02-11	30.900000	26.670000	29.010000	28.139999	0	28.139999
2016-02-12	27.570000	24.920000	27.160000	25.400000	0	25.400000
2016-02-16	25.520000	23.320000	24.959999	24.110001	0	24.110001
...	...	...	...	...	...	...
2016-02-19	23.440001	20.520000	22.389999	20.530001	0	20.530001
2016-02-22	20.350000	19.020000	20.139999	19.379999	0	19.379999
2016-02-23	21.160000	19.540001	19.750000	20.980000	0	20.980000
2016-02-24	22.870001	20.260000	22.280001	20.719999	0	20.719999

Date	High	Low	Open	Close	Volume	Adj Close
2016-02-25	21.260000	19.100000	20.540001	19.110001	0	19.110001
2016-02-26	20.129999	18.459999	18.889999	19.809999	0	19.809999
2016-02-29	20.809999	18.379999	20.490000	20.549999	0	20.549999
2016-03-01	20.170000	17.660000	19.840000	17.700001	0	17.700001
2016-03-02	18.410000	16.780001	17.980000	17.090000	0	17.090000
2016-03-03	17.559999	16.320000	17.250000	16.700001	0	16.700001
2016-03-04	17.350000	16.049999	16.480000	16.860001	0	16.860001
2016-03-07	18.040001	16.870001	17.980000	17.350000	0	17.350000
2016-03-08	18.889999	17.820000	18.379999	18.670000	0	18.670000
2016-03-09	19.110001	18.309999	18.559999	18.340000	0	18.340000
2016-03-10	19.590000	17.059999	18.170000	18.049999	0	18.049999
2016-03-11	17.270000	16.280001	17.090000	16.500000	0	16.500000
2016-03-14	17.670000	16.690001	17.010000	16.920000	0	16.920000
2016-03-15	17.850000	16.840000	17.600000	16.840000	0	16.840000
2016-03-16	16.330000	14.890000	15.960000	14.990000	0	14.990000
2016-03-17	15.380000	13.820000	15.340000	14.440000	0	14.440000
2016-03-18	14.360000	13.750000	14.050000	14.020000	0	14.020000
2016-03-21	14.730000	13.790000	14.570000	13.790000	0	13.790000
2016-03-22	14.760000	13.750000	14.570000	14.170000	0	14.170000
2016-03-23	15.030000	14.330000	14.570000	14.940000	0	14.940000
2016-03-24	16.440001	14.710000	16.299999	14.740000	0	14.740000
2016-03-28	16.040001	14.890000	15.650000	15.240000	0	15.240000
2016-03-29	15.890000	13.790000	15.740000	13.820000	0	13.820000
2016-03-30	13.890000	13.060000	13.690000	13.560000	0	13.560000
2016-03-31	14.280000	13.490000	13.730000	13.950000	0	13.950000
2016-04-01	15.280000	13.000000	15.230000	13.100000	0	13.100000

62 rows × 6 columns

In [180]:

```
VIX['Adj Close']
```

Out[180]:

```
Date
2016-01-04    20.700001
2016-01-05    19.340000
2016-01-06    20.590000
2016-01-07    24.990000
2016-01-08    27.010000
2016-01-11    24.299999
2016-01-12    22.469999
2016-01-13    25.219999
2016-01-14    23.950001
2016-01-15    27.020000
2016-01-19    26.049999
2016-01-20    27.590000
2016-01-21    26.690001
2016-01-22    22.340000
2016-01-25    24.150000
2016-01-26    22.500000
2016-01-27    23.110001
2016-01-28    22.420000
2016-01-29    20.200001
2016-02-01    19.980000
2016-02-02    21.980000
2016-02-03    21.650000
2016-02-04    21.840000
2016-02-05    23.379999
2016-02-08    26.000000
2016-02-09    26.540001
2016-02-10    26.290001
```

```
2016-02-11    28.139999
2016-02-12    25.400000
2016-02-16    24.110001
                 ...
2016-02-19    20.530001
2016-02-22    19.379999
2016-02-23    20.980000
2016-02-24    20.719999
2016-02-25    19.110001
2016-02-26    19.809999
2016-02-29    20.549999
2016-03-01    17.700001
2016-03-02    17.090000
2016-03-03    16.700001
2016-03-04    16.860001
2016-03-07    17.350000
2016-03-08    18.670000
2016-03-09    18.340000
2016-03-10    18.049999
2016-03-11    16.500000
2016-03-14    16.920000
2016-03-15    16.840000
2016-03-16    14.990000
2016-03-17    14.440000
2016-03-18    14.020000
2016-03-21    13.790000
2016-03-22    14.170000
2016-03-23    14.940000
2016-03-24    14.740000
2016-03-28    15.240000
2016-03-29    13.820000
2016-03-30    13.560000
2016-03-31    13.950000
2016-04-01    13.100000
Name: Adj Close, Length: 62, dtype: float64
```

In [181]:

```
names = ['ticker','date','date of contract','end data of contract','maturity','call','strike','bid
price','ask price','not important1','not important2','Black Scholes implied volatility','Current i
ndex level','not important3','not important4','not important5','interest rate']
```

In [182]:

```
df = pd.read_csv('SPX_2016_options.csv', header=None, names = names)
df
```

Out[182]:

	ticker	date	date of contract	end data of contract	maturity	call	strike	bid price	ask price	not important1	not important2	Black Scholes implied volatility	Current index level	impo
0	108105	20160104	736333	736344	11	1	1000	1007.40	1010.80	2000	42291	NaN	2012.66	-0.0
1	108105	20160104	736333	736344	11	1	1025	982.30	985.80	0	0	NaN	2012.66	-0.0
2	108105	20160104	736333	736344	11	1	1050	957.30	960.90	0	0	NaN	2012.66	-0.0
3	108105	20160104	736333	736344	11	1	1075	932.30	935.90	0	0	NaN	2012.66	-0.0
4	108105	20160104	736333	736344	11	1	1100	907.40	911.10	0	20	NaN	2012.66	-0.0
5	108105	20160104	736333	736344	11	1	1125	882.30	886.10	0	4	NaN	2012.66	-0.0
6	108105	20160104	736333	736344	11	1	1150	857.40	861.10	0	2	NaN	2012.66	-0.0
7	108105	20160104	736333	736344	11	1	1175	832.40	836.10	0	27	NaN	2012.66	-0.0
8	108105	20160104	736333	736344	11	1	1200	807.40	811.10	0	32	NaN	2012.66	-0.0
9	108105	20160104	736333	736344	11	1	1220	787.30	790.90	0	0	NaN	2012.66	-0.0
10	108105	20160104	736333	736344	11	1	1225	782.30	785.90	0	24	NaN	2012.66	-0.0
11	108105	20160104	736333	736344	11	1	1240	767.40	770.90	0	0	NaN	2012.66	-0.0
12	108105	20160104	736333	736344	11	1	1250	757.50	760.90	0	11	NaN	2012.66	-0.0

	ticker	date	date of contract	end data of contract	maturity	call	strike	bid price	ask price	not important1	not important2	Black Scholes implied volatility	Current index level	impo
13	108105	20160104	736333	736344	11	1	1260	747.40	750.90	0	0	NaN	2012.66	-0.0
14	108105	20160104	736333	736344	11	1	1270	737.50	740.90	0	1	NaN	2012.66	-0.0
15	108105	20160104	736333	736344	11	1	1275	732.50	735.90	0	16	NaN	2012.66	-0.0
16	108105	20160104	736333	736344	11	1	1280	727.50	730.90	0	0	NaN	2012.66	-0.0
17	108105	20160104	736333	736344	11	1	1290	717.40	720.90	0	0	NaN	2012.66	-0.0
18	108105	20160104	736333	736344	11	1	1300	707.40	710.90	0	3011	NaN	2012.66	-0.0
19	108105	20160104	736333	736344	11	1	1310	697.50	700.90	0	0	NaN	2012.66	-0.0
20	108105	20160104	736333	736344	11	1	1320	687.50	690.90	0	0	NaN	2012.66	-0.0
21	108105	20160104	736333	736344	11	1	1325	682.30	686.00	0	4	NaN	2012.66	-0.0
22	108105	20160104	736333	736344	11	1	1330	677.30	681.00	0	0	NaN	2012.66	-0.0
23	108105	20160104	736333	736344	11	1	1340	667.50	671.20	0	0	NaN	2012.66	-0.0
24	108105	20160104	736333	736344	11	1	1350	657.50	661.20	0	6	NaN	2012.66	-0.0
25	108105	20160104	736333	736344	11	1	1360	647.50	651.20	0	0	NaN	2012.66	-0.0
26	108105	20160104	736333	736344	11	1	1365	642.60	646.20	0	0	NaN	2012.66	-0.0
27	108105	20160104	736333	736344	11	1	1370	637.60	641.20	0	1	NaN	2012.66	-0.0
28	108105	20160104	736333	736344	11	1	1375	632.50	636.20	0	2	NaN	2012.66	-0.0
29	108105	20160104	736333	736344	11	1	1380	627.60	631.20	0	1	NaN	2012.66	-0.0
...	...	...	...	...	...	...	...	...	...	...	...	...	...	
619782	108105	20160429	736449	736785	336	-1	2000	121.40	122.90	0	1	0.183780	2065.30	-0.0
619783	108105	20160429	736449	736785	336	-1	2025	130.40	131.90	0	5	0.179158	2065.30	-0.0
619784	108105	20160429	736449	736785	336	-1	2050	140.00	141.60	0	498	0.174541	2065.30	-0.0
619785	108105	20160429	736449	736785	336	-1	2075	150.30	151.90	0	1000	0.169871	2065.30	-0.0
619786	108105	20160429	736449	736785	336	-1	2100	161.40	163.00	0	1	0.165287	2065.30	-0.0
619787	108105	20160429	736449	736785	336	-1	2125	173.20	174.90	0	0	0.160665	2065.30	-0.0
619788	108105	20160429	736449	736785	336	-1	2150	185.90	187.70	0	15	0.156147	2065.30	-0.0
619789	108105	20160429	736449	736785	336	-1	2175	199.60	201.40	0	0	0.151755	2065.30	-0.0
619790	108105	20160429	736449	736785	336	-1	2200	214.20	216.10	0	1	0.147451	2065.30	-0.0
619791	108105	20160429	736449	736785	336	-1	2225	229.80	231.80	0	0	0.143283	2065.30	-0.0
619792	108105	20160429	736449	736785	336	-1	2250	246.40	248.50	0	0	0.139247	2065.30	-0.0
619793	108105	20160429	736449	736785	336	-1	2275	264.10	266.20	0	0	0.135450	2065.30	-0.0
619794	108105	20160429	736449	736785	336	-1	2300	282.80	285.00	0	0	0.131973	2065.30	-0.0
619795	108105	20160429	736449	736785	336	-1	2325	302.50	304.80	0	0	0.128864	2065.30	-0.0
619796	108105	20160429	736449	736785	336	-1	2350	314.90	335.30	0	0	0.128019	2065.30	-0.0
619797	108105	20160429	736449	736785	336	-1	2375	335.40	356.90	0	0	0.124828	2065.30	-0.0
619798	108105	20160429	736449	736785	336	-1	2400	357.60	376.30	0	0	0.118683	2065.30	-0.0
619799	108105	20160429	736449	736785	336	-1	2500	451.40	472.30	0	0	0.120902	2065.30	-0.0
619800	108105	20160429	736449	736785	336	-1	2600	549.00	569.50	0	0	0.125484	2065.30	-0.0
619801	108105	20160429	736449	736785	336	-1	2700	647.70	668.20	0	0	0.135071	2065.30	-0.0
619802	108105	20160429	736449	736785	336	-1	300	0.00	0.35	0	0	0.664729	2065.30	-0.0
619803	108105	20160429	736449	736785	336	-1	400	0.00	0.50	0	0	0.583398	2065.30	-0.0
619804	108105	20160429	736449	736785	336	-1	500	0.15	0.70	0	0	0.530727	2065.30	-0.0
619805	108105	20160429	736449	736785	336	-1	600	0.45	1.10	0	0	0.493649	2065.30	-0.0
619806	108105	20160429	736449	736785	336	-1	700	0.90	1.55	0	0	0.457234	2065.30	-0.0
619807	108105	20160429	736449	736785	336	-1	750	1.25	1.90	0	0	0.442646	2065.30	-0.0
619808	108105	20160429	736449	736785	336	-1	800	1.60	2.25	0	0	0.426590	2065.30	-0.0
619809	108105	20160429	736449	736785	336	-1	850	2.10	2.70	0	0	0.412802	2065.30	-0.0
619810	108105	20160429	736449	736785	336	-1	900	2.65	3.30	0	0	0.399738	2065.30	-0.0
619811	108105	20160429	736449	736785	336	-1	950	3.30	4.00	0	1	0.387017	2065.30	-0.0

619812 rows × 17 columns

Question1

In [183]:

```
df = df.drop(['not important1', 'not important2','not important3', 'not important4', 'not importan
t5'], axis = 1)
df = df.dropna()
df
```

Out[183]:

	ticker	date	date of contract	end data of contract	maturity	call	strike	bid price	ask price	Black Scholes implied volatility	Current index level	interest rate
128	108105	20160104	736333	736344	11	1	1875	135.30	138.20	0.149708	2012.66	0.007121
129	108105	20160104	736333	736344	11	1	1880	130.10	133.90	0.184996	2012.66	0.007121
130	108105	20160104	736333	736344	11	1	1885	125.40	129.10	0.196155	2012.66	0.007121
131	108105	20160104	736333	736344	11	1	1890	120.70	124.40	0.203980	2012.66	0.007121
132	108105	20160104	736333	736344	11	1	1895	116.50	119.30	0.209911	2012.66	0.007121
133	108105	20160104	736333	736344	11	1	1900	111.40	115.00	0.211676	2012.66	0.007121
134	108105	20160104	736333	736344	11	1	1905	106.80	110.40	0.214528	2012.66	0.007121
135	108105	20160104	736333	736344	11	1	1910	102.80	105.40	0.217899	2012.66	0.007121
136	108105	20160104	736333	736344	11	1	1915	97.80	101.30	0.218560	2012.66	0.007121
137	108105	20160104	736333	736344	11	1	1920	93.90	96.40	0.220706	2012.66	0.007121
138	108105	20160104	736333	736344	11	1	1925	89.50	92.00	0.221447	2012.66	0.007121
139	108105	20160104	736333	736344	11	1	1930	84.90	88.20	0.223944	2012.66	0.007121
140	108105	20160104	736333	736344	11	1	1935	80.60	83.80	0.223046	2012.66	0.007121
141	108105	20160104	736333	736344	11	1	1940	76.40	79.50	0.222497	2012.66	0.007121
142	108105	20160104	736333	736344	11	1	1945	72.50	75.50	0.224489	2012.66	0.007121
143	108105	20160104	736333	736344	11	1	1950	68.20	71.20	0.221404	2012.66	0.007121
144	108105	20160104	736333	736344	11	1	1955	64.20	67.10	0.220221	2012.66	0.007121
145	108105	20160104	736333	736344	11	1	1960	60.00	62.90	0.216642	2012.66	0.007121
146	108105	20160104	736333	736344	11	1	1965	56.30	58.90	0.215669	2012.66	0.007121
147	108105	20160104	736333	736344	11	1	1970	52.40	55.10	0.213735	2012.66	0.007121
148	108105	20160104	736333	736344	11	1	1975	49.10	51.70	0.215254	2012.66	0.007121
149	108105	20160104	736333	736344	11	1	1980	45.40	47.70	0.211413	2012.66	0.007121
150	108105	20160104	736333	736344	11	1	1985	41.70	44.20	0.208785	2012.66	0.007121
151	108105	20160104	736333	736344	11	1	1990	38.50	40.70	0.207213	2012.66	0.007121
152	108105	20160104	736333	736344	11	1	1995	35.30	37.60	0.206186	2012.66	0.007121
153	108105	20160104	736333	736344	11	1	2000	32.30	34.30	0.204103	2012.66	0.007121
154	108105	20160104	736333	736344	11	1	2005	29.00	31.20	0.200594	2012.66	0.007121
155	108105	20160104	736333	736344	11	1	2010	26.10	28.20	0.197904	2012.66	0.007121
156	108105	20160104	736333	736344	11	1	2015	23.40	25.50	0.195975	2012.66	0.007121
157	108105	20160104	736333	736344	11	1	2020	20.60	22.40	0.190988	2012.66	0.007121
...	...	...	...	...	...	...	...	...	...	...	...	...
619782	108105	20160429	736449	736785	336	-1	2000	121.40	122.90	0.183780	2065.30	0.007088
619783	108105	20160429	736449	736785	336	-1	2025	130.40	131.90	0.179158	2065.30	0.007088
619784	108105	20160429	736449	736785	336	-1	2050	140.00	141.60	0.174541	2065.30	0.007088
619785	108105	20160429	736449	736785	336	-1	2075	150.30	151.90	0.169871	2065.30	0.007088
619786	108105	20160429	736449	736785	336	-1	2100	161.40	163.00	0.165287	2065.30	0.007088
619787	108105	20160429	736449	736785	336	-1	2125	173.20	174.90	0.160665	2065.30	0.007088
619788	108105	20160429	736449	736785	336	-1	2150	185.90	187.70	0.156147	2065.30	0.007088
619789	108105	20160429	736449	736785	336	-1	2175	199.60	201.40	0.151755	2065.30	0.007088
619790	108105	20160429	736449	736785	336	-1	2200	214.20	216.10	0.147451	2065.30	0.007088

	ticker	date	date of contract	end data of contract	maturity	call	strike	bid price	ask price	Black Scholes implied volatility	Current index level	interest rate
619791	108105	20160429	736449	736785	336	-1	2225	229.80	231.80	0.143283	2065.30	0.007088
619792	108105	20160429	736449	736785	336	-1	2250	246.40	248.50	0.139247	2065.30	0.007088
619793	108105	20160429	736449	736785	336	-1	2275	264.10	266.20	0.135450	2065.30	0.007088
619794	108105	20160429	736449	736785	336	-1	2300	282.80	285.00	0.131973	2065.30	0.007088
619795	108105	20160429	736449	736785	336	-1	2325	302.50	304.80	0.128864	2065.30	0.007088
619796	108105	20160429	736449	736785	336	-1	2350	314.90	335.30	0.128019	2065.30	0.007088
619797	108105	20160429	736449	736785	336	-1	2375	335.40	356.90	0.124828	2065.30	0.007088
619798	108105	20160429	736449	736785	336	-1	2400	357.60	376.30	0.118683	2065.30	0.007088
619799	108105	20160429	736449	736785	336	-1	2500	451.40	472.30	0.120902	2065.30	0.007088
619800	108105	20160429	736449	736785	336	-1	2600	549.00	569.50	0.125484	2065.30	0.007088
619801	108105	20160429	736449	736785	336	-1	2700	647.70	668.20	0.135071	2065.30	0.007088
619802	108105	20160429	736449	736785	336	-1	300	0.00	0.35	0.664729	2065.30	0.007088
619803	108105	20160429	736449	736785	336	-1	400	0.00	0.50	0.583398	2065.30	0.007088
619804	108105	20160429	736449	736785	336	-1	500	0.15	0.70	0.530727	2065.30	0.007088
619805	108105	20160429	736449	736785	336	-1	600	0.45	1.10	0.493649	2065.30	0.007088
619806	108105	20160429	736449	736785	336	-1	700	0.90	1.55	0.457234	2065.30	0.007088
619807	108105	20160429	736449	736785	336	-1	750	1.25	1.90	0.442646	2065.30	0.007088
619808	108105	20160429	736449	736785	336	-1	800	1.60	2.25	0.426590	2065.30	0.007088
619809	108105	20160429	736449	736785	336	-1	850	2.10	2.70	0.412802	2065.30	0.007088
619810	108105	20160429	736449	736785	336	-1	900	2.65	3.30	0.399738	2065.30	0.007088
619811	108105	20160429	736449	736785	336	-1	950	3.30	4.00	0.387017	2065.30	0.007088

528041 rows × 12 columns

Question2

In [184]:

```
df.loc[:,'Option_prices'] = df.loc[:, ['bid price','ask price']].mean(1)
```

Question3

In [185]:

```
df = df[df['Option_prices'] > 0.005]
df
```

Out[185]:

	ticker	date	date of contract	end data of contract	maturity	call	strike	bid price	ask price	Black Scholes implied volatility	Current index level	interest rate	Option_prices
128	108105	20160104	736333	736344	11	1	1875	135.30	138.20	0.149708	2012.66	0.007121	136.750
129	108105	20160104	736333	736344	11	1	1880	130.10	133.90	0.184996	2012.66	0.007121	132.000
130	108105	20160104	736333	736344	11	1	1885	125.40	129.10	0.196155	2012.66	0.007121	127.250
131	108105	20160104	736333	736344	11	1	1890	120.70	124.40	0.203980	2012.66	0.007121	122.550
132	108105	20160104	736333	736344	11	1	1895	116.50	119.30	0.209911	2012.66	0.007121	117.900
133	108105	20160104	736333	736344	11	1	1900	111.40	115.00	0.211676	2012.66	0.007121	113.200
134	108105	20160104	736333	736344	11	1	1905	106.80	110.40	0.214528	2012.66	0.007121	108.600
135	108105	20160104	736333	736344	11	1	1910	102.80	105.40	0.217899	2012.66	0.007121	104.100
136	108105	20160104	736333	736344	11	1	1915	97.80	101.30	0.218560	2012.66	0.007121	99.550
137	108105	20160104	736333	736344	11	1	1920	93.90	96.40	0.220706	2012.66	0.007121	95.150
138	108105	20160104	736333	736344	11	1	1925	89.50	92.00	0.221447	2012.66	0.007121	90.750

	ticker	date	date of contract	end data of contract	maturity	call	strike	bid price	ask price	Black Scholes implied volatility	Current index level	interest rate	Option_prices
139	108105	20160104	736333	736344	11	1	1930	84.90	88.20	0.223944	2012.66	0.007121	86.550
140	108105	20160104	736333	736344	11	1	1935	80.60	83.80	0.223046	2012.66	0.007121	82.200
141	108105	20160104	736333	736344	11	1	1940	76.40	79.50	0.222497	2012.66	0.007121	77.950
142	108105	20160104	736333	736344	11	1	1945	72.50	75.50	0.224489	2012.66	0.007121	74.000
143	108105	20160104	736333	736344	11	1	1950	68.20	71.20	0.221404	2012.66	0.007121	69.700
144	108105	20160104	736333	736344	11	1	1955	64.20	67.10	0.220221	2012.66	0.007121	65.650
145	108105	20160104	736333	736344	11	1	1960	60.00	62.90	0.216642	2012.66	0.007121	61.450
146	108105	20160104	736333	736344	11	1	1965	56.30	58.90	0.215669	2012.66	0.007121	57.600
147	108105	20160104	736333	736344	11	1	1970	52.40	55.10	0.213735	2012.66	0.007121	53.750
148	108105	20160104	736333	736344	11	1	1975	49.10	51.70	0.215254	2012.66	0.007121	50.400
149	108105	20160104	736333	736344	11	1	1980	45.40	47.70	0.211413	2012.66	0.007121	46.550
150	108105	20160104	736333	736344	11	1	1985	41.70	44.20	0.208785	2012.66	0.007121	42.950
151	108105	20160104	736333	736344	11	1	1990	38.50	40.70	0.207213	2012.66	0.007121	39.600
152	108105	20160104	736333	736344	11	1	1995	35.30	37.60	0.206186	2012.66	0.007121	36.450
153	108105	20160104	736333	736344	11	1	2000	32.30	34.30	0.204103	2012.66	0.007121	33.300
154	108105	20160104	736333	736344	11	1	2005	29.00	31.20	0.200594	2012.66	0.007121	30.100
155	108105	20160104	736333	736344	11	1	2010	26.10	28.20	0.197904	2012.66	0.007121	27.150
156	108105	20160104	736333	736344	11	1	2015	23.40	25.50	0.195975	2012.66	0.007121	24.450
157	108105	20160104	736333	736344	11	1	2020	20.60	22.40	0.190988	2012.66	0.007121	21.500
...	...	...	...	...	...	...	...	...	...	...	...	...	...
619782	108105	20160429	736449	736785	336	-1	2000	121.40	122.90	0.183780	2065.30	0.007088	122.150
619783	108105	20160429	736449	736785	336	-1	2025	130.40	131.90	0.179158	2065.30	0.007088	131.150
619784	108105	20160429	736449	736785	336	-1	2050	140.00	141.60	0.174541	2065.30	0.007088	140.800
619785	108105	20160429	736449	736785	336	-1	2075	150.30	151.90	0.169871	2065.30	0.007088	151.100
619786	108105	20160429	736449	736785	336	-1	2100	161.40	163.00	0.165287	2065.30	0.007088	162.200
619787	108105	20160429	736449	736785	336	-1	2125	173.20	174.90	0.160665	2065.30	0.007088	174.050
619788	108105	20160429	736449	736785	336	-1	2150	185.90	187.70	0.156147	2065.30	0.007088	186.800
619789	108105	20160429	736449	736785	336	-1	2175	199.60	201.40	0.151755	2065.30	0.007088	200.500
619790	108105	20160429	736449	736785	336	-1	2200	214.20	216.10	0.147451	2065.30	0.007088	215.150
619791	108105	20160429	736449	736785	336	-1	2225	229.80	231.80	0.143283	2065.30	0.007088	230.800
619792	108105	20160429	736449	736785	336	-1	2250	246.40	248.50	0.139247	2065.30	0.007088	247.450
619793	108105	20160429	736449	736785	336	-1	2275	264.10	266.20	0.135450	2065.30	0.007088	265.150
619794	108105	20160429	736449	736785	336	-1	2300	282.80	285.00	0.131973	2065.30	0.007088	283.900
619795	108105	20160429	736449	736785	336	-1	2325	302.50	304.80	0.128864	2065.30	0.007088	303.650
619796	108105	20160429	736449	736785	336	-1	2350	314.90	335.30	0.128019	2065.30	0.007088	325.100
619797	108105	20160429	736449	736785	336	-1	2375	335.40	356.90	0.124828	2065.30	0.007088	346.150
619798	108105	20160429	736449	736785	336	-1	2400	357.60	376.30	0.118683	2065.30	0.007088	366.950
619799	108105	20160429	736449	736785	336	-1	2500	451.40	472.30	0.120902	2065.30	0.007088	461.850
619800	108105	20160429	736449	736785	336	-1	2600	549.00	569.50	0.125484	2065.30	0.007088	559.250
619801	108105	20160429	736449	736785	336	-1	2700	647.70	668.20	0.135071	2065.30	0.007088	657.950
619802	108105	20160429	736449	736785	336	-1	300	0.00	0.35	0.664729	2065.30	0.007088	0.175
619803	108105	20160429	736449	736785	336	-1	400	0.00	0.50	0.583398	2065.30	0.007088	0.250
619804	108105	20160429	736449	736785	336	-1	500	0.15	0.70	0.530727	2065.30	0.007088	0.425
619805	108105	20160429	736449	736785	336	-1	600	0.45	1.10	0.493649	2065.30	0.007088	0.775
619806	108105	20160429	736449	736785	336	-1	700	0.90	1.55	0.457234	2065.30	0.007088	1.225
619807	108105	20160429	736449	736785	336	-1	750	1.25	1.90	0.442646	2065.30	0.007088	1.575
619808	108105	20160429	736449	736785	336	-1	800	1.60	2.25	0.426590	2065.30	0.007088	1.925
619809	108105	20160429	736449	736785	336	-1	850	2.10	2.70	0.412802	2065.30	0.007088	2.400
619810	108105	20160429	736449	736785	336	-1	900	2.65	3.30	0.399738	2065.30	0.007088	2.975
619811	108105	20160429	736449	736785	336	-1	950	3.30	4.00	0.387017	2065.30	0.007088	3.650

528041 rows × 13 columns

Question4

In [186]:

```
#We compare the columns Current index level and strike.
#When the current index level is under the strike we are out the money
df.loc[:,'Out_the_Money'] = df.loc[:,'Current index level'].lt(df.loc[:,'strike'])
df = df[df['Out_the_Money'] == True]
df
```

Out[186]:

	ticker	date	date of contract	end data of contract	maturity	call	strike	bid price	ask price	Black Scholes implied volatility	Current index level	interest rate	Option_prices	Out_th
156	108105	20160104	736333	736344	11	1	2015	23.40	25.50	0.195975	2012.66	0.007121	24.450	
157	108105	20160104	736333	736344	11	1	2020	20.60	22.40	0.190988	2012.66	0.007121	21.500	
158	108105	20160104	736333	736344	11	1	2025	18.10	20.00	0.188562	2012.66	0.007121	19.050	
159	108105	20160104	736333	736344	11	1	2030	15.90	17.70	0.186419	2012.66	0.007121	16.800	
160	108105	20160104	736333	736344	11	1	2035	13.80	15.60	0.184163	2012.66	0.007121	14.700	
161	108105	20160104	736333	736344	11	1	2040	11.80	13.60	0.181361	2012.66	0.007121	12.700	
162	108105	20160104	736333	736344	11	1	2045	10.00	11.80	0.178812	2012.66	0.007121	10.900	
163	108105	20160104	736333	736344	11	1	2050	8.40	9.80	0.174723	2012.66	0.007121	9.100	
164	108105	20160104	736333	736344	11	1	2055	6.90	8.40	0.172245	2012.66	0.007121	7.650	
165	108105	20160104	736333	736344	11	1	2060	5.70	7.20	0.170714	2012.66	0.007121	6.450	
166	108105	20160104	736333	736344	11	1	2065	4.60	5.90	0.167563	2012.66	0.007121	5.250	
167	108105	20160104	736333	736344	11	1	2070	3.70	4.90	0.165582	2012.66	0.007121	4.300	
168	108105	20160104	736333	736344	11	1	2075	2.90	3.70	0.160997	2012.66	0.007121	3.300	
169	108105	20160104	736333	736344	11	1	2080	2.20	3.30	0.161095	2012.66	0.007121	2.750	
170	108105	20160104	736333	736344	11	1	2085	1.65	2.75	0.159737	2012.66	0.007121	2.200	
171	108105	20160104	736333	736344	11	1	2090	1.25	4.40	0.178823	2012.66	0.007121	2.825	
172	108105	20160104	736333	736344	11	1	2095	0.95	2.75	0.168266	2012.66	0.007121	1.850	
173	108105	20160104	736333	736344	11	1	2100	0.75	1.50	0.157838	2012.66	0.007121	1.125	
174	108105	20160104	736333	736344	11	1	2105	0.50	2.10	0.169665	2012.66	0.007121	1.300	
175	108105	20160104	736333	736344	11	1	2110	0.50	1.65	0.170052	2012.66	0.007121	1.075	
176	108105	20160104	736333	736344	11	1	2115	0.25	0.95	0.159144	2012.66	0.007121	0.600	
177	108105	20160104	736333	736344	11	1	2120	0.15	0.65	0.154981	2012.66	0.007121	0.400	
178	108105	20160104	736333	736344	11	1	2125	0.20	0.60	0.160838	2012.66	0.007121	0.400	
179	108105	20160104	736333	736344	11	1	2130	0.05	0.75	0.166652	2012.66	0.007121	0.400	
180	108105	20160104	736333	736344	11	1	2135	0.25	0.35	0.165407	2012.66	0.007121	0.300	
181	108105	20160104	736333	736344	11	1	2140	0.15	0.30	0.164432	2012.66	0.007121	0.225	
182	108105	20160104	736333	736344	11	1	2145	0.05	0.25	0.161336	2012.66	0.007121	0.150	
183	108105	20160104	736333	736344	11	1	2150	0.15	0.20	0.169615	2012.66	0.007121	0.175	
184	108105	20160104	736333	736344	11	1	2155	0.05	0.25	0.171533	2012.66	0.007121	0.150	
185	108105	20160104	736333	736344	11	1	2160	0.10	0.15	0.172854	2012.66	0.007121	0.125	
...	...	...	...	...	...	...	...	...	...	...	...	...	...	
619719	108105	20160429	736449	736785	336	1	2175	63.30	64.60	0.149667	2065.30	0.007088	63.950	
619720	108105	20160429	736449	736785	336	1	2200	53.10	54.30	0.145166	2065.30	0.007088	53.700	
619721	108105	20160429	736449	736785	336	1	2225	43.90	45.10	0.140834	2065.30	0.007088	44.500	
619722	108105	20160429	736449	736785	336	1	2250	35.80	37.00	0.136751	2065.30	0.007088	36.400	
619723	108105	20160429	736449	736785	336	1	2275	28.80	29.80	0.132787	2065.30	0.007088	29.300	

	ticker	date	date of contract	end data of contract	maturity	call	strike	bid price	ask price	Black Scholes implied volatility	Current index level	interest rate	Option_prices	Out_th
619724	108105	20160429	736449	736785	336	1	2300	22.70	23.70	0.125693	2065.30	0.007088	23.200	
619725	108105	20160429	736449	736785	336	1	2325	17.70	18.60	0.125590	2065.30	0.007088	18.150	
619726	108105	20160429	736449	736785	336	1	2350	13.50	14.40	0.122337	2065.30	0.007088	13.950	
619727	108105	20160429	736449	736785	336	1	2375	10.20	11.10	0.119603	2065.30	0.007088	10.650	
619728	108105	20160429	736449	736785	336	1	2400	7.70	8.40	0.117197	2065.30	0.007088	8.050	
619729	108105	20160429	736449	736785	336	1	2500	2.35	2.95	0.111940	2065.30	0.007088	2.650	
619730	108105	20160429	736449	736785	336	1	2600	0.80	1.40	0.113541	2065.30	0.007088	1.100	
619731	108105	20160429	736449	736785	336	1	2700	0.25	0.95	0.119097	2065.30	0.007088	0.600	
619785	108105	20160429	736449	736785	336	-1	2075	150.30	151.90	0.169871	2065.30	0.007088	151.100	
619786	108105	20160429	736449	736785	336	-1	2100	161.40	163.00	0.165287	2065.30	0.007088	162.200	
619787	108105	20160429	736449	736785	336	-1	2125	173.20	174.90	0.160665	2065.30	0.007088	174.050	
619788	108105	20160429	736449	736785	336	-1	2150	185.90	187.70	0.156147	2065.30	0.007088	186.800	
619789	108105	20160429	736449	736785	336	-1	2175	199.60	201.40	0.151755	2065.30	0.007088	200.500	
619790	108105	20160429	736449	736785	336	-1	2200	214.20	216.10	0.147451	2065.30	0.007088	215.150	
619791	108105	20160429	736449	736785	336	-1	2225	229.80	231.80	0.143283	2065.30	0.007088	230.800	
619792	108105	20160429	736449	736785	336	-1	2250	246.40	248.50	0.139247	2065.30	0.007088	247.450	
619793	108105	20160429	736449	736785	336	-1	2275	264.10	266.20	0.135450	2065.30	0.007088	265.150	
619794	108105	20160429	736449	736785	336	-1	2300	282.80	285.00	0.131973	2065.30	0.007088	283.900	
619795	108105	20160429	736449	736785	336	-1	2325	302.50	304.80	0.128864	2065.30	0.007088	303.650	
619796	108105	20160429	736449	736785	336	-1	2350	314.90	335.30	0.128019	2065.30	0.007088	325.100	
619797	108105	20160429	736449	736785	336	-1	2375	335.40	356.90	0.124828	2065.30	0.007088	346.150	
619798	108105	20160429	736449	736785	336	-1	2400	357.60	376.30	0.118683	2065.30	0.007088	366.950	
619799	108105	20160429	736449	736785	336	-1	2500	451.40	472.30	0.120902	2065.30	0.007088	461.850	
619800	108105	20160429	736449	736785	336	-1	2600	549.00	569.50	0.125484	2065.30	0.007088	559.250	
619801	108105	20160429	736449	736785	336	-1	2700	647.70	668.20	0.135071	2065.30	0.007088	657.950	

165224 rows × 14 columns

Question5

In [187]:

```
%run RiskNeutralVolatilitySkewKurt_JVKR_3.ipynb
```

In [188]:

```
Kvector = [90, 95, 100, 105, 110];
IVvector= [.2, .16, .12, .07, .05];
S0 = 100
r = 0.07
T = 30 / 365
```

In [189]:

```
Data=RiskNeutralVolatilitySkewKurt_JVKR(Kvector, IVvector, S0, T, r)
```

In [190]:

```
colnames=["vol","skew","kurt"]
rownames=["Value"]
pd.DataFrame(Data, colnames,rownames)
```

Out[190]:

	Value
vol	0.125560

	Value
skew	-1.636387
kurt	6.777459

In [ ]:

```
dfVolatility = pd.DataFrame(columns =['date', 'maturity', 'volatility'])
uniqueDate = pd.unique(df['date'])
for date in uniqueDate:
    data = df.loc[df['date']==date,:]
    data = data.loc[data['call']==1,:]
    uniqueMaturity = pd.unique(data['maturity'])
    r = data['interest rate'].iloc[0]
    for maturity in uniqueMaturity:
        dataMaturity = data.loc[data['maturity']==maturity,:]
        T = maturity
        S0 = dataMaturity['Current index level'].iloc[0]
        Kvector = np.array(dataMaturity['strike'])
        IVvector = np.array(dataMaturity['Black Scholes implied volatility'])
        volatility = RiskNeutralVolatilitySkewKurt_JVKR(Kvector, IVvector, S0, T, r)[0]
        dfVolatility.loc[len(dfVolatility)] = [date, maturity, volatility]
```

In [193]:

```
dfVolatility
```

Out[193]:

	date	maturity	volatility
0	20160104.0	11.0	0.238559
1	20160104.0	46.0	0.155439
2	20160104.0	74.0	0.140036
3	20160104.0	102.0	0.123794
4	20160104.0	165.0	0.100083
5	20160104.0	256.0	0.073744
6	20160104.0	347.0	0.058081
7	20160104.0	382.0	0.053610
8	20160104.0	529.0	0.040796
9	20160104.0	711.0	0.032839
10	20160104.0	1082.0	0.025796
11	20160104.0	4.0	0.327603
12	20160104.0	18.0	0.183002
13	20160104.0	25.0	0.178980
14	20160104.0	32.0	0.168586
15	20160104.0	39.0	0.159701
16	20160104.0	53.0	0.148517
17	20160104.0	56.0	0.144918
18	20160104.0	60.0	0.145559
19	20160104.0	67.0	0.139891
20	20160104.0	80.0	0.135072
21	20160104.0	87.0	0.132380
22	20160104.0	116.0	0.119164
23	20160104.0	148.0	0.104598
24	20160104.0	178.0	0.094996
25	20160104.0	270.0	0.071187
26	20160104.0	361.0	0.056068
27	20160105.0	10.0	0.237456
28	20160105.0	45.0	0.151560

	date	maturity	volatility
29	20160105.0	73.0	0.137539
...	...	...	...
2250	20160428.0	246.0	0.069528
2251	20160428.0	337.0	0.056577
2252	20160429.0	21.0	0.138949
2253	20160429.0	49.0	0.127479
2254	20160429.0	77.0	0.111609
2255	20160429.0	112.0	0.102224
2256	20160429.0	140.0	0.094717
2257	20160429.0	231.0	0.075400
2258	20160429.0	266.0	0.068684
2259	20160429.0	322.0	0.059861
2260	20160429.0	413.0	0.049318
2261	20160429.0	595.0	0.037039
2262	20160429.0	966.0	0.027395
2263	20160429.0	5.0	0.172374
2264	20160429.0	7.0	0.191028
2265	20160429.0	12.0	0.136727
2266	20160429.0	14.0	0.149818
2267	20160429.0	19.0	0.123440
2268	20160429.0	28.0	0.135193
2269	20160429.0	32.0	0.130665
2270	20160429.0	35.0	0.127519
2271	20160429.0	42.0	0.121177
2272	20160429.0	56.0	0.119544
2273	20160429.0	62.0	0.120529
2274	20160429.0	63.0	0.119450
2275	20160429.0	91.0	0.109685
2276	20160429.0	124.0	0.098538
2277	20160429.0	154.0	0.093089
2278	20160429.0	245.0	0.072172
2279	20160429.0	336.0	0.057912

2280 rows × 3 columns

Question6

In [213]:

```
from scipy.interpolate import interp1d
from math import *
```

In [196]:

```
df30days = dfVolatility.loc[dfVolatility['maturity']==30,:]
df30days
```

Out[196]:

	date	maturity	volatility
68	20160106.0	30.0	0.178315
203	20160113.0	30.0	0.219870
295	20160120.0	30.0	0.241576
444	20160127.0	30.0	0.192939

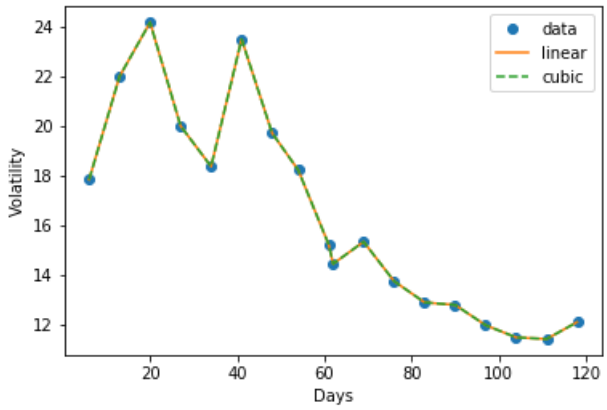
	date	maturity	volatility
444	20160127.0	30.0	0.199939
578	20160203.0	30.0	0.183618
713	20160210.0	30.0	0.234848
807	20160217.0	30.0	0.197081
927	20160223.0	30.0	0.182176
1065	20160301.0	30.0	0.152164
1094	20160302.0	30.0	0.144465
1234	20160309.0	30.0	0.153356
1359	20160316.0	30.0	0.137467
1516	20160323.0	30.0	0.128946
1634	20160330.0	30.0	0.127950
1779	20160406.0	30.0	0.119786
1924	20160413.0	30.0	0.114868
2050	20160420.0	30.0	0.114241
2212	20160427.0	30.0	0.121037

In [228]:

```
xdate = df30days['date']
x=[]
for i in xdate:
    date = i -20160000
    mois = floor(date /100)
    jour = date - mois *100
    if(mois == 1):
        x.append(jour)
    elif(mois == 2):
        x.append(jour+31)
    elif(mois == 3):
        x.append(jour+60)
    else:
        x.append(jour+91)
y = df30days['volatility']*100
f = interp1d(x, y)
f2 = interp1d(x, y, kind='cubic')
```

In [229]:

```
import matplotlib.pyplot as plt
plt.plot(x, y, 'o', x, f(x), '-', x, f2(x), '--')
plt.legend(['data', 'linear', 'cubic'], loc='best')
plt.xlabel('Days')
plt.ylabel('Volatility')
plt.show()
```



Question7

In [152]:

In [152]:

```
#Import data
VIX = DataReader("^VIX",  "yahoo", datetime(2016,1,1), datetime(2016,4,1))
VIX
```

Out[152]:

Date	High	Low	Open	Close	Volume	Adj Close
2016-01-04	23.360001	20.670000	22.480000	20.700001	0	20.700001
2016-01-05	21.059999	19.250000	20.750000	19.340000	0	19.340000
2016-01-06	21.860001	19.799999	21.670000	20.590000	0	20.590000
2016-01-07	25.860001	22.400000	23.219999	24.990000	0	24.990000
2016-01-08	27.080000	22.480000	22.959999	27.010000	0	27.010000
2016-01-11	27.389999	23.830000	25.580000	24.299999	0	24.299999
2016-01-12	23.930000	21.910000	22.969999	22.469999	0	22.469999
2016-01-13	26.110001	21.440001	21.719999	25.219999	0	25.219999
2016-01-14	26.280001	23.070000	24.750000	23.950001	0	23.950001
2016-01-15	30.950001	26.670000	28.959999	27.020000	0	27.020000
2016-01-19	27.590000	25.209999	25.400000	26.049999	0	26.049999
2016-01-20	32.090000	26.590000	27.780001	27.590000	0	27.590000
2016-01-21	28.430000	25.010000	27.790001	26.690001	0	26.690001
2016-01-22	24.549999	22.219999	24.209999	22.340000	0	22.340000
2016-01-25	24.309999	22.379999	23.299999	24.150000	0	24.150000
2016-01-26	24.020000	22.330000	23.750000	22.500000	0	22.500000
2016-01-27	27.219999	20.420000	22.879999	23.110001	0	23.110001
2016-01-28	23.809999	21.900000	22.150000	22.420000	0	22.420000
2016-01-29	21.740000	19.500000	21.590000	20.200001	0	20.200001
2016-02-01	23.660000	19.610001	21.320000	19.980000	0	19.980000
2016-02-02	22.420000	21.059999	21.340000	21.980000	0	21.980000
2016-02-03	27.700001	21.420000	21.490000	21.650000	0	21.650000
2016-02-04	23.139999	21.240000	22.290001	21.840000	0	21.840000
2016-02-05	24.110001	21.910000	22.090000	23.379999	0	23.379999
2016-02-08	27.719999	25.559999	25.889999	26.000000	0	26.000000
2016-02-09	28.309999	25.990000	28.299999	26.540001	0	26.540001
2016-02-10	26.600000	24.469999	25.750000	26.290001	0	26.290001
2016-02-11	30.900000	26.670000	29.010000	28.139999	0	28.139999
2016-02-12	27.570000	24.920000	27.160000	25.400000	0	25.400000
2016-02-16	25.520000	23.320000	24.959999	24.110001	0	24.110001
...	...	...	...	...	...	...
2016-02-19	23.440001	20.520000	22.389999	20.530001	0	20.530001
2016-02-22	20.350000	19.020000	20.139999	19.379999	0	19.379999
2016-02-23	21.160000	19.540001	19.750000	20.980000	0	20.980000
2016-02-24	22.870001	20.260000	22.280001	20.719999	0	20.719999
2016-02-25	21.260000	19.100000	20.540001	19.110001	0	19.110001
2016-02-26	20.129999	18.459999	18.889999	19.809999	0	19.809999
2016-02-29	20.809999	18.379999	20.490000	20.549999	0	20.549999
2016-03-01	20.170000	17.660000	19.840000	17.700001	0	17.700001
2016-03-02	18.410000	16.780001	17.980000	17.090000	0	17.090000
2016-03-03	17.559999	16.320000	17.250000	16.700001	0	16.700001
2016-03-04	17.350000	16.049999	16.480000	16.860001	0	16.860001
2016-03-07	18.040001	16.870001	17.980000	17.350000	0	17.350000

Date	High	Low	Open	Close	Volume	Adj Close
2016-03-08	18.889999	17.820000	18.379999	18.670000	0	18.670000
2016-03-09	19.110001	18.309999	18.559999	18.340000	0	18.340000
2016-03-10	19.590000	17.059999	18.170000	18.049999	0	18.049999
2016-03-11	17.270000	16.280001	17.090000	16.500000	0	16.500000
2016-03-14	17.670000	16.690001	17.010000	16.920000	0	16.920000
2016-03-15	17.850000	16.840000	17.600000	16.840000	0	16.840000
2016-03-16	16.330000	14.890000	15.960000	14.990000	0	14.990000
2016-03-17	15.380000	13.820000	15.340000	14.440000	0	14.440000
2016-03-18	14.360000	13.750000	14.050000	14.020000	0	14.020000
2016-03-21	14.730000	13.790000	14.570000	13.790000	0	13.790000
2016-03-22	14.760000	13.750000	14.570000	14.170000	0	14.170000
2016-03-23	15.030000	14.330000	14.570000	14.940000	0	14.940000
2016-03-24	16.440001	14.710000	16.299999	14.740000	0	14.740000
2016-03-28	16.040001	14.890000	15.650000	15.240000	0	15.240000
2016-03-29	15.890000	13.790000	15.740000	13.820000	0	13.820000
2016-03-30	13.890000	13.060000	13.690000	13.560000	0	13.560000
2016-03-31	14.280000	13.490000	13.730000	13.950000	0	13.950000
2016-04-01	15.280000	13.000000	15.230000	13.100000	0	13.100000

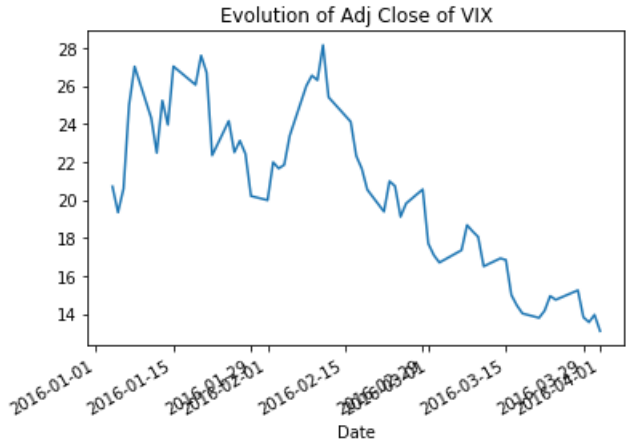
62 rows × 6 columns

In [159]:

```
VIX['Adj Close'].plot(x='date',y='Adj Close', title = 'Evolution of Adj Close of VIX')
```

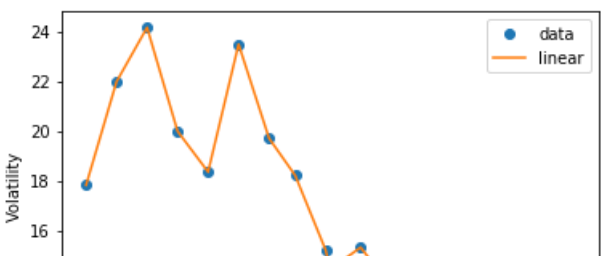
Out[159]:

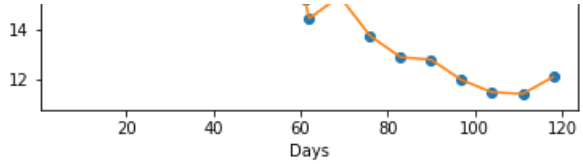
```
<matplotlib.axes._subplots.AxesSubplot at 0x24395725f98>
```



In [231]:

```
plt.plot(x, y, 'o', x, f(x))
plt.legend(['data', 'linear'], loc='best')
plt.xlabel('Days')
plt.ylabel('Volatility')
plt.show()
```





In [257]:

```
xnewdate = []
for i in VIX.reset_index()['Date']:
    if(i.month == 1 & i.day>=6):
        xnewdate.append(i.day)
    elif(i.month == 2):
        xnewdate.append(i.day+31)
    elif(i.month == 3):
        xnewdate.append(i.day+60)
    elif(i.month == 4 & i.day<=28):
        xnewdate.append(i.day+91)
```

In [258]:

```
yPred = f(xnewdate)
```

In [259]:

```
np.correlate(np.array(VIX['Adj Close']),yPred)
```

Out[259]:

```
array([16036.05433177, 15994.86034383, 15989.95915782, 15970.58340686,
       15857.21002584, 15695.67903297, 15565.18983371, 15479.98717942,
       15343.2106896 , 15214.15422672, 15017.31119078, 14839.46854553,
       14625.5016337 , 14434.33202841, 14341.53416262, 14216.18932594,
       14128.27528588, 14006.86629895, 13889.55728286, 13803.49609211,
       13696.71286694])
```

We have similar graphs.