**VIX analysis on SPX Index**

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In the field of investment, VIX is known as the “fear Index”. The purpose of the report is to carry out an analysis on VIX and establish if VIX can predict forward returns on SPX Index.

The analysis is split into the following five sections:

* Level of VIX Index
* Level of VIX Index with momentum
* VIX and Valuation
* VIX one-day spike
* VIX futures term structure

Each section will evaluate the respective items in order to reveal the level of explanatory power on SPX Index. The behaviour of VIX index will also be discussed throughout the report.

**A high level summary of the analysis result:**

**Level of VIX:** does not provide useful predictability of SPX’s forward return.

**Level of VIX with momentum:** is an improved model of the above. The VIX level of [22,28] along with an uptrending VIX indicates an average of -3.5% of forward 12 months return.

**VIX and Valuation:** we have constructed the factor score, which is a blended score of the VIX and valuation factors. The current score has reached the highest level that has never been seen before. The second highest score has appeared in 1999.

**VIX one-day spike:**  is only a short-lived phenomenon and does not provide predictability of long-term crisis. However, it can be used as a short-term mean-reversion signal to buy on SPX.

**VIX futures term structure:** has medium-term projection on market uncertainty. The trading strategy built on SPX index using VIX futures term structure performs poorly, however, the signal applies on VIX futures trading has significant outperformance with after-cost Sharpe Ratio of 1.4.

**Level of VIX Index**

Initially people will question if level of VIX can provide any insight on bear knocking down bull. We have looked at the forward 6 months and 12 months returns of SPX with respect to the VIX level and the conclusion is that VIX on its own does not provide much useful information, since all levels show positive forward returns. However we know that there were several crises in the analysed historical data since 1990.



One thing worth mentioning is that by comparing the average forward 6 months and 12 months returns, the level between [16 ~ 27] show weaker forward returns than the averages. The levels are highlighted in the above table.

**Level of VIX with momentum**

We take a step further to add the momentum of the VIX level to the analysis in order to determine uptrend / downtrend of VIX. Subsequently, we examine the forward returns with respect to both directions of trend and the level of VIX.

The trend is defined by short term exponential moving average (ST\_EMA) crossing long term exponential moving average (LT\_EMA). Uptrend is defined when ST\_EMA crossing above LT\_EMA and downtrend is defined when ST\_EMA crossing below LT\_EMA. Based on our “big data tuning engine”, we define the optimal short-term and long-term EMA parameters as 21 and 250 days respectively.

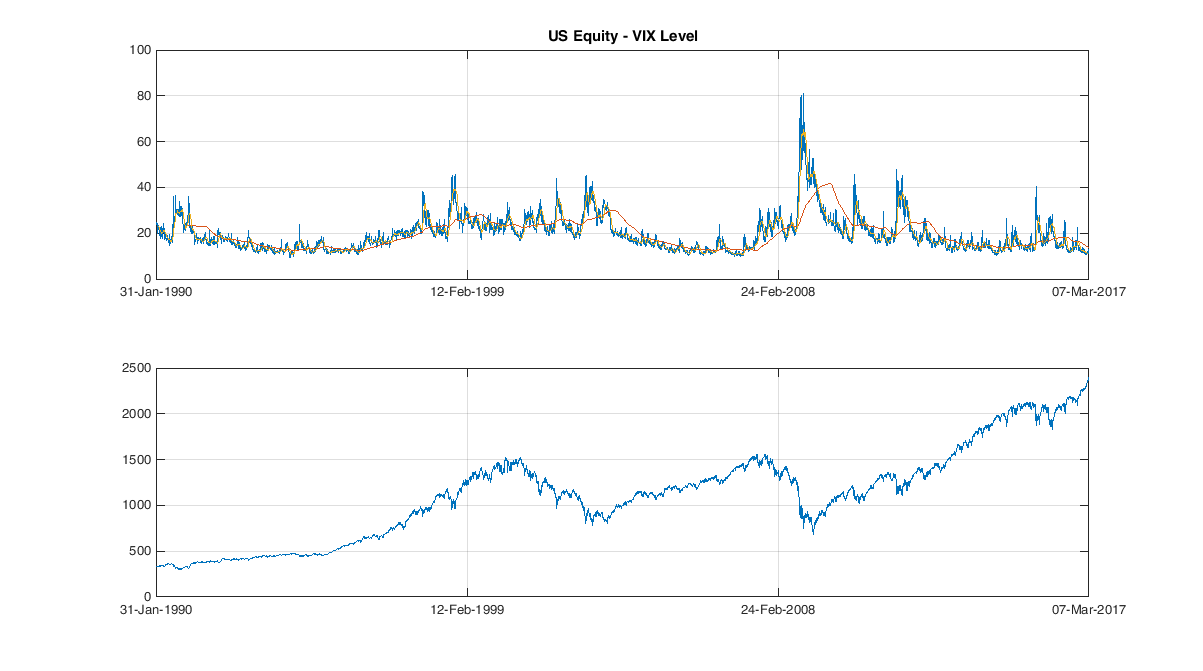
The below tables are split into uptrend and downtrend tables. (Up/Down column 1 meaning uptrend and 0 meaning downtrend)

**Two key results from the tables:**

* When VIX is trending upward and trading at the level of [22 ~ 28], SPX has negative forward 12 months returns at -3.5% on average. We often see VIX spiking to a much higher level when it is trading in this range.
* When VIX is trending downward and trading above 26, SPX on average has significantly higher return with average 12 months forward returns of 21.4%. High VIX levels often follow a sharp decline in the market. Additionally, VIX trending downward means that fear in the market starts fading away. We can conclude that when these two signals appear together, SPX is expected to deliver excessive high returns.







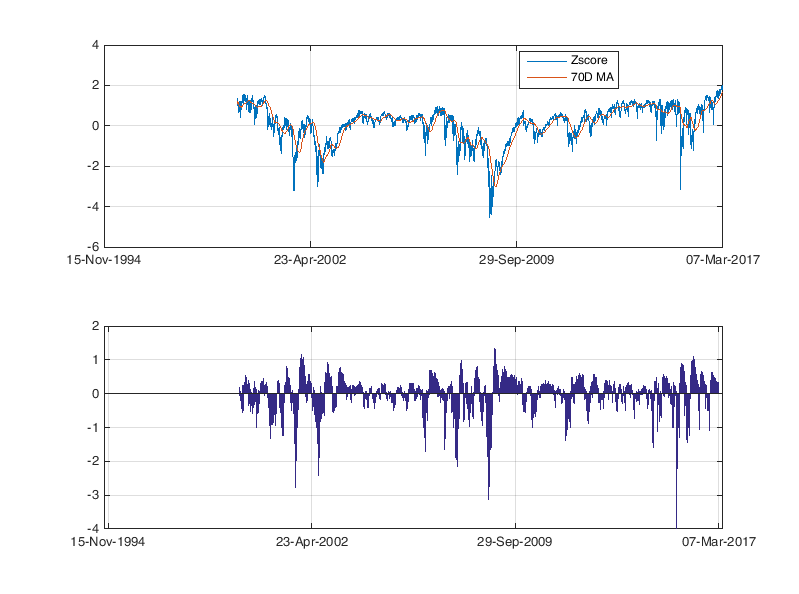
**VIX and Valuation**

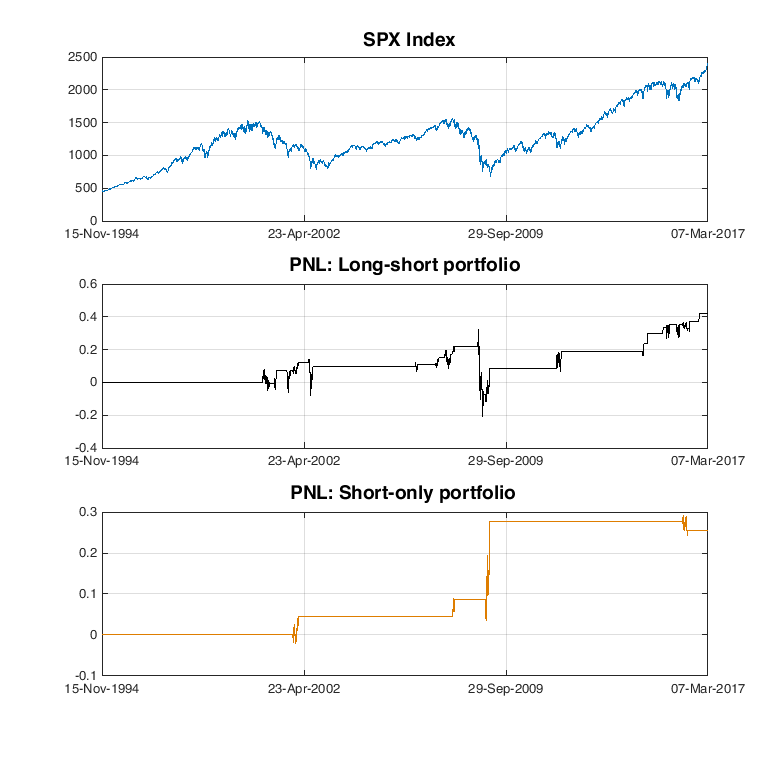
An interesting topic to explore is the combination of VIX and valuation to predict the forward returns of SPX. Valuation is represented by the PE ratio.

Note that the current VIX is at 11 the historical low level and the current PE level is at 22, which is the highest level since 2009. Looking back to the past two bear markets, 1999 tech bubble and 2008 financial crisis, we find some similarities of current situation with the two crises. From a valuation perspective, the current market PE is being stretched and it is mainly contributed by technology stocks. This is similar to 1999, although the PE has not yet reached the extreme level of 30 seen in 1999. It is because a certain part of Information technology sector is considered as value stocks now rather than grow stocks as in 1999. VIX was at 19-20 level in 1999.

From the volatility perspective, the current VIX has reached its historical low level. Such a low level was only observed in the pre-2008 financial crisis period. However, the valuation was not expensive at the time. Therefore, the current market can be seen as a “combination” of 1999 and 2008 crisis. Its combined factor of volatility and valuation has reached an unprecedented level, as we will illustrate below.

We constructed a factor by combining the z-score of PE ratio, z-score of price index and inverse z-score of VIX index. As seen in the below chart, the current factor score has reached the highest level in 20 years shown as the blue dotted line in the below chart. The second highest level appeared in 1999. At the time the forward 6 months, 12 months and 36 months returns were 3.0%, -3.1% and -37.8% respectively.

Taking a step further, we assess whether the factor can predict a short term downtrend. We calculated a momentum signal as the factor score minus its 40-days moving average in order to detect the speed of changes on the factor score. For the purpose of better illustration, we built a “trading model” using the momentum signal and looking at the model’s performance we determine the quality of the signal. We will not only look at the performance of long signals, since we know that the US market has been trending upwards since three decades and hence will yield good results. Assessing both short signals only and long-short signals, we see both delivering positive results. Therefore we conclude that the quality of signal is good. 

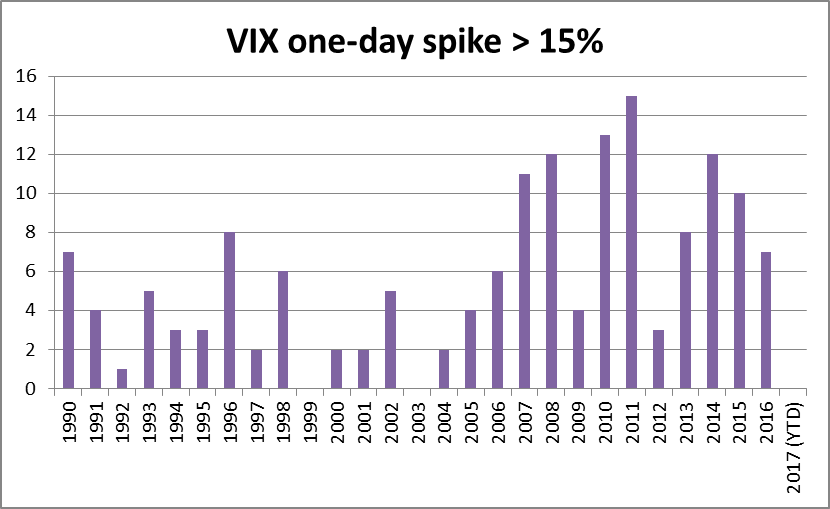


**VIX one-day Spike**

Often we see the VIX spiking when black swan events happen. On the remarkable “Brexit day” 23/06/16, VIX increased by 50% from 17.3 to 25.8. The move came in conjunction with a 3.4% decline in SPX index. The question arises whether a VIX spike is able to predict the “big cliff” in the market ahead.

We collated the largest one-day VIX spike in the recent three decades of VIX history and observed that there is a significant increase in number of days that VIX spikes more than 15% during the years of 2007 and 2008. In the same period, SPX Index dropped by as much as 45%. However, in contrast, it was not the case in the 2001 “doc com bubble”. There was only a one day spike over 15%. Additionally on the other end of the spectrum, 2011 is observed as the year with the highest number of one-day spike in the history along with fear from the European Debt crisis. However the market managed to walk out of the year unscratched. A similar phenomena happened in 2014 with concern on China’s hard landing.

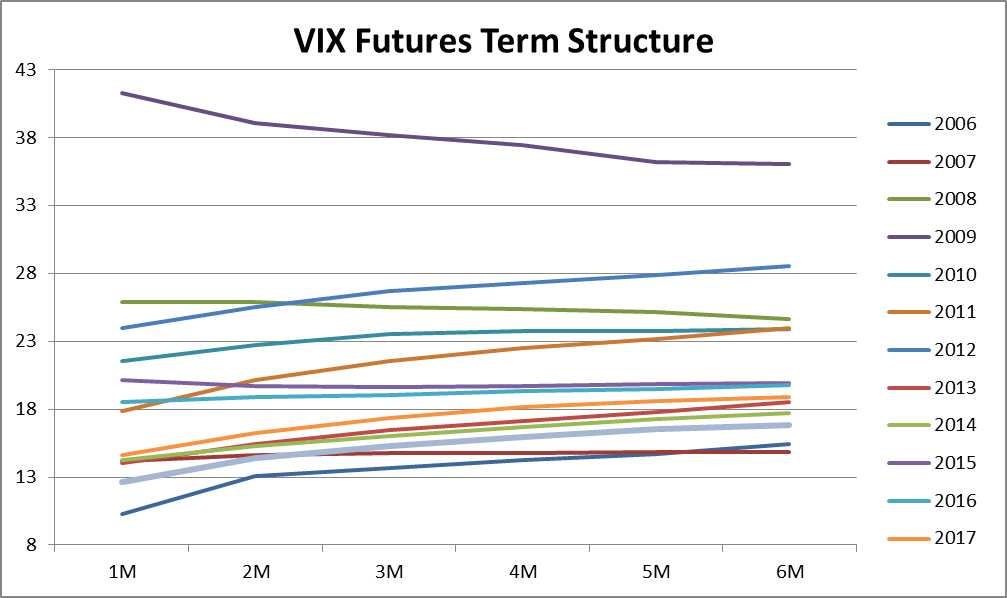
Conclusively, we have seen that VIX spike is often a short-lived phenomenon. It does not provide predictability for medium term or long term crisis. What happened in 2007 and 2008 may just be a coincidence. Nevertheless the spike does provide us with an opportunity to long SPX index in the short-term to capture the inefficiency of the market. It perfectly proves the statement “When people are in fear, you should be in greed”.



**VIX futures term structure**

We look at the VIX futures term structure and want to establish, if it can provide any insight on the SPX index. VIX index is calculated from the projection of VIX futures. VIX futures is only available for trading from 2004. In the most of its lifetime, VIX futures term structure is in Contango, which means that the nearest futures contract has lower price than the second nearest contract. When uncertainty in the market rises, investors seek short-term protection by buying short-term expiry contract, so the price of nearer contract will subsequently swing higher than the farther contract and change its term structure to Backwardation. We observed that the term structure remains in Backwardation during most of periods in late 2007 and early 2008.

Given the short history of VIX futures, there is no significance to conclude any result based on the term structure. However, one interesting point to mention is that in late 2007 and early 2008, when VIX was trading at sub-30 level and simultaneously the futures term structure has turned into Backwardation, there was a significant decline in SPX index. It coincides with what we observed in section “VIX level with momentum”.



**VIX Futures trading strategy based on the term structure**

We have also built a few strategies on SPX futures based on the signal from VIX Futures term structure. The results unfortunately are poor and fail to outperform the SPX long-only strategy. However, when the signal applies on VIX futures, it shows very encouraging performance. It is also known as “Carry trade”. The logic of trading strategy is shown as following:

* Calculate the term spread between the nearest contract and the second nearest contract
* Only trade when absolute value of spread is larger than 1
* Generate signals based on the term spread and capped the extreme signals value
* Calculate number of contracts to long/short based on signals
* Short 2nd nearest contract when signal is negative; Long 2nd nearest contract when signal is positive

Please note that given VIX futures were not so liquid during its early years of life, we applied wider bid-ask spread to transaction cost in order to compensate the liquidity issue.

The below table shows the statistics of the trading strategy. The back test result shows that the strategy has a stunning after-cost annualised rate of return of 47%, with volatility of 33%, which is equivalent to Sharpe ratio (Return/Volatility) of 1.41. The strategy has accumulated ~40,000% of return since 2004.



