Ad-hoc analysis on derivatives of Volatility Index

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1 Goal

The goal of the exercise is to determine how the VIX futures curve behaves in market selloffs (a market selloff is when the SPX 500 Index drops in value)
The exercise will take into account the following two models.
Model 1 - Behavior of the VIX Index vs Behavior of the SPX index.
Model 2 - Behavior of the VIX futures price movements vs. VIX index levels.

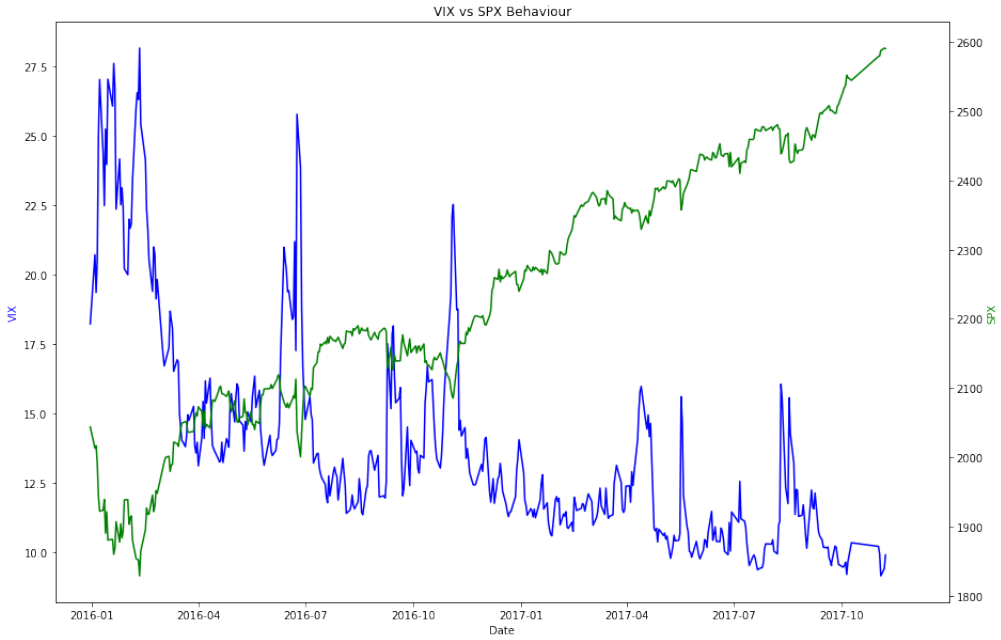
2 Experiment

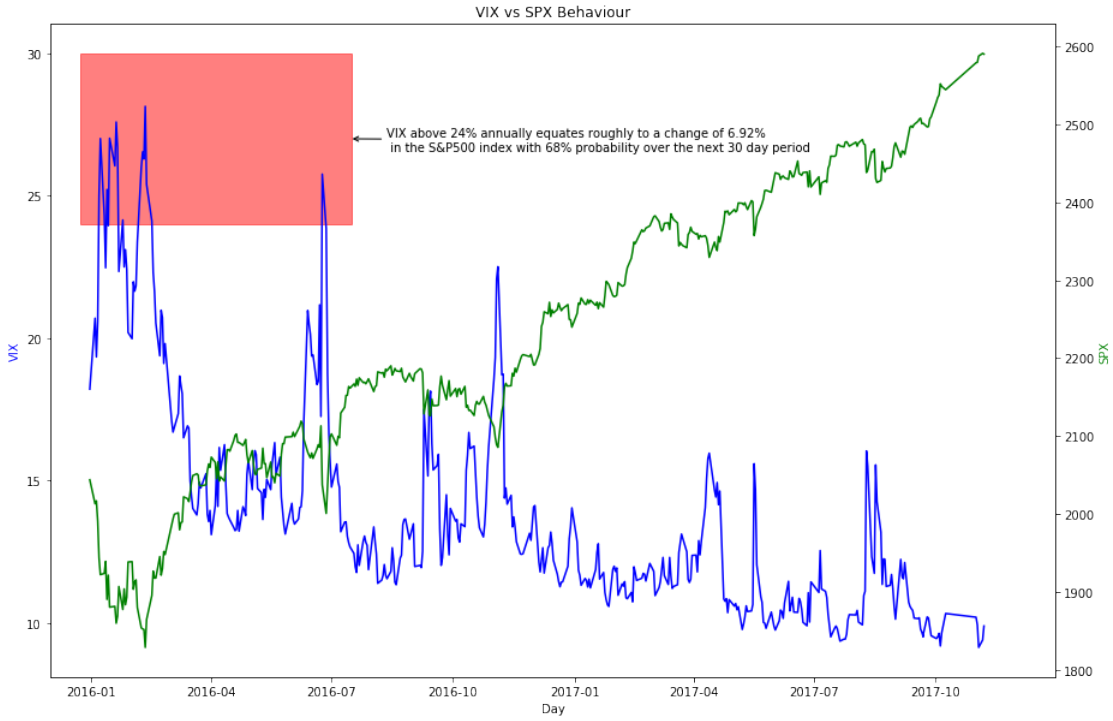
First, the data is loaded and pre-processed to transform it into a structured form. Then, we study the behaviour of SPX and VIX and how they are correlated with each other. We continue with studying the VIX behaviour by plotting its 50 day moving average. After this, we observe the changes in VIX because of the drop and rise of the S&P values and in what time frame. Then, we observe the relative movement of VIX Futures and how they perform during selloff. The analysis are validated through plots and charts and finally conclusions are stated.

3 Results and Conclusions

3.1 VIX vs SPX model

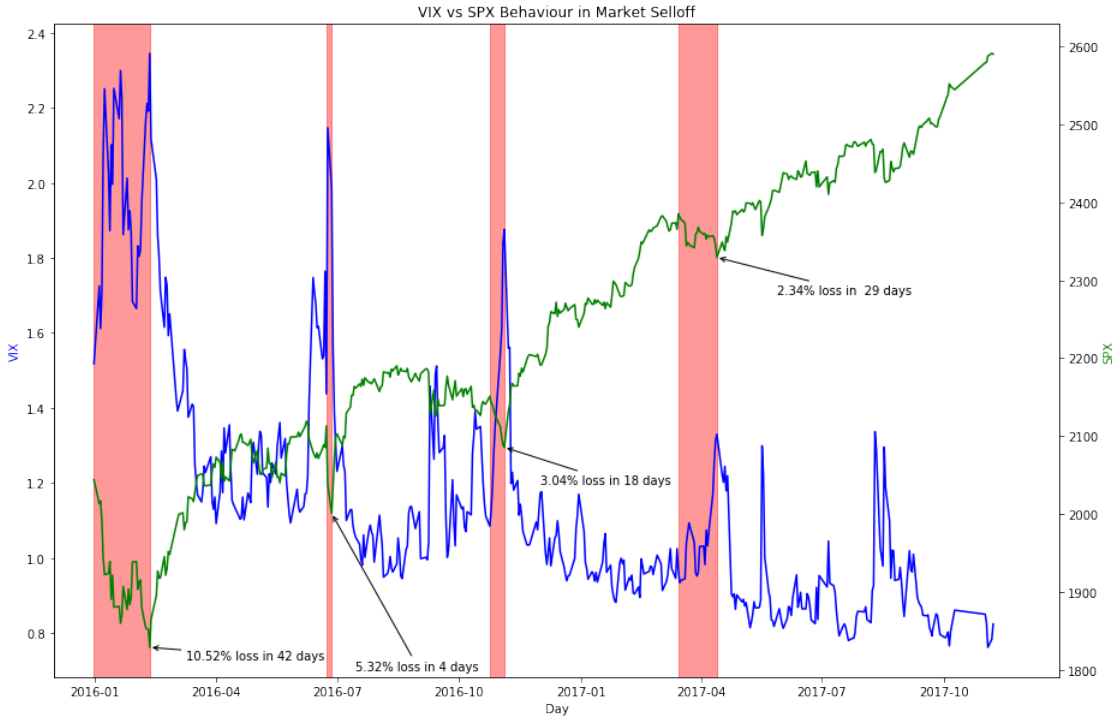
1. VIX is quoted in percentage points and translated very roughly into the expected change in the S&P500 index over the next 30 day period (and then annualized)
   For example, if the VIX is 15, this represents an expected annualized change of 15% in the S&P500 index which equates to a 4.33% change up or down for the S&P500 index over the next 30 day period.
   As you can see from the figure below, VIX above 24% annually equates roughly to a change greater than 6.92% in the S&P500 index over the next 30 day period.


VIX vs SPX Behaviour
VIX
SPX
Date
2016-01
2016-04
2016-07
2016-10
2017-01
2017-04
2017-07
2017-10

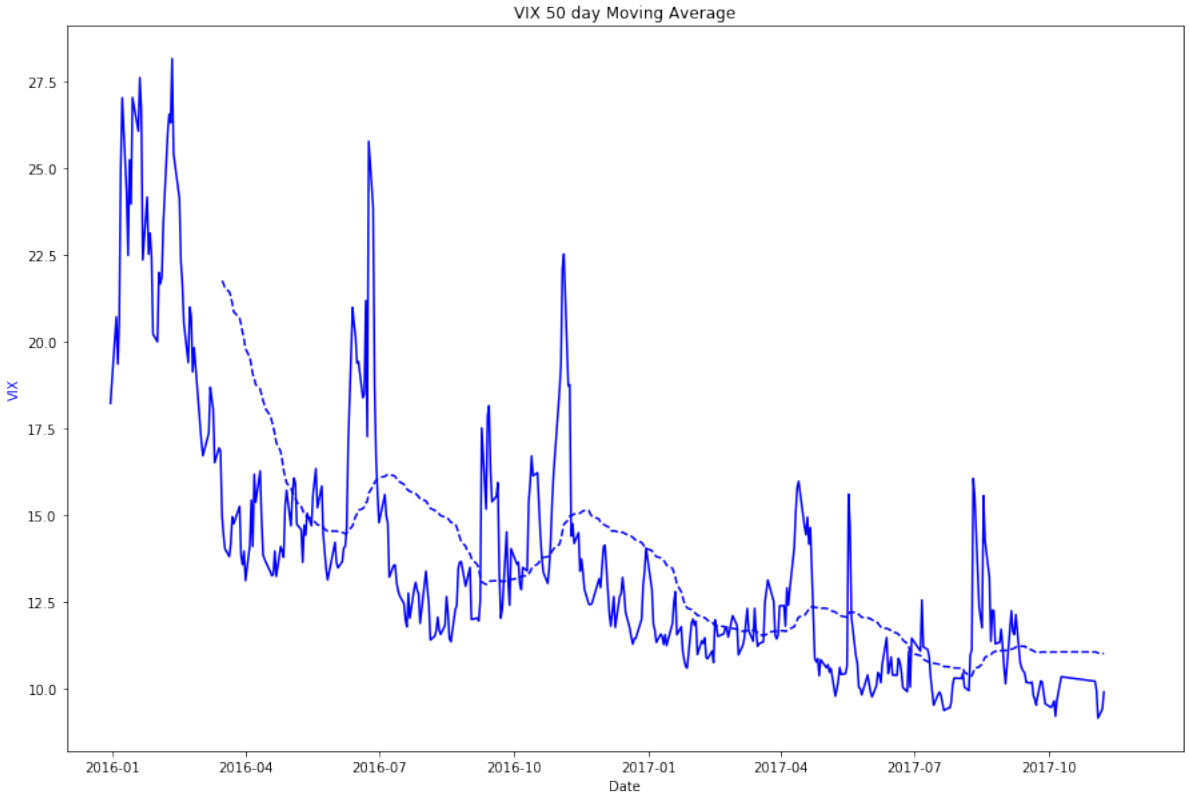

VIX vs SPX Behaviour
VIX above 24% annually equates roughly to a change of 6.92%
in the S&P500 index with 68% probability over the next 30 day period
VIX
SPX
Day
2016-01
2016-04
2016-07
2016-10
2017-01
2017-04
2017-07
2017-10

2. Correlation of daily percentage moves of the VIX index and S&P500 came out to be -0.819 when calculated on the entire available data of two years (2016-2017).
   Correlation of close to -0.819 means there is a strong negative relationship between SPX and VIX because they move in opposite directions.
   The relationship is negative because, as one variable increases, the other variable decreases.

3. VIX spikes higher during periods of selloff when S&P500 drops in value, largely reflecting the panic demand for puts.
   VIX stays normal when there is a gradual increase in S&P index and there is less need for people to purchase puts.
   As you can see from the figure below, there are VIX spikes in regions marked as red which signifies there is panic in the market during the selloff phase because of sharp decrease in the S&P500 levels.



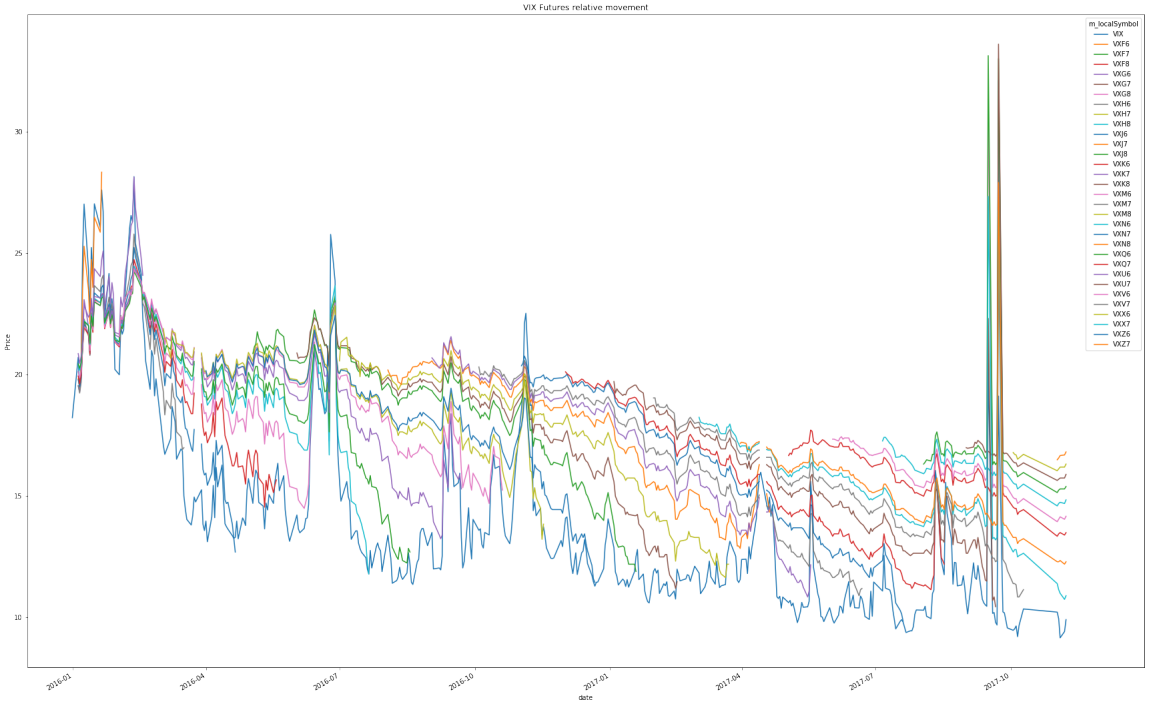
4. The VIX value moves up and down around the average most of the times and therefore it is called as a mean-reverting asset.
   The plot below depicts the VIX index moving close to the 50 day average and it it will move closer for less number of days averages.

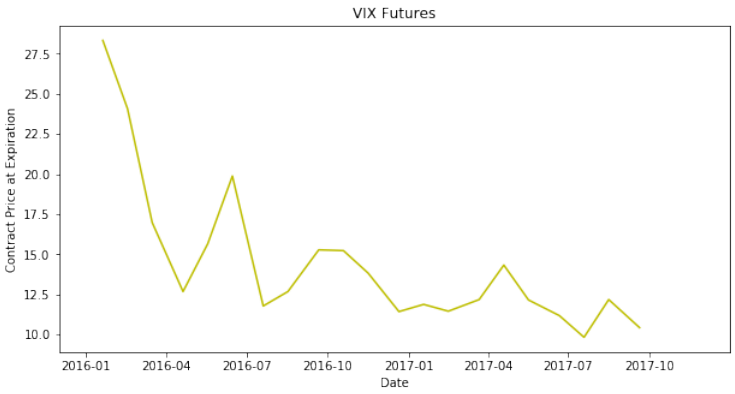


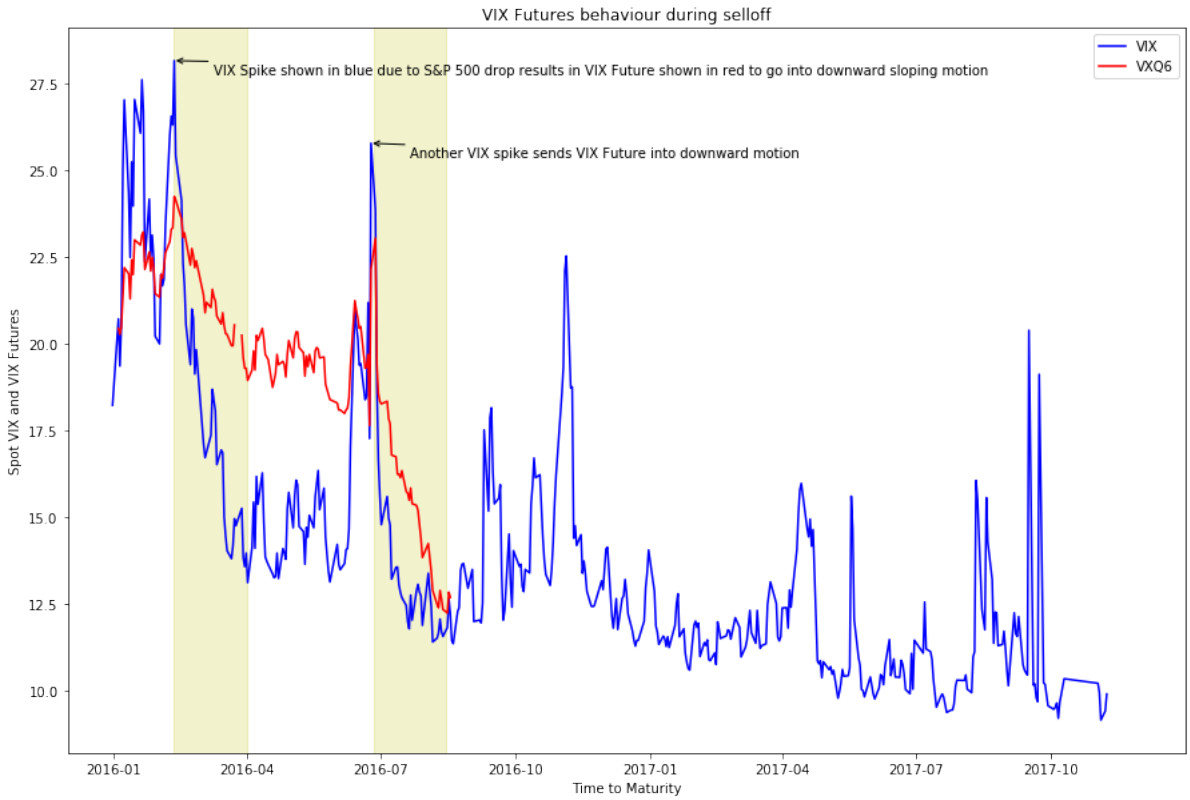
3.2 VIX Futures movement during selloff

1. When a futures curve is upward sloping from left to right, it is called contango. In case of the VIX, it is when near term VIX futures are cheaper than longer term VIX futures.
   The opposite situation, when near term futures are more expensive and futures curve is downward sloping, is called backwardation.

2. The plot below compares the relative movement of VIX Futures contracts and how they behave in the future with changes in the spot VIX value.







3. When there is a selloff or when S&P500 drops in value, VIX spikes as the report stated earlier and as a result, the VIX Futures curve will go into a downward sloping motion. This is shown in the figure above where VIX spikes and therefore VIX Futures go into backwardation. So, this behaviour can be interpreted in a way that market expects the VIX index to decrease from its current level going forward.
   Otherwise, VIX futures remain in contango for most of the time and the S&P500 tends to have positive performance.

4. The market can expect implied volatility to increase over the next few months if VIX futures are trading at a premium to the VIX index. Such an increase may result from a decline in the S&P 500 index.
   The market can expect implied volatility to decrease over the next few months when these futures contracts trade at a discount to the VIX index. Such a decrease may result from a rise in the S&P 500 index.

5. This interpretation is derived from the way prices of VIX futures contracts are set in the market and from the negative correlation relationship of the S&P 500 index and the VIX index.

6. The marketplace standpoint of the direction of implied volatility of SPX options is determined through the anticipatory nature of the prices of VIX futures contracts.