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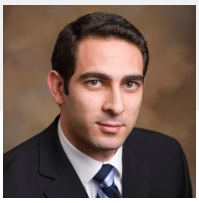

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VOLATILITY EPISODES DEMONSTRATE BENEFITS OF FACTOR DIVERSIFICATION

EXECUTIVE SUMMARY

- We studied the performance of various equity return factors prior to, during, and following a rise in the Chicago Board Options Exchange's Volatility Index (VIX) equal to at least one standard deviation from the index's long-term mean. We also analyzed high-volatility periods to see if there were any changes in their average characteristics over the course of the study, which ran from January 1, 1990, through March 31, 2018.
- Our analysis found that relative factor performance varied greatly in and around periods of high volatility. On average, equity markets rebounded sharply once volatility subsided. We also found that periods of high volatility shortened significantly following the 2008–2009 global financial crisis.
- We believe our findings support the case for maintaining a diversified factor profile in equity portfolios and for taking a patient approach to the volatility cycle.

Equity market volatility came roaring back in February 2018, shaking many investors who had grown accustomed to the relatively benign volatility environment that persisted throughout most of 2017. This sudden, albeit relatively brief, spike in volatility prompted us to look at past cycles in which the VIX rose at least one standard deviation above its long-term mean.

Our inquiry had several objectives:

- We wanted to analyze historical long/short returns for different equity return factors—such as size, value, and momentum—to identify performance patterns before, during, and after periods of high volatility.
- We hoped to identify any changes over time in the characteristics of high-volatility periods.
- We sought to determine what, if anything, investors could do to prepare for future volatility.

Our analysis identified a number of trends in relative factor performance before, during, and after high-volatility periods. However, we also found that periods of high volatility shortened significantly in the wake of the 2008–2009 global financial crisis (GFC), increasing the speed with which shifts in relative factor performance occurred.[1]

We believe our findings confirm the importance of maintaining adequate portfolio diversification, including factor diversification, even in the face of extended equity style cycles.

[1]We use a date range of September 15, 2008, through July 13, 2009, to define the GFC. During this period, the VIX breached and remained more than one standard deviation above its long-term mean.

FACTOR PERFORMANCE DURING HISTORICAL PERIODS OF HIGH VOLATILITY

We examined every case between January 1, 1990, and March 31, 2018, in which the VIX rose at least one standard deviation (equaling 27.2 points) above its long-term historical mean of 19.4. Our analysis tracked returns for the broad equity market,[2] on three commonly observed equity return factors[3] (size, value, and momentum), and the performance of the broad equity market and of a hypothetical equal-weighted factor portfolio. The latter was included to test whether an investor with diversified factor exposures potentially could have achieved a smoother performance profile across the volatility cycles studied.

Performance was measured over the following periods:

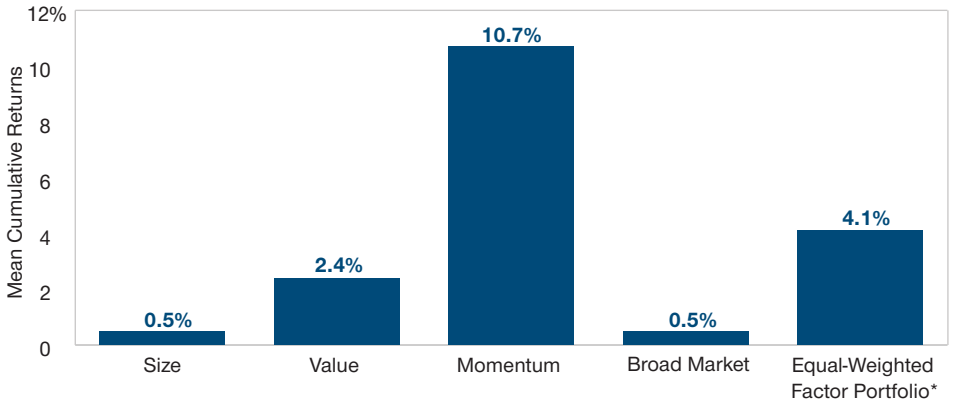
- Periods of high volatility, defined as episodes in which the VIX rose to at least one standard deviation above its long-term mean. Only periods lasting at least 10 trading days were included in our study.[4]
- The 60 days prior to periods of high volatility.
- The 60 days following periods of high volatility.

FACTOR PERFORMANCE PRIOR TO HIGH-VOLATILITY PERIODS

Our key observations are that returns for the size factor and for the broad market both were fairly flat going into periods of high volatility, while the value factor (as measured by the book/price ratio) and high-momentum stocks outperformed (Figure 1). The equal-weighted factor portfolio performed relatively well, with a mean return of approximately 4%, benefiting from its exposure to high-momentum stocks.

FIGURE 1: Average Performance Prior to High-Volatility Periods

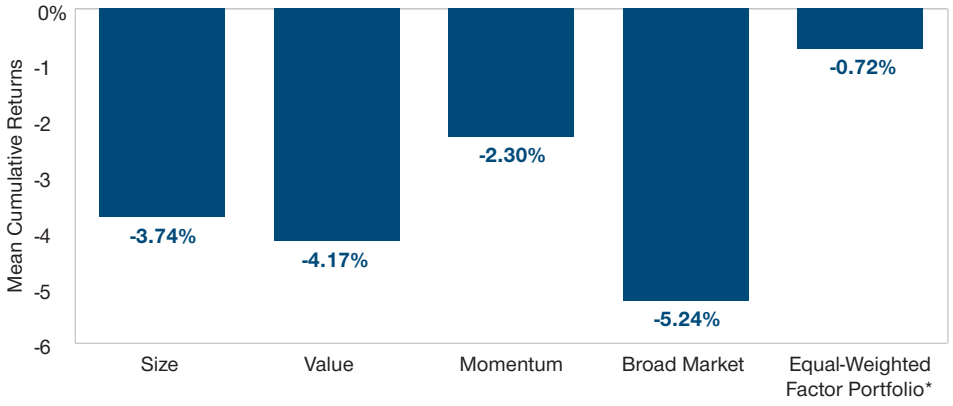
January 1, 1990, Through March 31, 2018



Sources: Kenneth R. French Data Library and Haver Analytics; data analysis by T. Rowe Price.
This page contains hypothetical data. See the back page for important information on hypothetical portfolios.

FIGURE 2: Average Performance During High-Volatility Periods

January 1, 1990, Through March 31, 2018



*Factor portfolios were created from the stocks in the broad market universe (see footnotes 2 and 3), which were ranked by size (market capitalization), value (book/price), and momentum (price movements over the previous 2 to 12 months) based on the highest and lowest deciles for each factor. The equal-weighted portfolio assigned a 1/3 weight to each factor. This page contains hypothetical data. See the disclosures on the back page for important information on hypothetical portfolios.
Sources: Kenneth R. French Data Library and CBOE/Haver Analytics; data analysis by T. Rowe Price.

Past performance is not a reliable indicator of future returns.

[2]The broad market returns and factor returns used in our analysis were drawn from the French Data Library, a research site maintained by Kenneth R. French, a finance professor at Dartmouth University and a noted academic researcher. Broad market returns were based on daily returns for a capitalization-weighted universe consisting of the U.S. common stocks listed on the New York Stock Exchange, the American Stock Exchange, and the Nasdaq market for which reliable price and return data are available, and include reinvested dividends and capital gains.

[3]Factor returns were based on portfolios created from the stocks in the broad market universe ranked by the following factors: for size, market capitalization; for value, book value/market capitalization (i.e., book/price); for momentum, price movements over the previous 2 to 12 months. Relative returns were based on the highest and lowest deciles in each factor ranking: for size, the return for the smallest decile minus the return for the largest decile; for value and momentum, the highest decile minus the lowest decile. Each factor return was given a 1/3 weight in the returns for the equal-weighted portfolio. For more details on the return methodology, please see the French Data Library, on the Web at http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html.

[4]In some cases, we allowed for short-term dips in the VIX below the mean plus 1 standard deviation threshold in order to avoid breaking one high-volatility period into two shorter ones separated by several lower-volatility days. See the appendix on pages 4 and 5 for a full list of the high-volatility periods and those included in our study.

If periods leading up to high-volatility events are considered the "normal" market environment, these results are as one would expect—the traditional risk premia yielded positive returns.

FACTOR PERFORMANCE DURING HIGH-VOLATILITY PERIODS

There was a sharp reversal in factor performance once the VIX breached the plus one standard deviation level (Figure 2). Momentum, the best performer going into high-volatility periods, saw its fortunes reversed, reflecting the tendency of many investors to sell their winners first.

Value stocks, meanwhile, suffered relative to more expensive securities, as value stocks are often considered to present higher risks. Similarly, large-cap stocks, often perceived by investors to be less risky, outperformed small-cap stocks by almost 4%, on average.

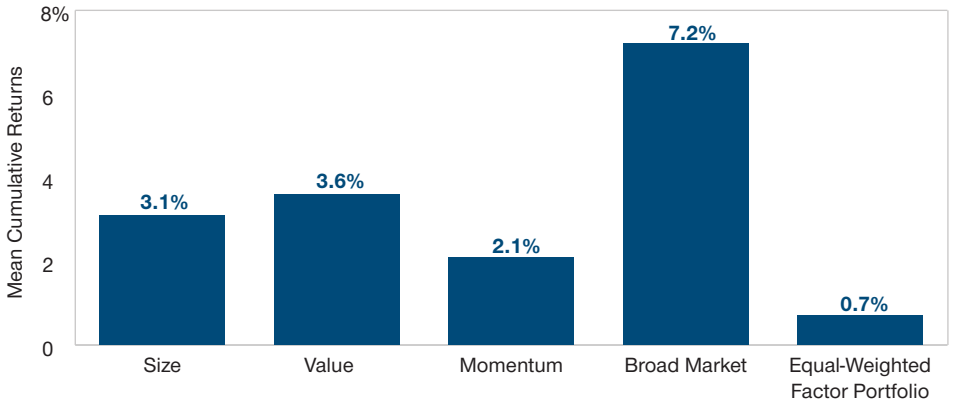
Finally, while the broad market sold off by an average of 5.2% during the high-volatility periods, the equal-weighted factor portfolio was down only slightly, on average.

FACTOR PERFORMANCE FOLLOWING HIGH-VOLATILITY PERIODS

As one would expect, the post high-volatility periods in our study were characterized by a return to risk-on investor behavior (see Figure 3). The broad market rebound strongly—up 7.2%, on average—suggesting that patient investors who maintained their equity market positions through the periods of high volatility were rewarded for their patience. Small-cap stocks outperformed large-cap stocks by approximately 3%, while value and high-momentum stocks also rebounded. The equal-weighted factor portfolio provided a positive return in post high-volatility periods, benefiting from its diversified factor exposure.

FIGURE 3: Average Performance in Post High-Volatility Periods

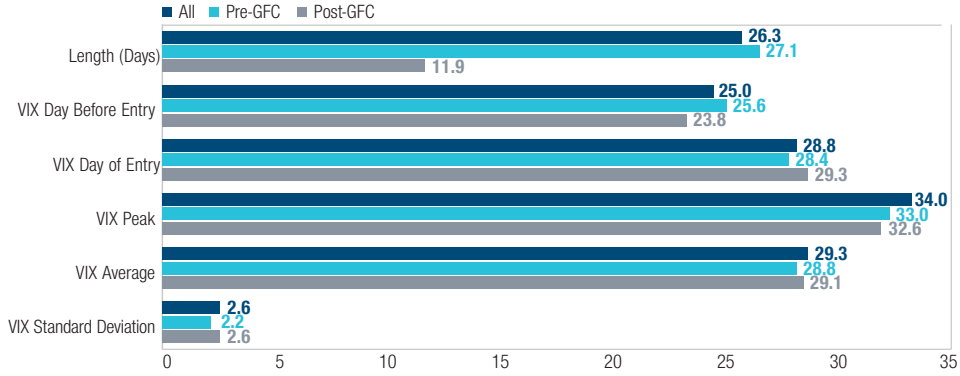
January 1, 1990, Through March 31, 2018



Sources: Kenneth R. French Data Library and CBOE/Haver Analytics; data analysis by T. Rowe Price.

FIGURE 4: Summary Statistics for High-Volatility Periods

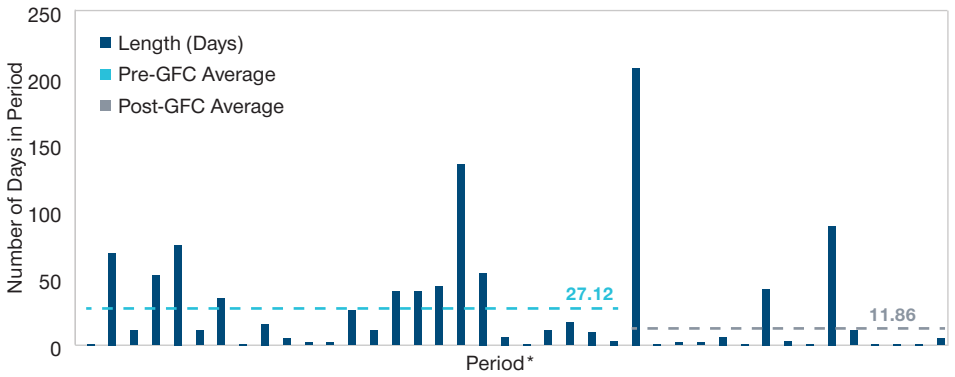
January 1, 1990, Through March 31, 2018



Source: CBOE/Haver Analytics; data analysis by T. Rowe Price.

FIGURE 5: Length of High-Volatility Periods Before and After the Global Financial Crisis

January 1, 1990, Through March 31, 2018



Source: CBOE/Haver Analytics; data analysis by T. Rowe Price.
*Period start and end dates can be found in the appendix on pages 4 and 5.

Past performance is not a reliable indicator of future returns.

HISTORICAL CHARACTERISTICS OF HIGH-VOLATILITY PERIODS

Before we interpret the observed differences in relative factor performance in and around periods of high volatility, we need to examine the characteristics of the high-volatility periods themselves to see if there have been trends—such as changes in their duration and intensity—that may have implications for investors and their portfolio strategies.

As previously mentioned, we looked at every period of high volatility (as measured by the VIX) from January 1, 1990, through March 31, 2018, in order to identify trends in the historical data. Figure 4 summarizes average characteristics for all the high-volatility periods in our sample and provides separate breakouts for periods before and after the GFC.

While most metrics were fairly consistent across pre- and post-GFC periods, the mean length of high-volatility periods was not:

- For the full sample, the mean high-volatility period was slightly more than 26 days.
- Prior to the start of the GFC, the mean high-volatility period lasted a bit more than 27 days.
- Following the end of the GFC, the mean length of high-volatility periods fell sharply, to just under 12 days.

Figure 5 provides a more detailed look at every high-volatility period during the time frame covered by our study. We see that only two of the periods following the GFC lasted longer than 11 days.[5] The more typical pattern in the post-GFC era has been a greater frequency of one- or two-day jumps in volatility that quickly revert.

CONCLUSIONS

As stated above, our objectives for this study were to examine the historical performances of key equity return factors in and around periods of high volatility and to measure the characteristics of the high-volatility periods themselves to see what implications they might have for portfolio management. Our key findings:

- Relative factor performance varied greatly prior to, during, and following periods of high equity market volatility.
- On average, the broad equity market rebounded sharply coming out of periods of high volatility.
- The mean length of high-volatility periods fell significantly following the end of the GFC.

To us, these findings speak to the importance of diversification and discipline. While variations in factor performance may tempt investors to try to time relative return trends, shorter periods of high volatility potentially could increase the risk of mistiming factor allocations.

Moreover, our analysis found that an equal-weighted factor portfolio experienced relatively consistent returns, on average, across the high-volatility periods included in our study. We believe investors would be well advised to reassess their equity portfolios regularly to ensure that any factor exposures are desired and (in our opinion) balanced relative to their risk profile.

The discipline to stick with a long-term investment strategy is also important. While the periods of high volatility we studied involved substantial equity sell-offs, the rebounds in performance following those episodes more than made up for losses suffered during them, on average.

These observations may be especially important as the post-GFC equity bull market extends into its 10th year. Long periods of strong equity performance can lead to complacency, but there also may be a temptation for investors to take risk off the table quickly when volatility returns to the market. We believe prudently diversified investors can take comfort in the fact that equities historically have rewarded those who have stayed with them for the long term.

[5]These periods occurred in the summers of 2010 and 2011. See the appendix for the full details of all historical periods covered by the study.

APPENDIX: PERFORMANCE STATISTICS DURING HIGH-VOLATILITY PERIODS

January 1, 1990, Through March 31, 2018

Period #	Included in Study	Entry Date	Exit Date	Length (Days)	VIX Prior to Entry	VIX Day of Entry	VIX Peak	VIX Average	VIX Standard Deviation	VIX Day of Exit
1		1/30/90	1/31/90	1	26.44	27.25	27.25	27.25	—	25.36
2	*	8/3/90	11/9/90	69	20.43	28.74	36.47	29.35	2.22	23.31
3	*	1/3/91	1/18/91	11	26.62	27.93	36.20	31.34	3.26	25.39
4	*	10/27/97	1/13/98	52	23.17	31.12	38.20	29.06	4.17	22.65
5	*	8/4/98	11/18/98	75	25.98	31.06	45.74	34.41	5.46	25.70
6	*	12/3/98	12/18/98	11	25.43	28.70	31.31	27.59	2.10	24.90

Period #	Included in Study	Entry Date	Exit Date	Length (Days)	VIX Prior to Entry	VIX Day of Entry	VIX Peak	VIX Average	VIX Standard Deviation	VIX Day of Exit
7	*	1/12/99	3/4/99	35	25.46	28.10	32.98	29.16	1.56	25.87
8		3/23/99	3/24/99	1	25.00	27.27	27.27	27.27	—	26.60
9	*	5/6/99	5/28/99	16	25.19	27.44	28.90	26.55	1.29	24.40
10		8/4/99	8/11/99	5	26.27	27.40	28.45	27.42	0.70	25.39
11		9/23/99	9/27/99	2	25.19	27.84	27.84	27.82	0.04	26.40
12		10/15/99	10/19/99	2	26.05	28.75	28.75	28.47	0.40	26.56
13	*	4/5/00	5/12/00	26	27.12	28.41	33.49	27.91	1.98	24.39
14	*	10/12/00	10/27/00	11	26.57	30.51	30.51	27.02	1.89	24.24
15	*	11/10/00	1/10/01	40	27.20	28.53	31.74	27.12	1.79	22.41
16	*	2/28/01	4/26/01	40	26.49	28.35	34.72	28.61	2.60	24.12
17	*	9/6/01	11/13/01	44	26.35	28.61	43.74	33.26	3.81	26.47
18	*	6/20/02	1/2/03	135	26.06	27.48	45.08	32.61	4.91	23.16
19	*	1/21/03	4/8/03	54	25.70	27.59	34.69	30.99	1.96	27.13
20		8/10/07	8/20/07	6	26.48	28.30	30.83	29.01	1.75	26.33
21		9/10/07	9/11/07	1	26.23	27.38	27.38	27.38	—	25.27
22	*	11/9/07	11/27/07	11	26.16	28.50	31.09	27.06	1.87	24.10
23	*	1/17/08	2/12/08	17	24.38	28.46	31.01	27.90	1.23	24.02
24	*	3/6/08	3/20/08	10	24.60	27.55	32.24	28.52	2.02	25.79
25		7/11/08	7/16/08	3	25.59	27.49	28.54	28.17	0.59	25.10
26	*	9/15/08	7/13/09	207	25.66	31.70	80.86	44.45	12.53	25.35
27		8/17/09	8/18/09	1	24.27	27.89	27.89	27.89	—	26.18
28		9/1/09	9/3/09	2	26.01	29.15	29.15	29.03	0.18	27.10
29		10/1/09	10/5/09	2	25.61	28.27	28.68	28.48	0.29	26.84
30		10/28/09	11/5/09	6	24.83	27.91	30.69	28.39	1.84	24.76
31		1/22/10	1/25/10	1	22.27	27.31	27.31	27.31	—	25.41
32	*	5/6/10	7/7/10	42	24.91	32.80	45.79	31.51	4.63	23.95
33		8/24/10	8/27/10	3	25.66	27.46	27.46	27.18	0.42	24.45
34		3/16/11	3/17/11	1	24.32	29.40	29.40	29.40	—	26.37
35	*	8/4/11	12/9/11	89	23.38	31.66	48.00	34.08	4.59	24.53
36	*	8/21/15	9/8/15	11	19.14	28.03	40.74	29.69	4.79	24.90
37		9/28/15	9/29/15	1	23.62	27.63	27.63	27.63	—	26.83
38		1/20/16	1/21/16	1	26.05	27.59	27.59	27.59	—	26.69
39		2/11/16	2/12/16	1	26.29	28.14	28.14	28.14	—	25.40
40		2/5/18	2/12/18	5	17.31	37.32	37.32	31.51	3.88	25.61

Source: CBOE/Haver Analytics; data analysis by T. Rowe Price.
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Standard deviation: A statistic that measures the historical volatility of a portfolio's returns. The higher the standard deviation, the greater the potential volatility risk incurred by the investor.

Book/price ratio: A measure of equity valuation, calculated by dividing the company's book value per share by the current price of the stock. The lower the ratio, the more expensive the stock. This is the inverse of the price/book ratio.

Risk premia: The additional returns that investors historically have received for holding assets exposed to particular risks, such as price volatility or market illiquidity, relative to less risky assets.

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Important Information–Hypothetical Portfolios (Figures 1 and 2, page 2; and Figure 3, page 3)
The equal weighted factor portfolio presented herein is hypothetical in nature and is shown for illustrative, informational purposes only. It does not reflect the actual returns of any portfolio /strategy and does not guarantee future results. Certain assumptions have been made for modeling purposes and are unlikely to be realized. No representation or warranty is made as to the reasonableness of the assumptions made or that all assumptions used in modeling analysis presented have been stated or fully considered. Changes in the assumptions may have a material impact on the information presented. Data shown for the hypothetical portfolio are as of the dates shown and represents the manager's analysis of sample portfolios as of that date and is subject to change over time. The hypothetical results were developed with the benefit of hindsight and have inherent limitations. Results do not reflect actual trading and the impact that material economic, market or other factors may have on weighting decisions. If the weightings change, results would be different. Returns include reinvested dividends and capital gains. Management fees, transaction costs, taxes, potential expenses, and the effects of inflation are not considered and would reduce returns. Actual results experienced by clients may vary significantly from the hypothetical illustrations shown. The information is not intended as a recommendation to buy or sell any particular security, and there is no guarantee that results shown will be achieved.

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