WHEN THE DUST FLIES...
How Volatility Events Affect Asset Class Performance

Some investors have been surprised by the duration of the current stock market rally and, until just recently, the very low level of equity market volatility (e.g., VIX). However, many are concerned about the possibility of market volatility spikes. We investigate asset class performance before, during, and after volatility events. Specifically, how do stocks and bonds perform during such events? Is asset class performance leading into an event different than after the event?

We first define two types of volatility events: “spikes” and “post peaks”. A volatility spike event is a significant sudden increase in volatility, and we measure asset class performance while “the dust is flying.” In contrast, a volatility post peak event is a period of high volatility that is followed by volatility returning to its pre-peak level, and we measure asset class performance “after the dust has settled.” While both types of events are of interest to investors, some investors may act at the onset of a volatility event (i.e., a spike), whereas others may wait until market volatility has calmed down (i.e., after the peak).

We examine 26 volatility spike events, and 25 post peak events, across a 68-year span, in a variety of market environments. History shows that while spike events produce large negative returns for equities and credit bonds (with positive returns for Treasuries), markets recover relatively quickly, approximately by the seventh month following the spike month.

For post peak events, we focus attention on asset class performance after the dust has settled, not around the peak volatility event itself. The increase in volatility and accompanying equity and credit market declines may be unnerving to some investment committees. These investors may wish to wait until the “dust settles” – either out of caution or time needed for deliberation – before re-examining their investment strategy. History shows that once the dust has settled, equity and credit markets tend to perform well, often better than before the volatility event.

The evidence from both types of volatility events suggests that the damage from volatility events is transitory and is likely to be repaired after a reasonable period. These results provide support for investment committees who intend to “stay the course,” and possibly re-balance with increased allocations to risky assets.

All investments involve risk, including the possible loss of capital. There is no guarantee that any particular asset allocation will meet your investment objectives. The findings shown herein are derived from statistical models. Reasonable people may disagree about the appropriate model and assumptions. There can be no assurance that model returns can be achieved. Please see the “Important Information” section for additional disclosures.

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Introduction

Each year, the recipient of the Nobel Memorial Prize in Economic Sciences is asked for their view on the market. This year’s recipient, Dr. Richard Thaler, shared the following last October:

“I don’t know about you, but I’m nervous, and it seems like when investors are nervous, they’re prone to being spooked,” Thaler said. “Nothing seems to spook the market … We seem to be living in the riskiest moment of our lives, and yet the stock market seems to be napping. I admit to not understanding it.”

Some investors are surprised by the duration of the current stock market rally and, until just recently, the low level of US equity market volatility. Given robust current stock and bond valuations, geopolitical concerns, and record low implied volatility, many fret about potential volatility events and the market corrections that typically accompany them.2

Recently, PGIM Fixed Income’s Dr. Arvind Rajan argued that it is very difficult to predict such market corrections:

“… [w]e live in a dynamic and in many ways unprecedented macroeconomic environment, in which global regulation, trade, banking, and politics have all changed substantially over the past few decades and especially since the 2008 crisis – and partly in response to it. While historical data remain very useful in understanding our current macroeconomic conditions and relationships, it is unreasonable to expect that the challenges facing market participants will likely be captured by primarily looking at variables and relationships derived only from past history and prior crises.”3

Following market volatility events, investment committees may question whether their investment strategy in place before the event remains the appropriate strategy. We explore if there is a fundamental change in the market (e.g., returns, volatilities, and correlations) following a volatility event that would require a re-evaluation of a committee’s investment strategy.

Why might market fundamentals change after a volatility event? Periods of low volatility may reflect investor complacency and a relatively high level of risk tolerance. A volatility event, however, can increase investor risk aversion and the risk premia demanded, producing a change in relative asset class performance going forward. A volatility event may produce worries of a slowing economy, prompting a fiscal and monetary policy reaction that alters investor forecasts of risk and asset class performance.

Volatility events may also reveal structural weaknesses (e.g., excessive leverage) which can diminish investor outlook for certain industry sectors and strategies. From an international perspective, a volatility event may diminish demand for USD assets, producing downward pressure on the dollar. While such changes might be expected immediately after a spike in volatility, do these changes persist “after the dust settles,” once volatility returns to its pre-event level?

Identifying Volatility Events

We construct a modified “VIX” index as our measure of US equity market volatility, measured monthly and calculated as the average daily VIX value during a month.3

There are many possible ways to define a “volatility event,” and we consider two types:

1. **VIX Spike Event.** A VIX spike event is a significant sudden increase in the VIX.5 An example might be a 1.5x change (i.e., a 50% increase) in the average VIX over two months, from month \( t_0 \) to \( t_1 \). In this case, month \( t_0 \) would be labelled as the spike month, and the two-month period (i.e., months \( t_0 \) and \( t_1 \)) encompasses the spike event period. We classify spike events according to the change multiple (e.g., 1.5x, 2x, or 3x). Some investors may view a spike event (i.e., “when the dust flies”) as an immediate signal to act, even though it is unknown whether the volatility event is transitory or a harbinger of further increases.

   A spike event captures the initial sharp increase in volatility. Volatility may continue to increase, producing consecutive spike events, one month after the next. To capture only the initial sharp volatility spike, we impose an exclusion window so that another spike event is not included in this study until at least nine months after the current spike event.

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2 Not everyone considers the current low level of volatility to be an anomaly. While volatility is low relative to history, it is at a level consistent with the standard Gordon growth model for equity valuation. See, “The Low Volatility Puzzle: Are Investors Complacent?” Federal Reserve Bank of New York, 13 November 2017 [http://libertystreeteconomics.newyorkfed.org; accessed 13 November 2017].
3 A. Rajan, “Can We Predict the Next Market Crash?”, PGIM Fixed Income Perspectives, p. 16, October 2017.
4 The VIX is a measure of forward-looking volatility constructed using implied volatilities on equity index options. We use the VXO (calculated from options on the S&P 100) from Jan 1986 to Dec 1989 and the VIX (calculated from options on the S&P 500) from Jan 1990 to Oct 2017. To extend our VIX time series prior to Jan 1986 we generate a monthly market volatility index using daily price returns for the Dow Jones Industrial Average (DJI). Using month-end VIX values, rather than the monthly averages of daily VIX values, does not materially change the results of this study.
5 To qualify as an event, the two-month VIX change must also be greater than 5 VIX points. This condition screens out “noisy” volatility events when volatility values are extremely low.
Some investors may wish to wait until the change in volatility has passed (∙ i.e., “after the dust has settled”) – either out of caution or time needed for deliberation – before re-examining their investment strategy. This leads to our second type of volatility event.

2. VIX Post Peak Event. A VIX post peak event occurs when, after a period of several months, the VIX has fallen significantly from its recent peak toward pre-peak levels. If the VIX in month $t_{p+9}$ falls to less than 2/3 the value in month $t_p$, we call month $t_p$ a VIX peak month. The post peak event period includes the two months leading into the peak month (i.e., month $t_{p-1}$ and month $t_p$) and the nine months following the peak month (i.e., month $t_{p+1}$ through month $t_{p+9}$). Consequently, we assume a post peak event has a duration of 11 months.

As volatility declines from its peak, there could be a succession of post peak events. To avoid treating a series of overlapping post peak events, which are part of the same volatility event, as independent events, we apply an exclusion window to post peak events so that another post peak event is not included in this study until at least nine months after the current post peak event.

The following schematics (Figure 1) illustrate our two types of volatility events. Both types of events are forward looking as an investor can identify both events contemporaneously, using currently available information. Consequently, any investment decisions made in reaction to these volatility events are implementable.

We examine equity market volatility events (both spikes and peaks) over the past 68 years, spanning many market environments. How do asset class fundamentals change, if at all, following these volatility events?

![Figure 1: Schematic of Two Types of Volatility Events](source: PGIM IAS)

**VIX Spike Events**

We first consider VIX spike events. We identify 26 distinct spike months in which there is a two-month increase in the average VIX of at least 50%, or 1.5x (Figure 2).

Figure 3 sorts spike events by the magnitude of the VIX change (i.e., the multiplier) and compares performance leading into the spike event with that following the spike. We define the pre-spike period as the 21-month period ending in month $t_{p-2}$ (i.e., includes returns for month $t_{p-2}$ through month $t_{p-1}$) and the post-spike period as the 21-month period after month $t_p$ (i.e., includes returns for month $t_{p+1}$ through month $t_{p+21}$). We choose 21 months as our period length as a compromise between being too long and overlapping with other volatility events and too short making performance statistics too noisy. We identify 26 VIX spikes (≥ 1.5x); 11 spikes (≥ 2.0x); and 3 spikes (≥ 3.0x).

Figure 3 shows that, on average, the VIX in the post-spike period is higher than its pre-spike level. For example, for all 26 spike events, the average VIX value (indexed at $t_{p-2}$) in the pre-spike period is 1.18, and 1.33 in the post-spike. We have DJI data for all 26 spike events, but SPX data for only 15 of those events. We also see that 9 months is a good approximation of how long it takes the VIX to recover back to its pre-spike level. The figure shows that there is little relationship between the multiplier size and the time it takes the VIX to recover to its pre-spike level.

6 We have chosen a two-month change in the average VIX, expressed as the ratio of VIX($t_p$)/VIX($t_{p-2}$) to identify a spike event because we use monthly average VIX values. A monthly VIX average may not reflect a sudden volatility increase if it occurs towards the end of the month. A two-month change criterion is more likely to capture increases in monthly average volatility. While we identified Jul 1950 as a VIX spike event, we do not include it in this study because we do not have complete equity data available for the pre-spike period.
Asset Class Performance during Spike Events

How do various asset classes perform during the two-month volatility spike event period? Figure 4 (left panel) shows that, on average, the spike event period generally has very poor equity market performance. On average, the S&P 500 (“SPX”) has a cumulative two-month (i.e., months \( t_{0-1} \) and \( t_0 \)) loss of -8.2%. However, the equity market generally recovers rather quickly, returning to its pre-spike level (i.e., month \( t_{0-2} \)), on average, seven months after the spike month.

Figure 4 (right panel) illustrates performance in the fixed income markets. The 10y US Treasury has strong total returns (2.1%) during the two-month spike event period. In contrast, US high yield (HY) and investment grade (IG) credit exhibit a cumulative two-month excess returns of -9.2% and -3.3%, respectively, but both recover approximately nine months after the peak month.

Asset Class Performance: Pre- & Post-Spike Events

Broad Equity and Fixed-Income Markets

We examine broad equity and bond market performance pre- and post- volatility spikes. Figure 5 (left panel) shows that on average, equity markets displayed similar 21-month cumulative performance both before and after spikes. The average S&P 500 cumulative monthly total return at the end of the pre-spike period was 20.3%, and a bit higher, at 26.7%, in the post-spike period.

Figure 5 (right panel) provides results for the individual spike events. Of the 15 events covered by the S&P 500 index, only one event (8/07) has a significant negative return in the post-spike period. This event had the misfortune that its post-spike period included the 2008 financial crisis. Our definition of a spike event does not rule out the potential for further increases in volatility following the initial volatility spike.

Monthly data for all asset classes do not exist for the entire period from 1950. For example, while we have price returns for the Dow Jones Industrial (DJI) index from 1950, monthly total returns for the S&P 500 (SPX) do not begin until 1986. Consequently, for our analysis we need to group sets of events so that we can measure and compare the relationship (i.e., returns and volatilities) between asset classes using complete time series.
Figure 4: Cumulative Monthly Returns – Pre- & Post-VIX Spike Event Periods

Note: Figures show asset class cumulative returns before, during, and after spike events, averaged across all events available for the index (with the exception of “DJI (15 Events)” and “10y US Treasury (9 Events)” which cover fewer spike events so as to correspond to the 15 SPX and 9 IG/HY events). We measure cumulative monthly returns beginning in month t_{t-23} up to and including t_{t+21}, a 44-month period. Index = 1 at t_{t-23}.

Source: Barclays POINT, Datastream, FRB St. Louis (FRED), Global Financial Data, PGIM IAS.

Figure 5: Cumulative Equity Market Monthly Returns – Pre- and Post-VIX Spike Event Periods

Note: The left panel shows the average cumulative total return for the indicated asset class; the right panel shows cumulative total returns for all 15 spike events available for the S&P 500. Index = 1 at t_{t-23} and at t_{t}.

Source: Barclays POINT, Datastream, Global Financial Data, PGIM IAS.

10y US Treasury returns were stronger in the pre-spike period with a 13.0% cumulative total return, but only 9.1% in the post-spike period (Figure 6; left panel). Credit markets performed much better in the post-spike period compared to the pre-spike. Average HY and IG cumulative excess returns were 1.3% and 0.5%, respectively, in the pre-spike period compared to 16.9% and 5.3%, respectively, after the spike.

Figure 7 shows the maximum S&P 500 drawdown (for months t_{t-1} to t_{t+9}) for the 15 spike events covered by the S&P 500. For example, for the Oct 1987 spike month, the maximum drawdown was -29.6% which occurred in month t_{t+1} (i.e., Nov 1987). For the 15 events, the average maximum drawdown was -14.8%. Figure 7 also shows cumulative total returns (since t_{t-1}) at month nine after the spike month. The average cumulative return was 2.4%.
Figure 7: S&P 500 Maximum Drawdown in Spike Event & Cumulative Performance at Month Nine after Spike Month (15 Spike Events)

Note: This figure shows the maximum drawdown for the S&P 500 (after month $t_0$) and the month of the maximum drawdown, for the 15 spike events. In addition, the figure shows the S&P 500 cumulative total returns (month $t_0-1$ through month $t_0+9$) for each event.
Source: Global Financial Data, PGIM IAS.

Figure 8 shows that all asset classes are more volatile in the post-spike period compared to the pre-spike period. This is consistent with the VIX (Figure 3) where the VIX is higher in the post-spike period compared to the pre-spike period. The pre-spike period, which does not include the peak month and the month immediately before, represents a relatively stable period of returns. In contrast, the post-spike period includes months immediately after the spike month during which volatility only gradually settles back to pre-spike levels which makes the post-spike period returns relatively more volatile. For example, S&P 500 index monthly total return volatility was 14.6% in the pre-spike period, rising to 16.2% in the post-spike period.

**Equity “Winners” and “Losers”**

After a volatility spike, do pre-spike “winners” continue winning and “losers” keep losing? For each spike event, we identify the equity sector with the best performance (i.e., the “winner” sector) in the pre-spike period and the sector with the worst performance (i.e., the “loser” sector). We then average the performance of the “winners” across all events, and likewise for the “losers.” This produces average “winner” and “loser” performance. In the post-spike period we use the same “winner” sectors from the pre-spike period to
generate the average “winner” sector performance in the post-spike period, likewise for the “loser” sector. For example, Healthcare was the “winner” sector in the period before the 2015 spike event so it is classified as the “winner” sector in the 2015 event post-spike period irrespective of its actual relative performance in the post-spike period.8

By construction, “winner” and “loser” performance diverges in the pre-spike period. The average “winner” cumulative monthly total return in the pre-spike period was 44.5% and the average “loser” return was -20.2% (Figure 9). In the post-spike period, however, whatever relative return momentum the “winners” had over the “losers” is lost, at least for a while, as performance of “winners” and “losers” is roughly similar. Remarkably, the very brief spike event has been sufficient to break whatever momentum “winners” had over “losers.”

**Equity: Factors**

Figure 10 displays the cumulative pre- and post-spike performance for the popular Fama-French equity factors (i.e., market less risk-free rate, “market” (Mkt-RF); small minus big, “size” (SMB); and high minus low, “value” (HML)) as well as momentum (MOM). There is a large divergence in relative performance among these factors. In the pre-spike period, the momentum and value factors were the clear outperformers, but they performed particularly poorly post-spike, while the size and market factors perform better. Clearly, while the overall market performs well in the post-spike period, there are significant shifts in performance among the other equity market factors.

In summary, volatility spike events are rapid and large increases in volatility over a two-month period. Since 1950, there have been 26 spike events where the increase in the VIX has been at least 50%. During the two-month spike event period, the SPX (DJI) cumulatively loses, on average, -8.2% across 15 events (-6.4% across 26 events), 10y US Treasuries have a cumulative total return of 2.1% across 26 events (4.4% across 9 events), while HY and IG have cumulative excess returns of -9.2% and -3.3%, respectively, across 9 events. Furthermore, the average maximum drawdown for the SPX following a spike event was -14.8%. Spike events have certainly been traumatic.

However, the market reaction to spike events quickly fades (if not from memory!). Seven months after the spike month, on average, the SPX has recovered to its level immediately before the spike event, and the credit markets have recovered by the ninth month. The 21-month cumulative total returns for the equity market after the spike event have, on average, been better than the 21-month cumulative returns before the spike event.

While the markets recover relatively quickly following volatility spikes, some investors may wait for the dust to settle before re-examining their investment strategy. We now turn our attention to the performance of asset markets once we wait for the “dust to settle.”

8 (“winner” sector / “loser” sector) for the eight spike events (1: IT/materials); (2: utilities/IT); (3: consumer staples/IT); (4: telecom/healthcare); (5: energy/financials); (6: consumer discretion/energy); (7: consumer discretion/financials); (8: healthcare/energy).
VIX Post Peak Events

As discussed earlier, a volatility post peak event is fundamentally different than a spike event. A spike captures a sudden initial increase in the VIX (“when the dust starts to fly”) whereas a post peak event captures the aftermath of a period of high volatility (“after the dust has settled”). Since 1950, we identify 25 distinct peaks, months in which there is a decline of at least 1/3 in the VIX nine months later (Figure 11).

There is a high level of correspondence between peak and spike events (compare Figure 11 with Figure 2). In fact, of the 25 peak event months, 14 of them occur within ±1 month of a spike event month. However, a post peak event requires that volatility calms down whereas a spike event could be the beginning of a prolonged period of higher volatility. Nevertheless, when peak and spike events occur near each other, cumulative asset class returns immediately surrounding a peak or spike event will be similar. However, the “dust settled” and post-spike event returns may be very different as they cover different time windows in relation to the peak/spike month.

Figure 12 illustrates volatility dynamics, measured as the ratio of $\text{VIX}(t_0)$, the VIX in the peak month, to $\text{VIX}(t_{0-2})$, the VIX value two months prior. On average, across the 25 events, the VIX begins its move to the peak approximately two months prior (i.e., starting with the move from month $t_{0-2}$ to month $t_{0-1}$). On average the VIX moves by a multiple of approximately $1.7x$ from month $t_{0-2}$ to the peak month $t_0$. It then takes the VIX approximately 7 months following the peak month to decline to $2/3$ (= $1/1.5$) of its peak level, and stay there (i.e., “for the dust to settle”).

The actual duration of a VIX post peak event varies by event (see Appendix Figure A1). While the average time it took for the VIX to decline to $2/3$ of its peak level was 7 months, some declines happened more quickly and some took longer – up to 14 months. While the VIX decline from a peak may be quick, there is a risk that this is only a temporary respite, to be followed by further VIX increases. Our goal is to identify VIX declines that are likely to remain at this lower level (i.e., “the dust has settled”). Since investors don’t know ex ante, when “the dust will have settled”, we conservatively assume it takes 9 months, a bit longer than the 7-month average. Consequently, for this study we assume a full VIX post peak event duration of 11 months which includes the two-month VIX increase period leading into the peak month, and the nine months following the peak.

For each post peak event, we define the “quiet” period as the 21-month period up to and including month $t_{0-2}$, and the “dust settled” period as the 21-months starting after $t_{0+9}$ (i.e., returns from month $t_{0+10}$ through month $t_{0+30}$). Figure 12 shows the “quiet,” post peak event, and “dust settled” periods.

Figure 13 presents detailed information for each VIX post peak event, assuming our full 11-month post peak event duration. The figure shows the months for the “quiet” and “dust settled” periods, as well as the cumulative DJI and S&P 500 total returns in these periods. The average spike in the VIX is approximately 1.7x its level in month $t_{0-2}$. As of 2017 year-end, with S&P 500 = 2,745 and VIX = 11.0, the average VIX post peak event would likely see a peak month VIX value of 18.7. In addition, Figure 13 shows the maximum equity drawdown during the 11-month duration (from month $t_{0-1}$ to month $t_{0+9}$) of the post peak event, with an average equity market (S&P 500) drawdown of approximately -11.9%.

We identified 6/1950 and 1/2016 as post peak events, but do not include them in this study because equity data are unavailable for either the pre-peak or post-peak periods.
Figure 12: VIX Post Peak Events – Identifying “Quiet” and “Dust Settled” Periods
(Average Ratio of $VIX(t_{0+x})/VIX(t_{0-2})$ across all Post Peak Events)
(Jun 1950 – Oct 2017; 25 events)

Note: We define $t_0$ as the VIX peak month. This figure shows the average monthly VIX in month $x$, (i.e., $VIX(t_{0+x})$), relative to the VIX two months prior to $t_0$ (i.e., $VIX(t_{0-2})$) across all the events. By construction, this ratio peaks at time $t_0$. We see that, on average, the ratio is back to approximately 1.0 (actually, 0.86) in the ninth month after the peak month. The average VIX value in the “quiet” period is 1.08, and 0.94 in the “dust settled” period.

Source: CBOE, Global Financial Data, PGIM IAS.
### Market Performance during Post Peak Events

In the months immediately surrounding the VIX peak, equity market (DJI) performance is typically poor with an average cumulative equity market return of -6.6% around the VIX peak month (t<sub>0-1</sub> to month t<sub>0+2</sub>). In contrast, the 10y US Treasury performed well around the peak month. For example, from month t<sub>0-1</sub> to month t<sub>0+2</sub>, the average cumulative return for the US Treasury was 5.2%. 

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**Figure 13: Identification of VIX Post Peak Events, “Quiet” Periods and “Dust Settled” Periods (assuming a full 11-month post peak event period) (Jun 1950 – Oct 2017)**

<table>
<thead>
<tr>
<th>Peak Month (t&lt;sub&gt;0&lt;/sub&gt;)</th>
<th>“Quiet” Period (t&lt;sub&gt;0-22&lt;/sub&gt; to t&lt;sub&gt;0-2&lt;/sub&gt;)</th>
<th>“Dust Settled” Period (t&lt;sub&gt;0-10&lt;/sub&gt; to t&lt;sub&gt;0-30&lt;/sub&gt;)</th>
<th>(DJI/SPX) Cumulative Total Return during “Quiet” Period</th>
<th>(DJI/SPX) Cumulative Total Return during “Dust Settled” Period</th>
<th>VIX(t&lt;sub&gt;0&lt;/sub&gt;)</th>
<th>VIX(t&lt;sub&gt;0-2&lt;/sub&gt;)</th>
<th>Maximum (DJI/SPX) Drawdown during Post Peak Event Period</th>
<th>10y Tsy Cumulative Total Return during Post Peak Event Period</th>
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<tbody>
<tr>
<td>3/1955</td>
<td>5/1953-1/1955</td>
<td>1/1956-9/1957</td>
<td>46.0%</td>
<td>0.7%</td>
<td>1.1</td>
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<td>0.4%</td>
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<td>1/1962-9/1963</td>
<td>9/1964-5/1966</td>
<td>0.4%</td>
<td>9.7%</td>
<td>2.9</td>
<td>14.8%</td>
<td>1.7%</td>
<td>3.1%</td>
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<td>6/1968-2/1970</td>
<td>2/1971-10/1972</td>
<td>-17.6%</td>
<td>13.8%</td>
<td>0.9</td>
<td>10.8%</td>
<td>50.8%</td>
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<td>8/1977-4/1979</td>
<td>48.9%</td>
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<td>-4.9%</td>
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<td>8/1979-4/1981</td>
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<td>20.5%</td>
<td>40.1%</td>
<td>-5.8%</td>
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<td>6/1985-2/1987</td>
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<td>37.8%</td>
<td>73.9%</td>
<td>59.8%</td>
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<td>37.1%</td>
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<td>35.6%</td>
<td>25.6%</td>
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<td>10/2009-6/2011</td>
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<td>36.2%</td>
<td>34.7%</td>
<td>21.8%</td>
<td>50.1%</td>
<td>11.3%</td>
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<td>6/2012</td>
<td>8/2010-4/2012</td>
<td>4/2013-12/2014</td>
<td>42.8%</td>
<td>29.5%</td>
<td>32.6%</td>
<td>36.7%</td>
<td>9.5%</td>
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</tbody>
</table>

**Average**

| 17.5% / 21.7% | 18.5% / 25.3% | 1.7 | 4.6% / 10.1% | -11.5% / -11.9% | 9.3% |

Source: CBOE, Datastream, FRB St. Louis (FRED), Global Financial Data, PGIM IAS.
However, perhaps surprisingly, the equity market recovers relatively quickly as the average cumulative total return for the DJI over the duration of the 11-month post peak event period is +4.6% across all 25 events and +10.3% for the S&P 500 across 15 events (Figure 13). It is important to note that by the time the “dust settled” period begins (i.e., month t₀+10) the equity market has, on average, already recovered from the volatility event.

The 10y US Treasury performs well throughout the duration of the post peak event, although its performance starts to level off once the equity markets start to recover. Over the 11-month duration of the post peak event period, the 10y US Treasury produced an average cumulative total return of 9.0% (Figure 13).

### Asset Class Performance: Before and After Post Peak Events

#### Broad Equity and Fixed-Income Markets

We examine the broad equity and bond markets preceding and following post peak events. Figure 14 (left panel) shows that equity markets displayed similar performance both before and after post peak events. The average S&P 500 cumulative total return at the end of the “quiet” period was 21.7%, and higher at 25.3% in the “dust settled” period. This seems to suggest that reducing equity exposure in reaction to a traumatic volatility spike event may not be a good strategy.

Figure 14 (right panel) shows that average credit market excess returns were broadly similar between the “dust settled” and “quiet” periods. Average HY and IG cumulative excess returns were 13.6% and 1.7%, respectively, in the “quiet” period compared to 10.8% and 3.0% in the “dust settled” period. 10y Treasury returns were stronger in the “quiet” period with cumulative total returns of 14.8%, but only 6.5% in the “dust settled” period.

Asset class performance during a post peak event period is related to its ensuing “dust settled” period performance – but the relationship is not strong. Figure 15 (left panel) shows that for the equity markets there is a negative correlation (ρ = -0.29 for S&P 500) between average “dust settled” period and post peak event period monthly returns. When post peak event performance is poor, “dust settled” performance tends to be a bit stronger. However, for Treasuries (middle panel) and credit bonds (right panel), the correlation between peak period performance and dust settled performance is weak.

---

10 In the Appendix, we include “quiet” period and “dust settled” period cumulative performance for macroeconomic indicators (e.g., 2-30y Treasury slope (Figure A8), unemployment (Figure A10; left panel), inflation (Figure A10; right panel), and GDP (Figure A10; right panel)).

11 Some investors have asked about equity and fixed-income market returns in the “dust settled” period conditional on the level of interest rates and the level of equity market valuation leading into the post peak event. Please see Figures A4 - A7 in the Appendix for these results.
Figure 15: VIX Post Peak Event Period Returns vs. Subsequent “Dust Settled” Period Returns
(Average Monthly Equity & Treasury Total Returns and Credit Excess Returns)

Equity Markets
10y US Treasury
Credit Excess Returns

Note: Each point represents the average monthly performance of the specified asset class in the 11m post peak event period and in the ensuing 21m “dust settled” periods. Source: Barclays POINT, Global Financial Data, FRB St. Louis, and FRED. PGIM IAS.

Figure 16 shows that all asset classes are less volatile in the “dust settled” period compared to the “quiet” period. This is opposite to the spike event pre- and post-spike volatilities in which volatility pattern was higher after spike events. This result highlights that market volatility in the “dust settled” period has materially declined from the level before the volatility event. The “dust has clearly settled.”

In terms of monthly total return correlations, following a post peak event there is a notable decrease (in absolute value) in the correlation between the S&P 500 and 10y Treasury returns as the average correlation moves from -0.19 in the “quiet” period to -0.01 in the “dust settled” period. In addition, while the average correlation between credit (HY and IG) excess returns and equity indices is little changed (slightly lower), the correlation between credit excess returns and Treasury returns declines (in absolute value). For example, the average correlation between IG and Treasuries moves from -0.26 in the “quiet” period to -0.10 in the “dust settled” period.

Figure 16: Volatility (annualized) of Asset Class Monthly Total Returns (“Quiet” Period vs. “Dust Settled” Period)

Note: Each point represents the average monthly total return volatility (annualized) of the asset class in the “quiet” and the “dust settled” periods, averaged across all post peak events in the date range. For example, across all 15 post peak events in the 1970 – 2017 period, the average monthly S&P 500 total return volatility in the “quiet” period was approximately 16.1%, and 12.9% in the “dust settled” period. Date ranges for each index are: DJI (1950-2017); 10y Treasury (1953-2017); S&P 500 (1970-2017); R2000 (1978-2017); HY ExRet (1988-2017); and IG ExRet (1988-2017).
Source: Barclays POINT, Datastream, FRB St. Louis (FRED), Global Financial Data, PGIM IAS.
Figure 17: Average Asset Class Monthly Return Correlations during “Quiet” and “Dust Settled” Periods (Oct 1988 – Oct 2017; 8 events)

<table>
<thead>
<tr>
<th></th>
<th>“Quiet” Period</th>
<th></th>
<th>“Dust Settled” Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>S&amp;P 500</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R2000</td>
<td>0.79</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>DJI</td>
<td>0.91</td>
<td>0.72</td>
<td>1</td>
</tr>
<tr>
<td>10y Tsy</td>
<td>-0.19</td>
<td>-0.18</td>
<td>-0.20</td>
</tr>
<tr>
<td>HY</td>
<td>0.45</td>
<td>0.55</td>
<td>0.38</td>
</tr>
<tr>
<td>IG</td>
<td>0.45</td>
<td>0.57</td>
<td>0.39</td>
</tr>
</tbody>
</table>

Note: Each cell represents the correlation of monthly total returns for the indicated asset class, for either the “quiet” or “dust settled” period, averaged across all post peak events. Source: Barclays POINT, Datastream, FRB St. Louis (FRED), Global Financial Data, PGIM IAS.

Figure 18: Optimal Asset Allocation (S&P 500 and 10y Treasury); Mean-Variance Frontier (Jan 1970 – Oct 2017, 17 events)

Note: We use annualized average total returns and annualized volatility to construct efficient mean-variance frontiers. Source: Datastream, FRB St. Louis (FRED), PGIM IAS.

Asset Allocation

Following a volatility post peak event, the changes in broad asset class fundamentals (returns, volatilities and correlations) have implications for portfolio construction. The drop in the negative correlation between equities and 10y Treasury shift (i.e., from negative in the “quiet” period to approximately zero in the “dust settled” period) suggests a decrease in the potential diversification benefit. Furthermore, equity returns have been higher with lower volatility and Treasury returns have been lower with little-changed volatility in the “dust settled” period, compared to the “quiet” period. The mean-variance frontier in Figure 18 shows the “dust settled” efficient frontier is shifted upward compared to the “quiet” period, with a higher allocation to stocks for an assumed 10% overall portfolio volatility target.

Equity: “Winners” and “Losers”

Figure 19 shows the performance of the “winner” and “loser” sector portfolios during volatility post peak events (same sectors as in Figure 9). Portfolios are constructed in the same way as for spike events. For each post peak event we identify the sector that had the best cumulative performance (“winner”) and the sector with the worst cumulative performance (“loser”) at the end of the
“quiet” period and follow this same “winner”/ “loser” into the “dust-settled” period. From this we calculate the average “winner” performance and the average “loser” performance.

The results are similar to those for spike events: “winners” and “losers” exhibit very divergent performance in the “quiet” period (by construction) with an average “winner” cumulative monthly total return at the end of the period of 44.9% and with an average “loser” return of -12.4%. In the “dust settled” period, much, but not all, of the relative return momentum the “winners” had over the “losers” is lost as their performance converges.

Equity: Factors

Figure 20 (right panel) shows that market, value, and momentum equity factors perform better than the size factor leading into the VIX post peak event. In the “dust settled” period following the post peak event, the market and momentum factors continue to do well, much better than the size and value factors. This post-peak event pattern is different than the observed post-spike event pattern (Figure 10) where the momentum and value factors significantly underperformed the market and size factors following spike events.

Summary

We examine the performance of several asset classes before, during and after major equity market volatility events. We define two types of volatility events: “spikes” (i.e., a significant sudden increase in volatility) and “peaks” (i.e., a high level of volatility that precedes a nine-month return to its pre-peak level).

We examine 26 volatility spike events, and 25 post peak events, across a 68-year span and in a variety of market environments. History shows that while spike events produce large negative returns for equities and credit bonds (with positive returns for Treasuries), the markets recover relatively quickly, approximately by the seventh month following the spike month.

For post peak events, while the markets behave similarly to spike events around the peak month, our attention is on asset class performance after the dust has settled, as this may be when investment committees re-evaluate their portfolio allocation and may take action. History shows that once the dust has settled, equity and credit markets tend to perform well, often better than before the volatility event.

The evidence from both types of volatility events supports investment committees who intend to “stay the course” and possibly re-balance with increased allocations to risky assets.

We wish to acknowledge Ms. Junying Shen for her valuable assistance on this project.
APPENDIX

Actual VIX Post Peak Events

Figure A1: Identification of VIX Post Peak Events; Actual “Quiet” and “Dust Settled” Periods
(Post peak event period varies by event)
(Jun 1950 – Oct 2017)

<table>
<thead>
<tr>
<th>Peak Month (t₀)</th>
<th>Actual Post Peak Event Duration (months)</th>
<th>“Quiet” Period (t₂₂₋₉₃)</th>
<th>Actual “Dust Settled” Period</th>
<th>(DI/ SPX) Cumulative Total Return in “Quiet” Period</th>
<th>(DI/ SPX) Cumul. Total Return in Actual “Dust Settled” Period</th>
<th>VIX(t₀)</th>
<th>DI/ SPX Cumulative Total Return in Actual Post Peak Event Period</th>
<th>Maximum (DI/ SPX) Drawdown in Actual Post Peak Event Period</th>
<th>10y Treasury Cumulative Total Return in Actual Post Peak Event Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/1955</td>
<td>9</td>
<td>5/1953-1/1955</td>
<td>11/1995-7/1957</td>
<td>46.6%</td>
<td>12.6%</td>
<td>1.1</td>
<td>11.4%</td>
<td>-0.7%</td>
<td>0.0%</td>
</tr>
<tr>
<td>8/1957</td>
<td>7</td>
<td>1/1956-6/1957</td>
<td>2/1958-10/1959</td>
<td>6.6%</td>
<td>43.2%</td>
<td>1.7</td>
<td>-11.8%</td>
<td>-13.7%</td>
<td>9.8%</td>
</tr>
<tr>
<td>5/1962</td>
<td>12</td>
<td>7/1960-3/1962</td>
<td>4/1963-12/1964</td>
<td>13.0%</td>
<td>32.0%</td>
<td>4.2</td>
<td>-7.2%</td>
<td>-18.6%</td>
<td>2.9%</td>
</tr>
<tr>
<td>11/1963</td>
<td>9</td>
<td>1/1962-9/1963</td>
<td>7/1964-3/1966</td>
<td>0.4%</td>
<td>15.3%</td>
<td>2.9</td>
<td>10.9%</td>
<td>1.7%</td>
<td>2.5%</td>
</tr>
<tr>
<td>8/1975</td>
<td>6</td>
<td>10/1973-6/1975</td>
<td>1/1976-9/1977</td>
<td>-4.7%</td>
<td>-5.3%</td>
<td>5.7%</td>
<td>15.2%</td>
<td>-2.4%</td>
<td>-3.2%</td>
</tr>
<tr>
<td>10/1976</td>
<td>5</td>
<td>12/1974-8/1976</td>
<td>2/1977-10/1978</td>
<td>48.9%</td>
<td>58.1%</td>
<td>1.3</td>
<td>1.0%</td>
<td>0.9%</td>
<td>6.4%</td>
</tr>
<tr>
<td>10/1978</td>
<td>9</td>
<td>12/1976-8/1978</td>
<td>2/1979-10/1980</td>
<td>-7.3%</td>
<td>10.3%</td>
<td>9.8%</td>
<td>45.3%</td>
<td>3.5%</td>
<td>4.4%</td>
</tr>
<tr>
<td>8/1982</td>
<td>9</td>
<td>10/1980-6/1982</td>
<td>4/1983-12/1984</td>
<td>-14.3%</td>
<td>-4.1%</td>
<td>3.9%</td>
<td>18.4%</td>
<td>2.1%</td>
<td>-1.8%</td>
</tr>
<tr>
<td>8/1984</td>
<td>5</td>
<td>10/1982-6/1984</td>
<td>12/1984-8/1986</td>
<td>21.5%</td>
<td>37.8%</td>
<td>45.0%</td>
<td>65.7%</td>
<td>2.9%</td>
<td>16.7%</td>
</tr>
<tr>
<td>10/1987</td>
<td>13</td>
<td>12/1985-8/1987</td>
<td>10/1988-6/1990</td>
<td>83.9%</td>
<td>72.8%</td>
<td>50.8%</td>
<td>40.7%</td>
<td>-16.8%</td>
<td>-14.4%</td>
</tr>
<tr>
<td>8/2002</td>
<td>7</td>
<td>10/2000-6/2002</td>
<td>2/2003-10/2004</td>
<td>-11.0%</td>
<td>-31.0%</td>
<td>23.1%</td>
<td>35.5%</td>
<td>-10.2%</td>
<td>-12.7%</td>
</tr>
<tr>
<td>10/2008</td>
<td>16</td>
<td>12/2006-8/2008</td>
<td>1/2010-9/2011</td>
<td>-1.5%</td>
<td>-4.9%</td>
<td>13.6%</td>
<td>21.2%</td>
<td>-10.1%</td>
<td>-45.4%</td>
</tr>
<tr>
<td>5/2010</td>
<td>9</td>
<td>7/2008-3/2010</td>
<td>12/2011-9/2012</td>
<td>-11.4%</td>
<td>-4.4%</td>
<td>20.5%</td>
<td>17.9%</td>
<td>-10.8%</td>
<td>-12.4%</td>
</tr>
<tr>
<td>8/2011</td>
<td>7</td>
<td>10/2009-6/2011</td>
<td>2/2012-10/2013</td>
<td>36.2%</td>
<td>34.7%</td>
<td>26.7%</td>
<td>38.3%</td>
<td>-6.0%</td>
<td>-12.4%</td>
</tr>
<tr>
<td>6/2012</td>
<td>8</td>
<td>8/2010-4/2012</td>
<td>1/2013-9/2014</td>
<td>42.8%</td>
<td>29.5%</td>
<td>37.5%</td>
<td>41.5%</td>
<td>0.1%</td>
<td>-8.8%</td>
</tr>
</tbody>
</table>

Average 9 17.5% / 21.7% 19.9% / 27.7% 1.7 0.6% / 2.6% -11.5% / -10.3% 6.6%

Note: Actual post peak event duration refers to the number of months (x) it takes the VIX to decline to 2/3 of its peak level, and stay there, that is when VIX(t₀+x)/VIX(t₀) = 0.67, from and including month t₀+x.

Source: CBOE, Datastream, FRB St. Louis (FRED), Global Financial Data, PGIM IAS.

Cumulative Monthly Return by Post Peak Event: Equity and Treasury Markets

Figure A2 (left panel) shows performance volatility for the equity market (DJI) across post peak events in the “dust settled” period is much less than during the “quiet” period. The right panel shows that volatility was slightly higher in the “dust settled” period for the 10y Treasury.

Figure A3 shows that the volatility of HY and IG across VIX events in the “dust settled” period is also lower than during the “quiet” period.
Returns Conditional on Interest Rate Levels

We sort the VIX post peak events by the level of the 10y Treasury yield in month $t$. We then split the post peak events into “low” (LIR) and “high” (HIR) interest rate groups (Figure A4). We averaged the post peak events within each group for the cumulative monthly total return curves (Figure A5).

While we find that the general pattern for equity returns is the same for both the high and low interest rate groups, we see that cumulative monthly equity returns are higher in the “dust settled” period for the LIR group. In contrast, for 10y Treasury returns, we see that the LIR group exhibits significantly poorer performance in the “dust settled” period compared to the HIR group.
Returns Conditional on CAPE Levels

We sort the post peak volatility events by the cyclically adjusted price earnings ratio (CAPE) at $t_{0-2}$. We then split the post peak events into low and high CAPE groups (Figure A6). We averaged the events within each group for the cumulative monthly total return curves (Figure A7).

Figure A5: Cumulative Monthly Returns by Interest Rate Group

Figure A6: Average CAPE
(Jun 1950 – Oct 2017; 25 events)
(Current CAPE = 33.2)

<table>
<thead>
<tr>
<th>CAPE Group</th>
<th>Average CAPE</th>
<th>Event CAPE Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low (13 events)</td>
<td>13.0</td>
<td>(6.7, 17.8)</td>
</tr>
<tr>
<td>High (2 events)</td>
<td>23.4</td>
<td>(18.3, 38.3)</td>
</tr>
</tbody>
</table>

Note: Our data comes from Prof. Shiller’s online data collection.

Figure A7: Cumulative Monthly Returns by CAPE Group

Note: “Equity” refers to the DJI and “Treasury” refers for the 10y US Treasury. Each line represents the cumulative 21-month return for the indicated CAPE group, both prior and post the VIX post peak event, averaged across all events in the specified group. Events were sorted based on their value at $t_{0-2}$. The vertical grey bar represents the 11m period between the end of the “quiet” period and the beginning of the “dust settled” period.
Cumulative monthly equity total returns are high for both CAPE groups in the “dust settled” period. Interestingly, however, the high CAPE group outperforms the low CAPE group. For 10y Treasury returns, we see that while the high and low CAPE groups exhibit similar behavior in both periods the low CAPE group outperforms the high CAPE group in the “dust settled” period.

**Macroeconomic Indicators: 2-30y Treasury Slope, Unemployment, Inflation and GDP**

How does the macroeconomy change after post peak events? In the “quiet” period, we see that 2-30y Treasury yield curve slope starts, on average, from a relatively flat level 115bp and steepens substantially to 176bp leading into the post peak event (Figure A8). The fact that the curve has an above-average steepness in the “dust settled” period may reflect attempts by the Federal Reserve to lower short-term interest rates in response to the volatility event.

---

**Figure A8: 2-30y Treasury Yield Slope During “Quiet” and “Dust Settled” Periods**  
(Feb 1977 – Oct 2017, 13 events)

- **Quiet” period**
- **“Dust settled” period**

Note: 2-30y Treasury yield slope is measured as the difference between month-end 30y CMT yield and 2y CMT yield.

Source: FRB St. Louis (FRED), PGIM IAS.

---

**Figure A9: 2-30y Treasury Yield Spread**  
(Feb 1977 – Oct 2017)

- **Historical long-term average 2-30y Treasury yield spread = 133bp**

Source: FRB St. Louis (FRED), PGIM IAS.

Figure A10 shows that the unemployment rate increases leading into the post peak event. By the end of the post peak event unemployment has increased from 6.4% at tₜ₋₂ to 6.7% by tₜ+10. Furthermore, the beginning of the “dust settled” period is also the beginning of a sustained improvement in the unemployment rate: by the end of the “dust settled” period, unemployment is back close to the its level at the beginning of the “quiet” period. This helps to explain the stock market’s relatively strong performance in the “dust settled” period as the economy appears to be on a sustained recovery path.
The strong economic recovery is also reflected in the inflation and growth rates in the “dust settled” period. Over the 21 months of the “quiet” period, GDP increased 4.8%, but increased 6.5% over the “dust settled” period. Meanwhile, average inflation (CPI) was roughly the same in both periods.
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