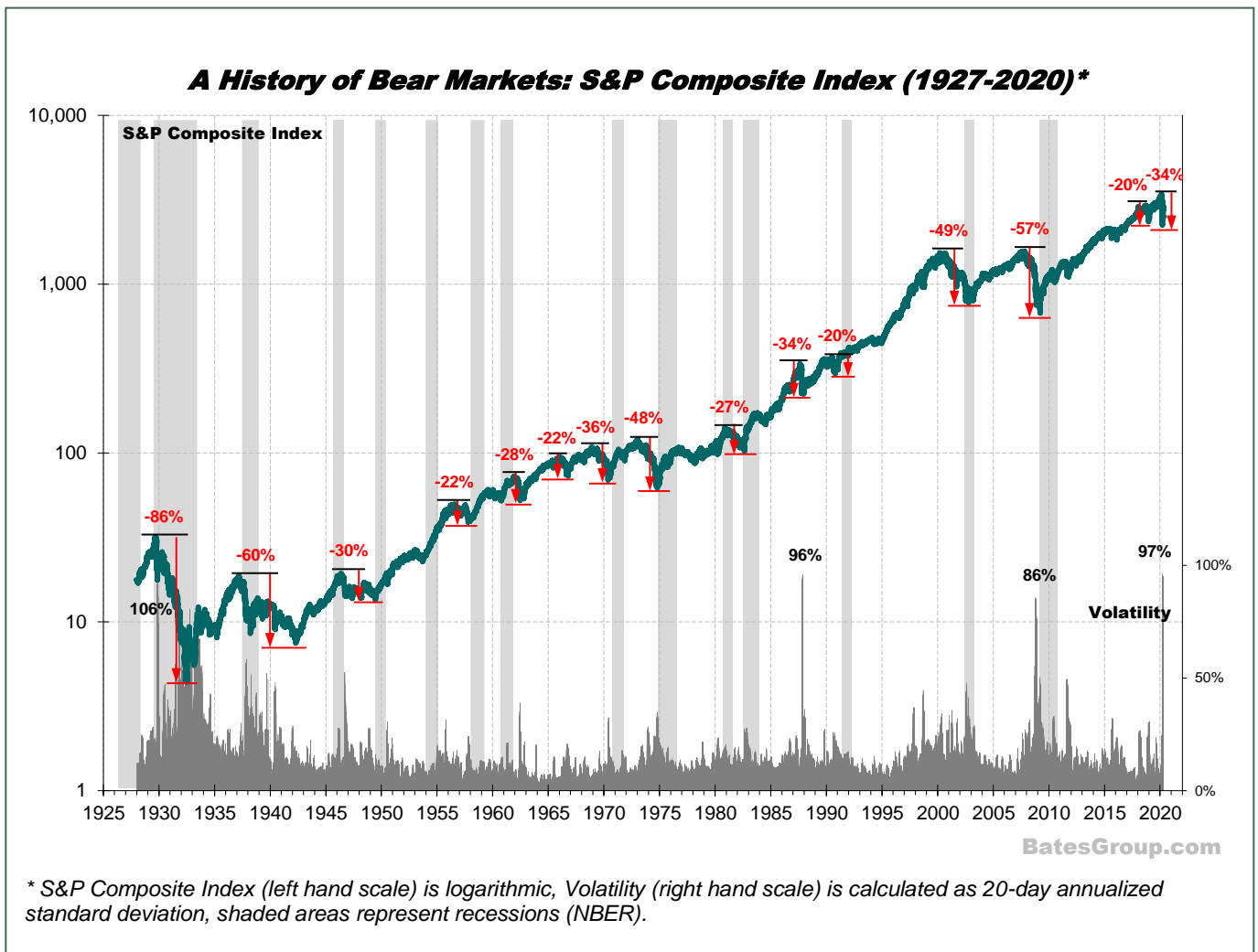


Bear Markets, Black Swan Events, and Volatility

Capital Market Insights



Life in the Time of Corona

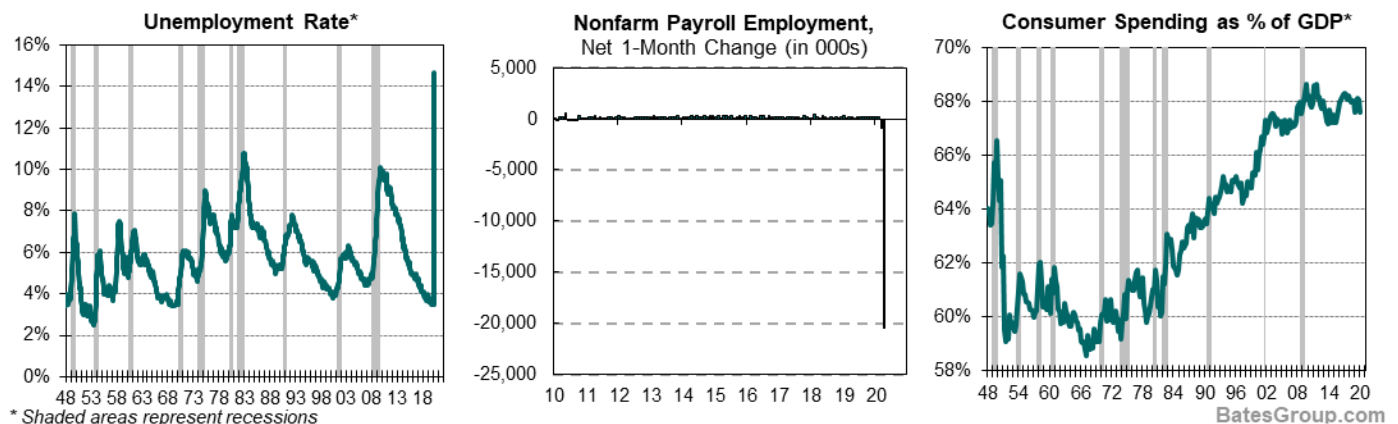
The first 4 months of this year have been challenging for the equity markets. With a global pandemic suddenly arising—the likes of which have not been seen in more than 100 years—U.S. economic activity largely halted, and unemployment skyrocketed, reaching in excess of 40 million initial unemployment claims in just 10 weeks. This was a massive jump in the unemployed and equal to over 26 percent of the U.S. workforce. Adding to the dire employment outlook are those counted as part of the “gig economy” and who cannot file for unemployment. By some estimates, the gig economy, or “1099 workforce,” comprises an additional 20 million people.

Given that two-thirds of the U.S. economy depends on consumer spending, the sharp rise in unemployment led to deep uncertainty regarding the direction of the economy and corporate profits throughout the coming quarters and year. At this point, how the future will unfold remains unclear. Will the economy experience a V-shaped recovery and quickly bounce back or is the recovery likely to be a long, protracted U-shape? That remains a key question. One thing is clear though, life in the time of corona is currently very challenging for people, the economy, and the markets—and much is uncertain.

The uncertainty over the economic damage from the coronavirus has already had a significant impact on the equity market. In March, the S&P 500 Index plunged into bear market territory as volatility soared to historic levels. Not only was the stock market’s slide into bear country the steepest in history, but it also ranked as the quickest. And, when it comes to volatility, regardless of how it’s measured, 2020 has been one for the record books. In terms of price swings, the average daily percentage change in the S&P 500 in 2020 (to date) was more than 2 percent. The last time the stock market experienced such a high average level of price swings was in 1933. Volatility in terms of standard deviation also jumped to historic levels, with March’s dramatic surge second only to the surge in volatility during the Stock Market Crash of 1929.

The sudden appearance of a severe global pandemic is just the most recent example of a “black swan event” roiling the markets. By definition, black swans are rare and seldom seen, and as such are difficult, if not impossible, to predict. They can be triggered by either unexpected market, economic, or external factors such as geopolitical, war, or terrorist events.

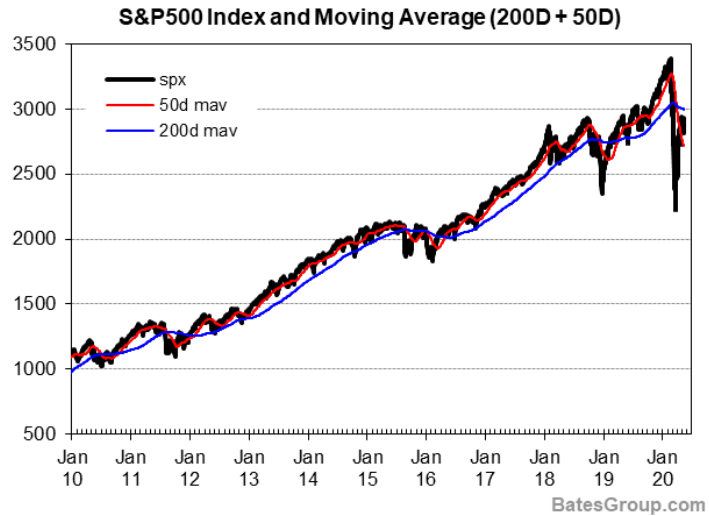
Over the next few pages, we examine in detail bear markets, black swan events, and volatility to gain some perspective on how the recent—or current?—bear market compares with historical periods.



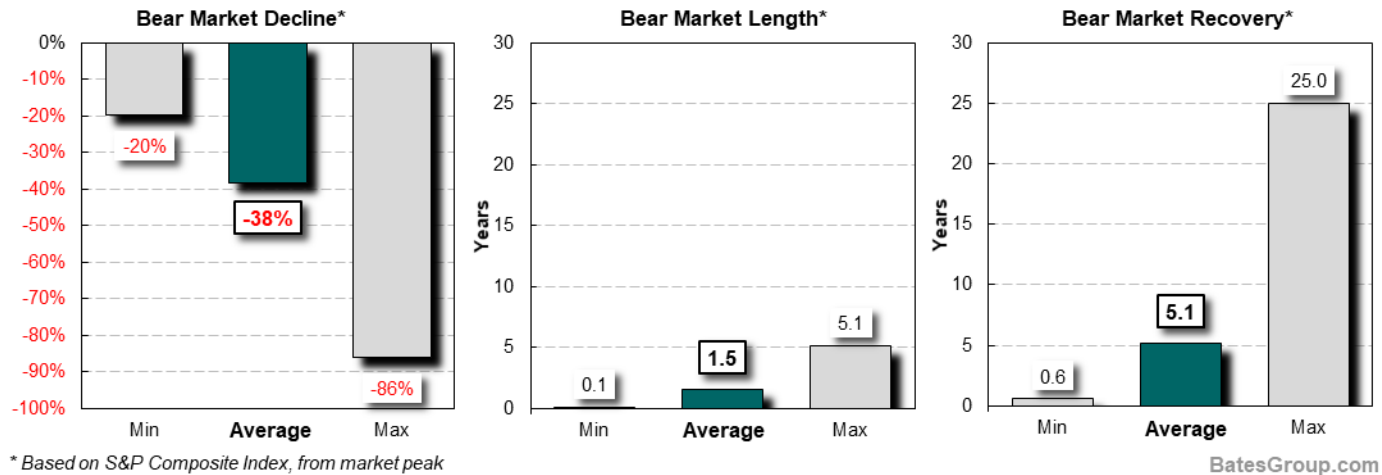
Bear Market Trends

Since the inception of the Standard & Poor’s Composite Index¹ in 1927, 15 bear markets² have occurred in the U.S. with an average decline of 38 percent and an average duration of just over 1.5 years. Over the past 90 years, bear markets have occurred on average every 6 years. Two of those bear markets were before World War II (WW II), and the remaining 13 occurred in the post-war period (see table on page 9).

The last 2 years have been distinguished by two bear markets. The first began on September 20, 2018, and ended on December 24, 2018, with the S&P 500 Index falling 20 percent. After the low was reached in December 2018, the market bounced back, and by the end of 2019, the S&P climbed 44 percent.



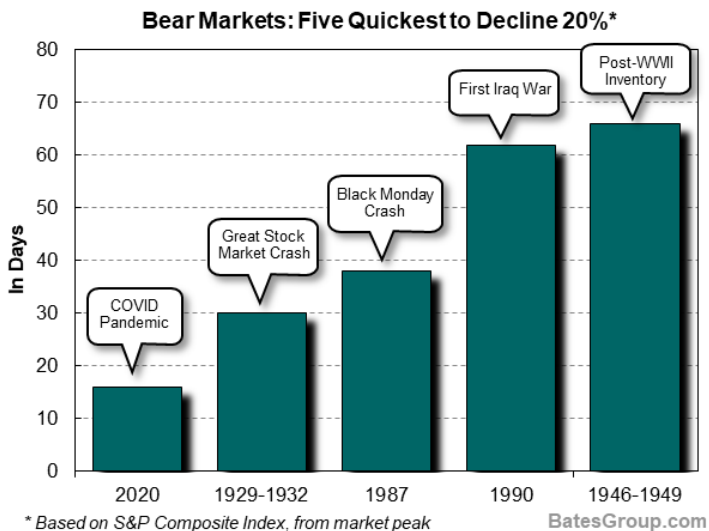
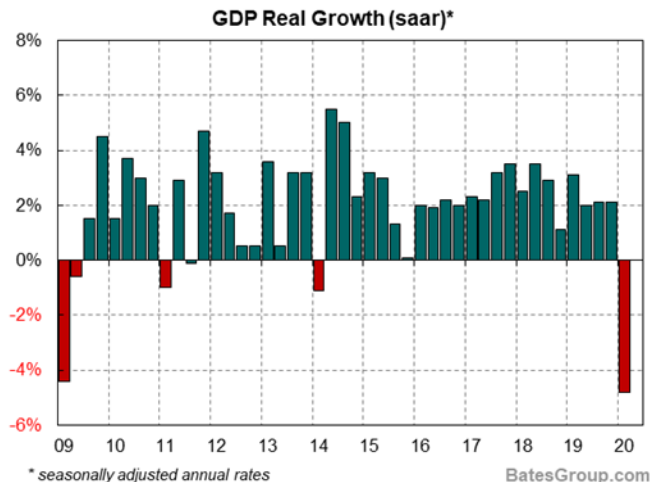
However, that brief bull market run came to an end in early 2020 as the coronavirus outbreak turned into a global health emergency and intensified in the U.S. and around the world. In February, investors became increasingly concerned over the impact that the pandemic would have on the U.S. economy, and as a result, the S&P 500 Index entered a second bear market this year, falling 34 percent between February 19 and March 23.



¹ The first daily comprehensive stock market index developed in the U.S. was the S&P 90 Index, which consisted of 50 industrial, 20 rail, and 20 utility stocks. In March 1957, the S&P 90 Composite Index was expanded and became the S&P 500 Composite Index. Throughout the report, we will be referring to both the S&P 90 and the S&P 500 indices as the S&P 500 Index or S&P Composite Index.

² There is no formal definition of a bear market, but it is generally accepted today as referring to a 20 percent decline in the S&P 500 Index from a market peak. Prior to 2001, the Federal Reserve considered a bear market as a 15% to 20% decline in the S&P 500 Index (see Federal Reserve Bank of San Francisco, *When were the most prolific bull and bear market periods in the United States?*, February 2001).

Because we are more than likely in the early stages of this devastating pandemic, whether the broader equity market will continue to fall further or rebound to new highs remains to be seen. Currently, the consensus view is that if job losses continue to mount and the economic output remains depressed, then a V-shaped recovery is unlikely. The likelier scenario would be a slower and more gradual U-shaped economic recovery with a market recovery beginning once the equity market reaches a bottom. Whether the equity market has already reached a bottom in March 2020 or has further to fall is also unknown.



2020: Steepest Decline in History

We compared the decline in the first quarter of this year with prior stock market downturns and found that the S&P’s steep sell-off and entry into bear market territory in February and March 2020 was the most rapid decline for equity markets in 100 years, beating out even the Stock Market Crash of 1929.

It took just 16 days from the stock market peak on February 19, 2020, for the S&P Composite Index to fall 20 percent. By comparison, during the Stock Market Crash of 1929 it took 30 days.

Other events leading to quick declines into bear country include the Black Monday crash in 1987, the first Iraq War in 1990, and the Post-WW II inventory recession in 1946. Because we measure bear market declines from the stock market peak, Black Monday ranks number three in terms of steepest sell-offs. However, if measured by 1-day price changes, October 1987’s 20.5-percent plunge would rank as the first and only bear market to take just 1 day.

Overall, there was a significant variation in the time it took for the S&P Index to fall 20 percent and enter a bear market, ranging from just 16 days in 2020 to a 310-day decline in 1980 to 1981.³ In comparison, for the 15 bear markets the stock market has experienced since 1929, the average time it took to fall 20 percent was 148 days, or 5 months.

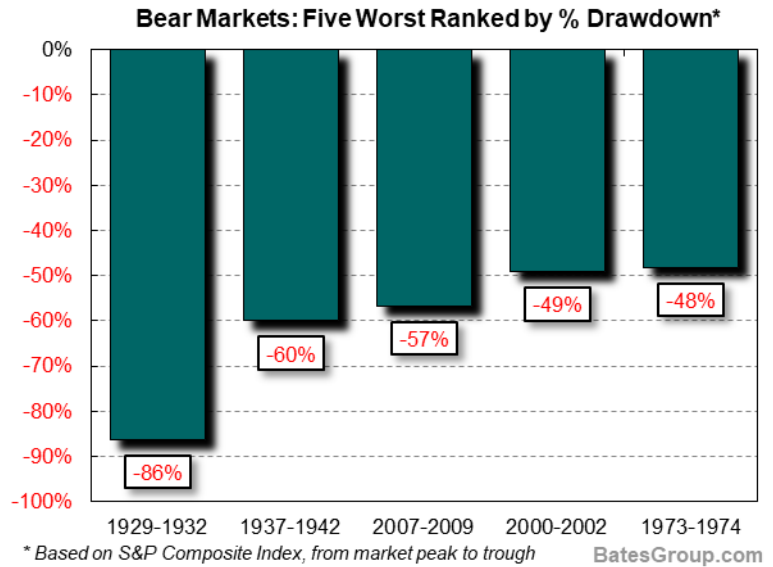
³ A previous version of this report had a misprint with “...to 1989.”

Bear Markets Ranked

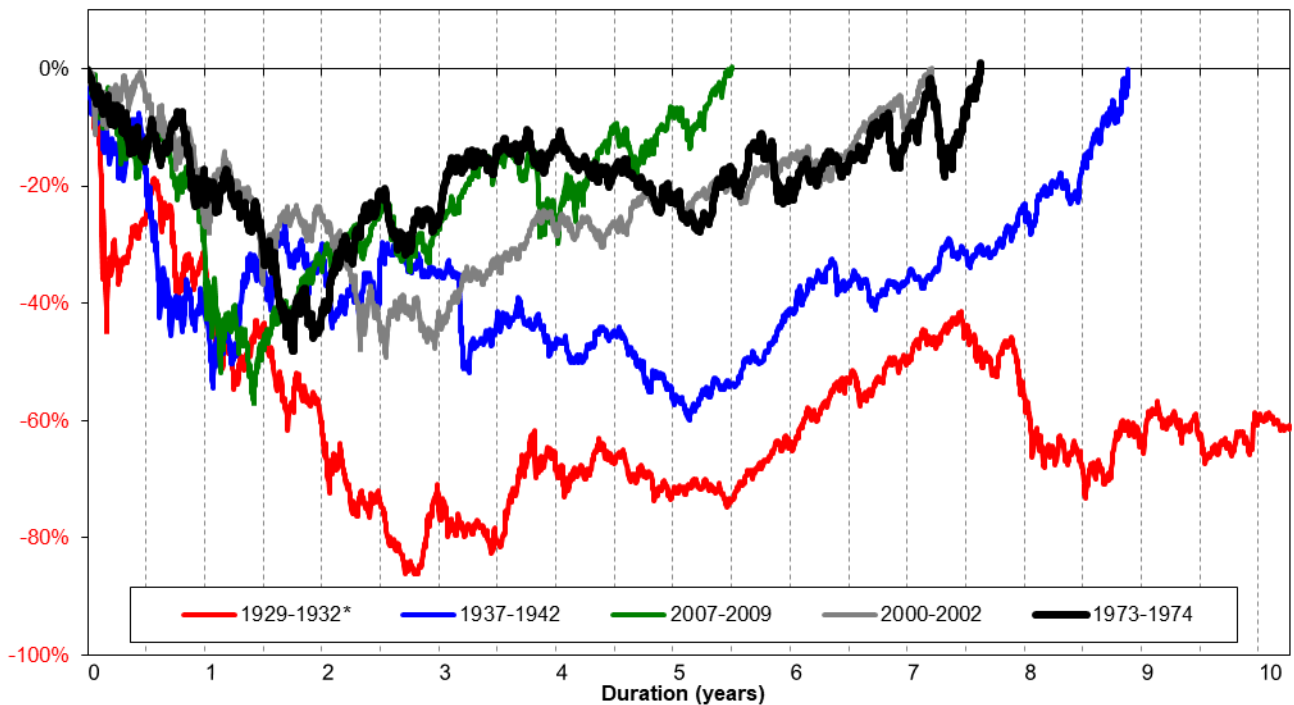
Although the market downturn in the first quarter of this year was the steepest since inception of the S&P Composite Index, it did not (to date) rank in the top five worst bear markets in U.S. history. The Stock Market Crash of 1929 still has the distinction of not only having the largest drawdown or downturn, falling 86 percent from its high, but also taking the longest from which to recover. After reaching a high of 31.86 in mid-September 1929, it took the S&P Index 25 years to reach that index level again.

The second worst bear market started in March 1937 and lasted 5 years. During that timeframe, the S&P Composite Index fell 60 percent before reaching a bottom in April 1942. It would take another 4 years, or until January 1946, before the market fully recovered to reach its March 1937 level—a span of nearly 9 years.

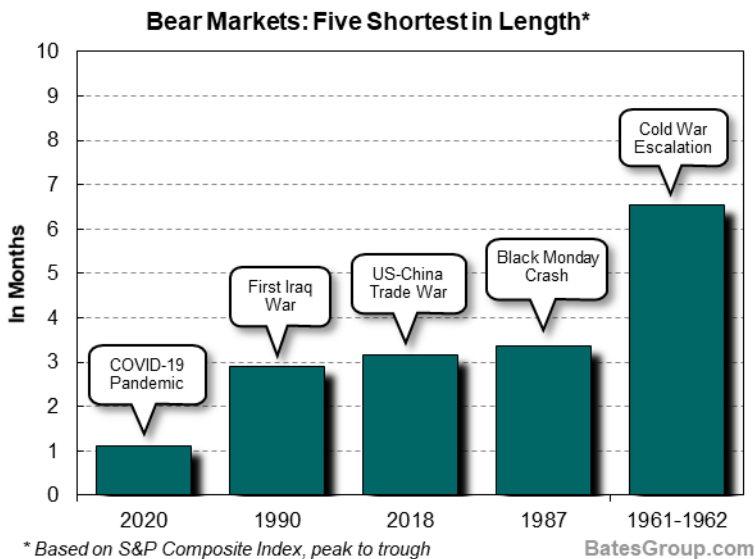
In recent times, two bear markets have the doubtful distinction of being included in the list of the top five worst bear markets in U.S. history—the Financial Crisis of 2007 to 2009 and the Dot-Com crash of 2000 to 2002. During the Financial Crisis, the S&P 500 Index fell 57 percent, while the Dot-Com crash led to a 49-percent decline in the S&P index.⁴



Five Worst Bear Markets in U.S. History
(Based on S&P 500 Index % Change from Peak)



⁴ The Dot-Com crash had the greatest impact on the technology-heavy Nasdaq Composite Index, with the index falling 77 percent.



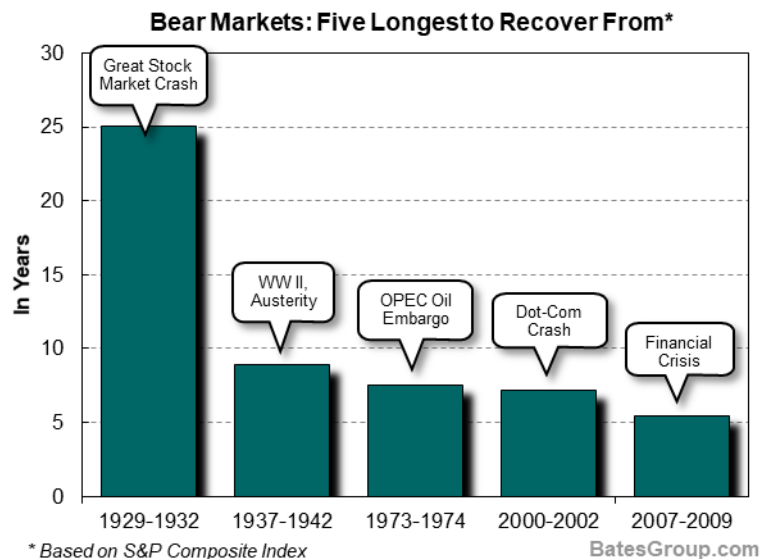
In terms of duration, bear markets, on average, take 20 months until a bottom is reached. If we assume that the bear market in 2020 is finished, then it would rank as the shortest bear market on record at only 33 days, or 1 month. Excluding this year, the quickest bear market (peak to trough) was in 1990 when it took just under 3 months for the market to reach a bottom before bouncing back.

The longest bear market was the 1937 to 1942 bear market that occurred during the Great Depression and continued through the start of WW II. With two major events weighing on the equity markets, that bear market lasted 5 years.

However, in terms of length, the 1937 to 1942 bear market was an exception, as the majority of bear markets historically last between 15 to 37 months.

Although bear markets bottom out in 1.5 years on average, recoveries⁵ can take years before the equity market regains lost ground. On average, it takes approximately 5 years for the stock market to bounce back and reach the level prior to the sell-off. Some recoveries were quick though, with two taking just over half a year to reach new highs. In contrast, it took 25 years for the S&P Index to recover from the Stock Market Crash of 1929 and reach a new high (see table on page 9).

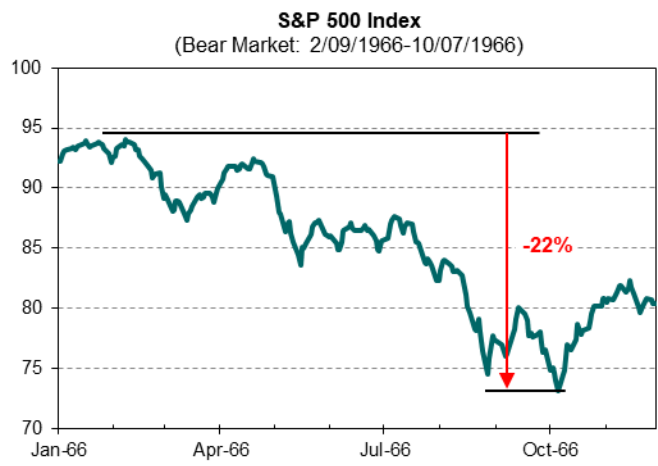
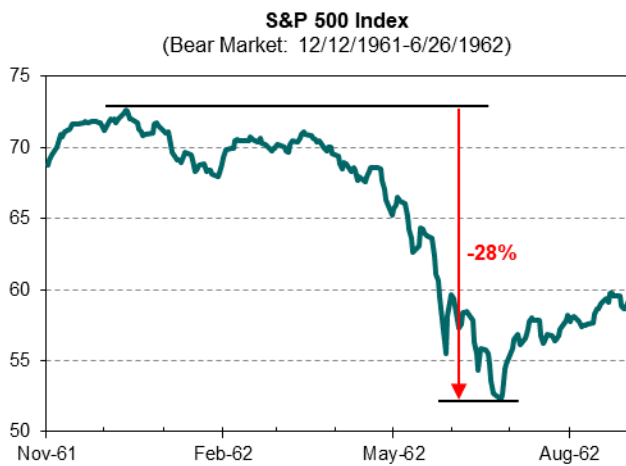
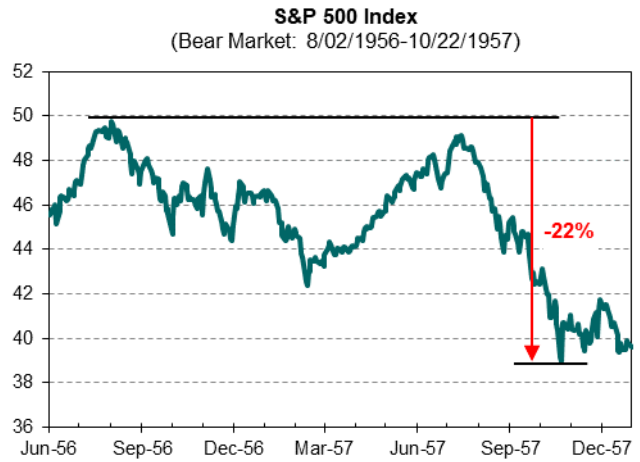
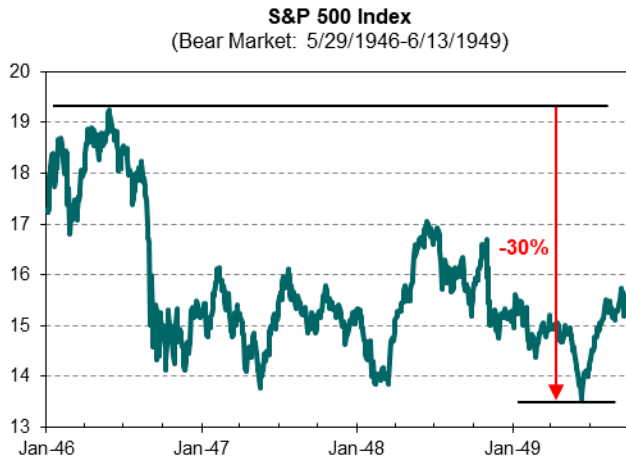
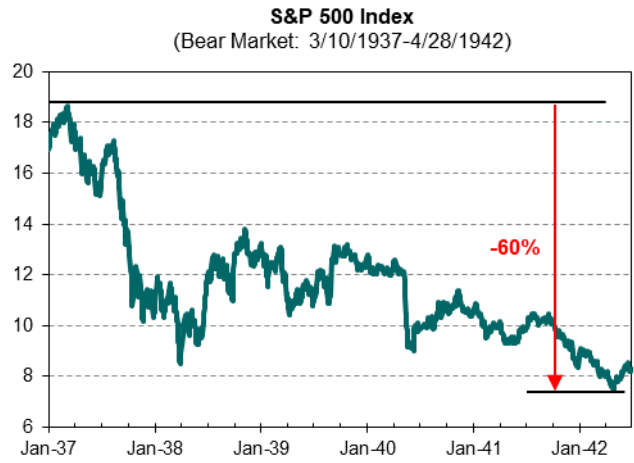
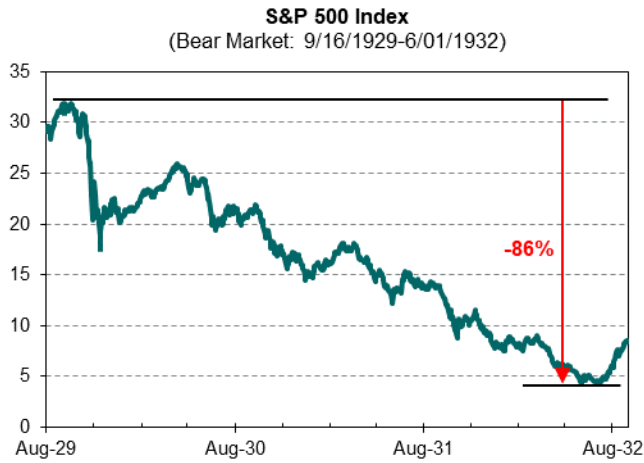
And how does the 2020 bear market rank in terms of recovery? It is still an open question whether the bear market bottomed out in March and is now in the recovery phase, or if it will decline further. Much depends on the type of recovery the U.S. economy will have and the confidence investors will have in the strength of that economic recovery.



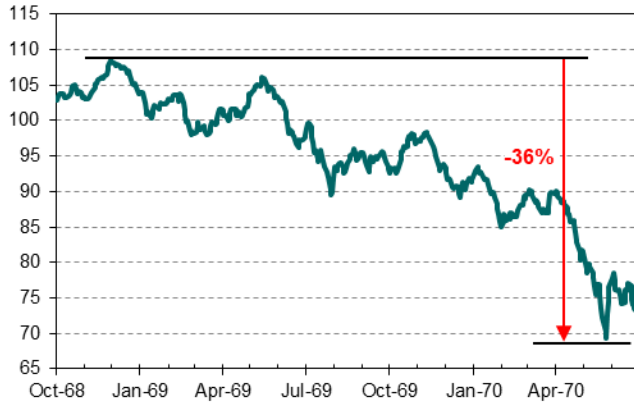
It is worth noting, however, that when equity markets do fall into bear market territory, they typically tend to do so in a series of steps with sell-offs followed by brief bounce backs, then more downward slides and bounce backs, et cetera. This is a pattern that has been exhibited through most of the bear markets over the past 100 years (see charts on pages 7-9). Time will tell if the markets in 2020 follow a similar pattern.

⁵ A recovery is defined as the time it takes for the stock market index to return to the high where it stood before the bear market began.

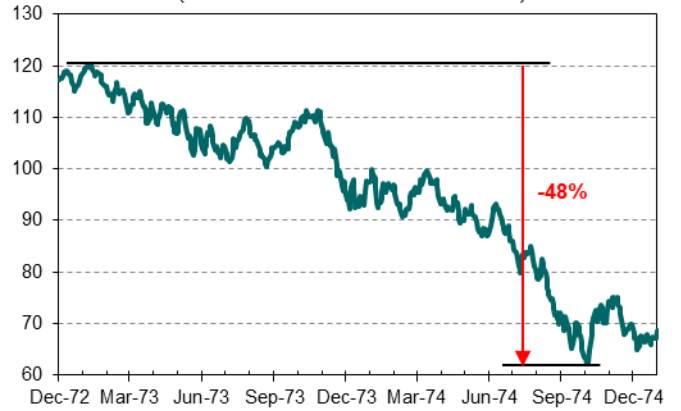
S&P 500 Bear Markets (1929 to 2020)



S&P 500 Index
(Bear Market: 11/29/1968-5/26/1970)



S&P 500 Index
(Bear Market: 1/11/1973-10/03/1974)



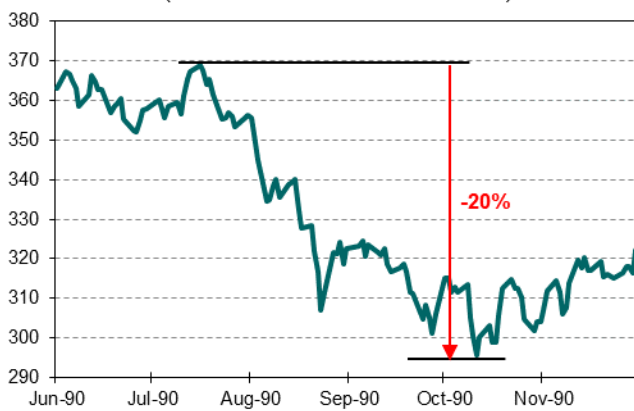
S&P 500 Index
(Bear Market: 11/28/1980-8/12/1982)



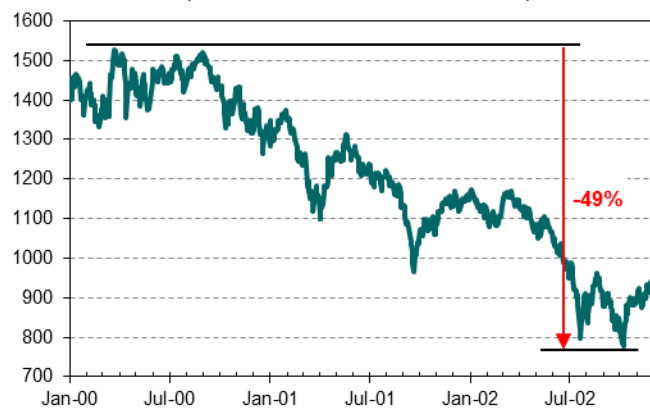
S&P 500 Index
(Bear Market: 8/25/1987-12/04/1987)

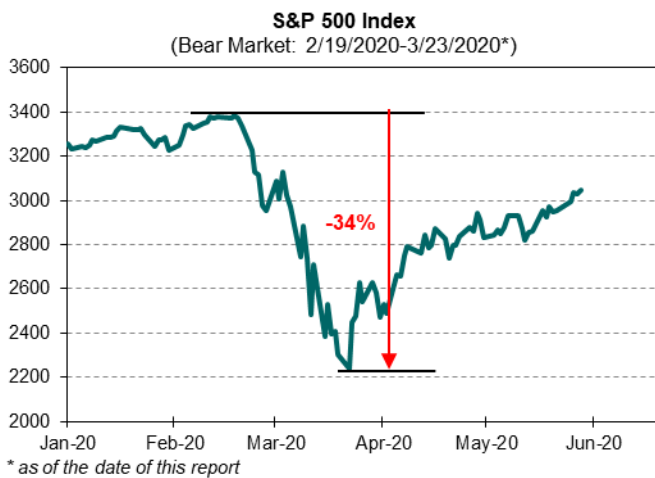
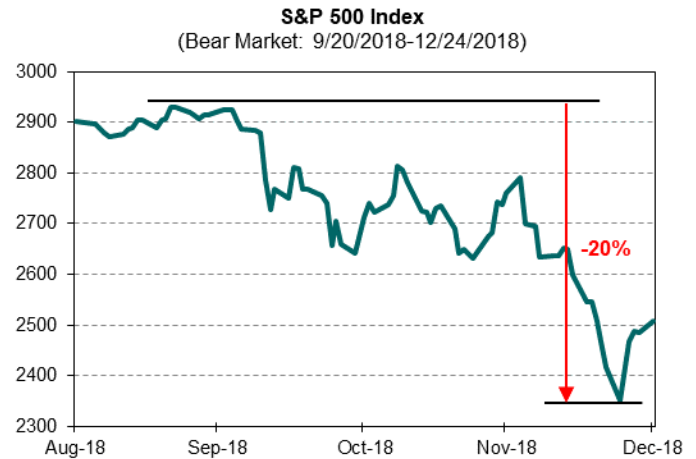
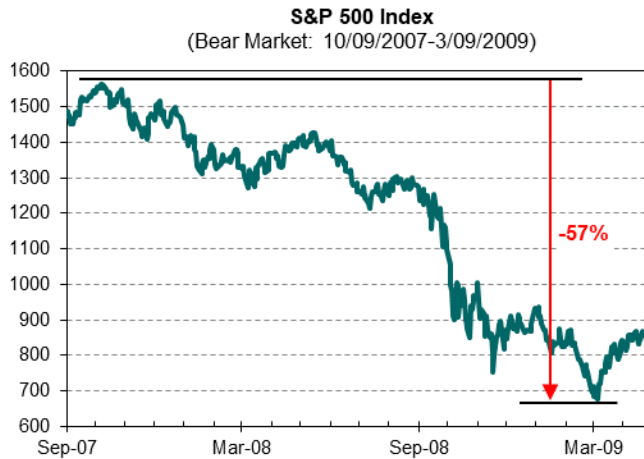


S&P 500 Index
(Bear Market: 7/16/1990-10/11/1990)



S&P 500 Index
(Bear Market: 3/24/2000-10/09/2002)





* as of the date of this report

A History of Bear Markets (1929 to 2020)

| ----- Date ----- | | ----- Index Value ----- | | Percent | Duration | Recession | Years to | Comments |
|------------------|-------------|-------------------------|---------|-------------|-----------|------------|------------|----------------------------------|
| Start | End | Start | End | Loss | (Months) | | Recover | |
| 16-Sep-1929 | 1-Jun-1932 | 31.86 | 4.40 | -86% | 33 | Yes | 25.0 | Crash of 1929 |
| 10-Mar-1937 | 28-Apr-1942 | 18.67 | 7.47 | -60% | 61 | Yes | 8.9 | Austerity measures, WWII |
| 29-May-1946 | 13-Jun-1949 | 19.25 | 13.55 | -30% | 36 | Yes | 4.0 | Post WWII inventory recession |
| 2-Aug-1956 | 22-Oct-1957 | 49.74 | 38.98 | -22% | 15 | Yes | 2.1 | Cold War concerns |
| 12-Dec-1961 | 26-Jun-1962 | 72.64 | 52.32 | -28% | 6 | No | 1.7 | Bay of Pigs, Cold War escalation |
| 9-Feb-1966 | 7-Oct-1966 | 94.06 | 73.20 | -22% | 8 | No | 1.2 | Vietnam War concerns |
| 29-Nov-1968 | 26-May-1970 | 108.37 | 69.29 | -36% | 18 | Yes | 3.3 | Vietnam tensions in U.S. |
| 11-Jan-1973 | 3-Oct-1974 | 120.24 | 62.28 | -48% | 21 | Yes | 7.5 | OPEC oil embargo |
| 28-Nov-1980 | 12-Aug-1982 | 140.52 | 102.42 | -27% | 21 | Yes | 1.9 | Volker high interest rates (20%) |
| 25-Aug-1987 | 4-Dec-1987 | 336.77 | 223.92 | -34% | 3 | No | 1.9 | Black Monday crash |
| 16-Jul-1990 | 11-Oct-1990 | 368.95 | 295.46 | -20% | 3 | Yes | 0.6 | Iraq invades Kuwait (Iraq War) |
| 24-Mar-2000 | 9-Oct-2002 | 1527.46 | 776.76 | -49% | 31 | Yes | 7.2 | Dot-com crash |
| 9-Oct-2007 | 9-Mar-2009 | 1565.15 | 676.53 | -57% | 17 | Yes | 5.5 | Financial crisis |
| 20-Sep-2018 | 24-Dec-2018 | 2930.75 | 2351.10 | -20% | 3 | No | 0.6 | US-China trade war |
| 19-Feb-2020 | 23-Mar-2020 | 3386.15 | 2237.40 | -34% | 1* | No | -- | COVID-19 |
| Average | | -- | -- | -38% | 20 | Yes | 5.1 | -- |

Source: Bloomberg LP, based on S&P 500 Index returns. Start and End refer to peak and trough. Duration is the length of the bear market from peak to trough. Years to Recover is from the pre-bear market peak to when the Index reach the prior level.

*As of the date of publication, March 23, 2020, was the lowest point reached from the market peak in February 2020.

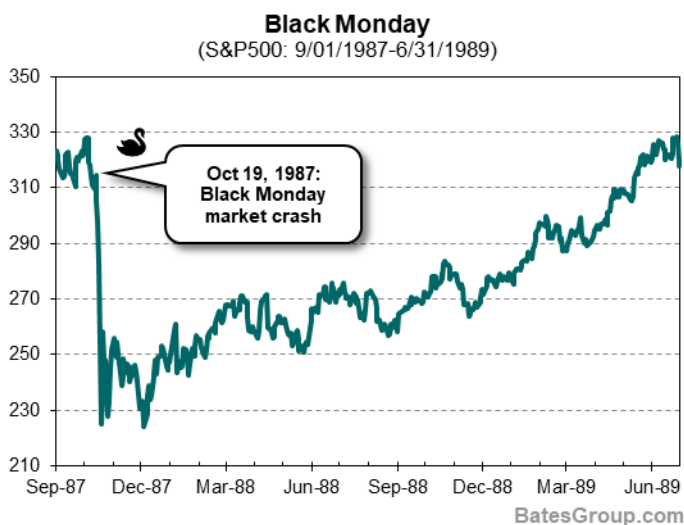
Black Swan Events

Black swan events are primarily considered to be events that are rare or unpredictable, have a significant impact, and are extremely difficult, if not impossible, to predict (except with hindsight bias). The term was originally coined after a black swan, which was historically considered mythical or *rara avis*.⁶ More recently, the term has been used to refer to unexpected negative events occurring in the financial markets.⁷

Although black swan events do have significant impacts on the capital markets, they are not necessarily synonymous with bear markets. Sometimes the impact can be brief and unassociated with a bear market, and at other times black swan events can have a lingering impact by either initiating or prolonging a bear market. The Russian financial crisis in 1998 and Volmageddon in 2018 are two examples of a brief market shock without lingering market effects. In contrast, the collapse of Lehman Brothers had a prolonged and major impact on the capital markets.

It should be noted that black swan events are not necessarily associated just with economic or capital market events. They can often be triggered by unexpected external, or non-market related factors such as geopolitical, war, or terrorist events. The outbreak of the Korean War in 1950 is one example of an external shock. President Eisenhower's heart attack in 1955 and the 9/11 terrorist attacks in 2001 are other examples.

Over the next few pages, we discuss some of those events in more detail in order to provide additional insights on what black swan events are and how they can affect equity markets. Those and other major black swan events are further summarized in the table on page 12.



Black Monday (1987)

Black Monday was an example of a black swan event with a significant and lingering impact on the equity market. In a single trading session (October 19, 1987), the S&P 500 Index fell an unprecedented 20 percent, and the Dow Jones Industrial Average lost 509 points, or 23 percent. For both the S&P 500 and the Dow Industrials, that drop was by far the largest one-day drop since the 1929 Stock Market Crash. For comparison, the 1-day decline for the two indices on Black Monday was, in percentage terms, almost twice the 1-day decline lost by the indices in October 1929.

⁶ The term was first referenced by Roman satirist Juvenal (ad c. 60-130) "*rara avis in terris nigroque simillima cygno,*" or a rare bird on this earth, like nothing so much as a black swan (Oxford Reference). Black swans were considered mythical birds until the first one was observed in Australia in 1697 by the Dutch explorer Willem de Vlamingh.

⁷ The concept of black swan events applying to the financial markets was first used by Nassim Nicholas Taleb in 2001. Taleb posited that black swans have three characteristics: (1) they are outliers, or events outside the realm of regular expectations, (2) they can have extreme effects, and (3) they are, after the fact, predictable with hindsight bias (retrospective determinism) (see Nassim Nicholas Taleb, *Fooled by Randomness*, 2001 and *The Roots of Unfairness: the Black Swan in Arts and Literature*, Journal of the International Comparative Literature Association, November 2004).

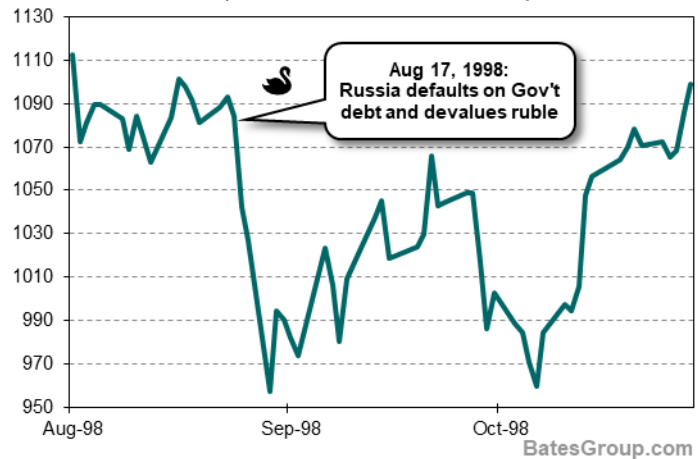
Prior to Black Monday, there was little indication that the markets would plunge more than 20 percent in 1 day. Few signals existed that the markets were largely overvalued and there was little inflationary pressure as well as no signs of economic weakness. Most market professionals believe it was a combination of program trading, herd mentality, and panic selling that led to the record 1-day market sell-off. The impact of this black swan event lingered through the end of the year before the market began to recover, and it took the S&P 500 Index almost 18 months to eventually recover.

Russian Default and Devaluation (1998)

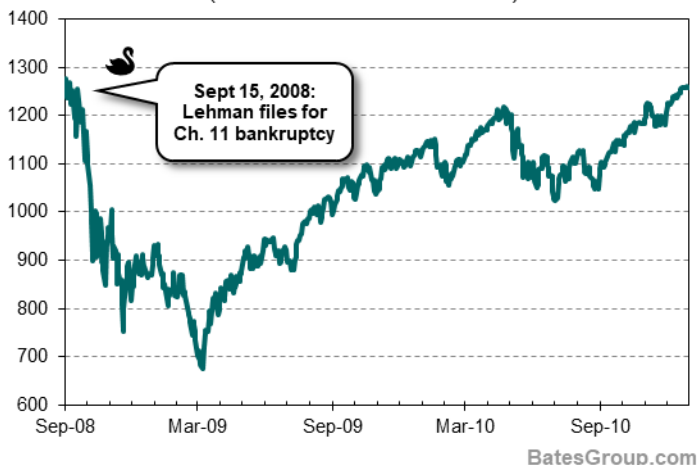
One example of a brief but significant black swan event impacting U.S. equity markets was the Russian financial crisis in August 1998. On August 17, Russia simultaneously defaulted on its government debt and devalued the country’s currency. Even though exposure to Russian assets in the U.S. was minimal, this “one-two punch” had a significant, albeit brief, impact on equity markets in the U.S.

During the last week of August that year, the S&P 500 Index declined 12 percent before quickly rebounding. The Russian crisis also led to the collapse of Long Term Capital Management (LTCM) in September 1998, and a series of interest rate cuts by the U.S. Federal Reserve from late September through mid-November 1998.

Russian Debt Default & Currency Devaluation
(S&P500: 8/01/1998-10/31/1998)



Collapse of Lehman Brothers
(S&P500: 9/02/2008-12/31/2010)



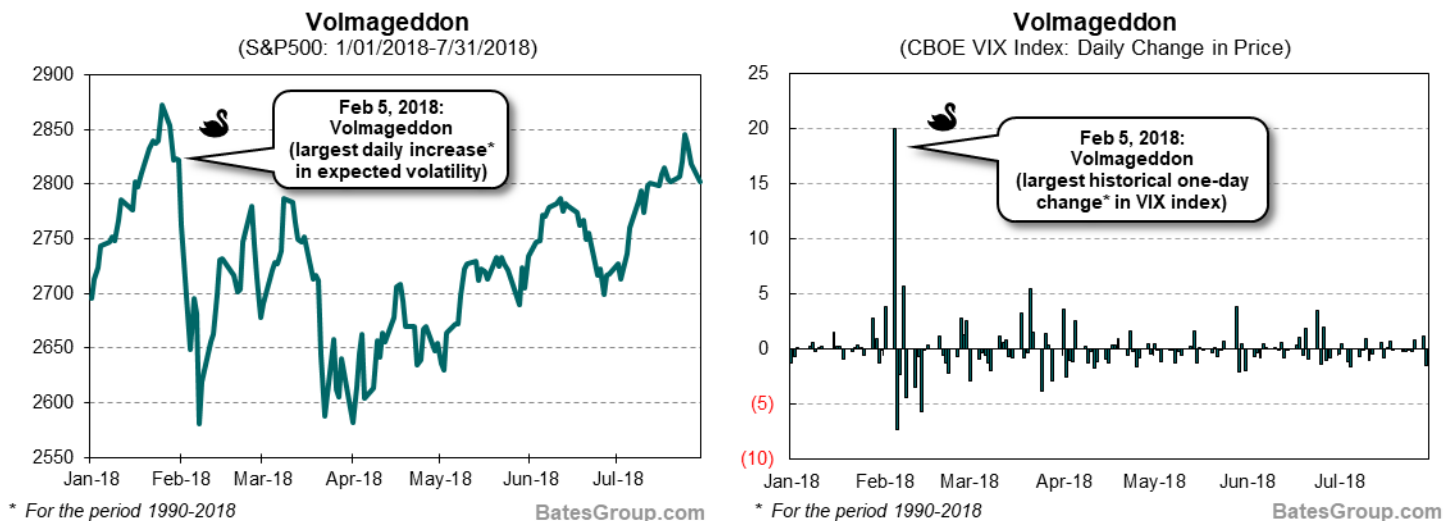
Collapse of Lehman Brothers (2008)

The sudden collapse of Lehman Brothers in September 2008 was an example of a black swan event with a significant and prolonged impact on capital markets. Although the equity markets were already in the midst of a bear market, there was no expectation that one of the oldest and largest investment banks in the U.S. would collapse and file for bankruptcy protection virtually overnight. Such a sudden shock led investors to question the strength of the global financial system and caused a domino effect leading to a global financial meltdown.

By the time the bear market ended 6 months later in March 2009, the S&P 500 Index had declined 46 percent from the Friday prior to Lehman’s overnight collapse and 57 percent from the market peak in 2007. It would take more than 2 years for the S&P 500 Index to reach the level just prior to the Lehman collapse, and at least 5 years to completely recover from the financial crisis that began in 2007.

Volmageddon (2018)

Another more recent example of a brief, albeit significant black swan event, was an event commonly known as Volmageddon. On February 5, 2018, the Dow Jones Industrial Index experienced its worst intraday decline in history, falling 1,500 points during the trading session. As the day ended, the S&P 500 Index had fallen 4.1 percent and the CBOE Volatility (VIX) Index, which tracks expected or implied volatility for the S&P 500, surged, at the time, an unprecedented 20 points or 115 percent. This surge was the largest 1-day jump in the VIX since inception of the index.

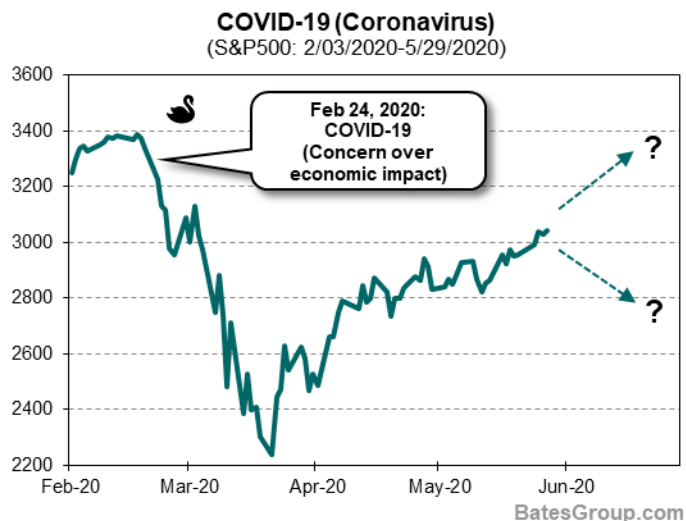


Prior to the extreme 1-day rise in the VIX Index, market volatility in 2017 and early 2018 was relatively benign, with no indication that a 4.1-percent decline in the S&P 500 Index would lead to such a significant rise in the volatility index. Previously, when the equity market declined around 4.1 percent ($\pm 0.2\%$) in a single trading session, the VIX Index rose on average only 7.2 points.

The cause for the 1-day surge in the VIX Index will likely be debated for several years, but initial post-mortem analyses point to a combination of portfolio rebalancing for exchange-traded products (ETPs) that traded in VIX futures and sudden automatic liquidation triggers.

COVID-19 (2020)

It is still early in 2020, but the COVID-19 pandemic is just the most recent example of a black swan event that could have a significant and prolonged impact on the financial markets. The novel virus was first observed in December 2019 when a cluster of pneumonia cases appeared in Wuhan, China. By January 21, 2020, the first coronavirus case was confirmed in the U.S. and on January 30, the World Health Organization (WHO) declared the coronavirus a global health emergency. The pandemic came on with



breathtaking speed, and as the deadly virus quickly spread around the world, countries began implementing public shutdown/lockdown measures to slow the spread of the virus and limit the number of deaths.

By mid-February, it became apparent that this once-in-a-century pandemic (if compared to the 1918 Spanish Flu) could have a significant impact on global supply chains as well as final demand. U.S. businesses began issuing revenue and profit warnings, and Apple, one of the largest companies in the S&P 500 Index, had to revise downward its own guidance given just 2 weeks earlier.

At the time of this report, it is still uncertain how severe and long lasting the economic impact will be. Shutdowns have already had a significant negative impact on jobs and economic output, and successfully reopening the economy will be a challenge. Reopen too soon and there could be a risk of a second and even more deadly spike in cases, similar to the 1918 influenza pandemic. That could be economically devastating. According to a 2008 Federal Reserve report, an influenza pandemic similar to the 1918 pandemic could lead to a significant recession and “several years of negative economic consequences.”⁸ If such an economic scenario because of the coronavirus plays out, it could have a prolonged negative impact on the equity markets.

A History of Black Swan Events (1929 to 2020)

| Date | --- Change (in %) --- | | Volatility (x 1SD) | During | | Event |
|----------------|-----------------------|--------------|-----------------------|-----------|--------------|---|
| | 1 Day | 1 Week | | Bear Mkt? | Type | |
| 28-Oct-1929 | -12.9% | -12.4% | 8 | Y | Economic | Black Tuesday, panic selling |
| 10-May-1940 | -3.0% | -13.5% | 3 | Y | War | Germany invades France |
| 8-Dec-1941 | -3.8% | -6.3% | 3 | Y | War | Attack on Pearl Harbor |
| 3-Sep-1946 | -9.9% | -9.8% | 6 | Y | Economic | Coincidental large block trades |
| 26-Jun-1950 | -5.4% | -7.6% | 5 | N | War | Outbreak of Korean War |
| 26-Sep-1955 | -6.6% | -4.3% | 5 | N | Geopolitical | Pres. Eisenhower heart attack |
| 28-May-1962 | -6.7% | -3.7% | 8 | Y | Economic | Flash (specialist) crash, Cuba crisis |
| 22-Nov-1963 | -2.8% | 2.8% | 5 | N | Terror | Pres. Kennedy assassination |
| 19-Oct-1987 | -20.5% | -12.2% | 11 | Y | Economic | Black Monday |
| 27-Oct-1997 | -6.9% | -2.9% | 5 | N | Economic | Asian financial crisis |
| 31-Aug-1998 | -6.8% | -5.2% | 3 | N | Economic | Russian debt default, ruble devaluation |
| 11-Sep-2001* | -- | -4.9% | -- | Y | Terror | 9/11 terrorist attacks |
| 15-Sep-2008 | -4.7% | 0.3% | 3 | Y | Economic | Lehman Bros. collapse |
| 6-May-2010 | -3.2% | 0.5% | 3 | N | Economic | Flash crash, program trading |
| 8-Aug-2011 | -6.7% | -1.7% | 6 | N | Economic | U.S. Government debt downgraded |
| 5-Feb-2018 | -4.1% | -5.2% | 6 | Y | Economic | Volmageddon, surge in volatility index |
| 16-Mar-2020 | -12.0% | -15.0% | 5 | Y | Pandemic | Coronavirus pandemic, Fed intervention |
| Average | -7.2% | -5.9% | 5 | -- | -- | -- |

Percentage change based on S&P 500 Composite Index prices. Volatility is calculated as 5 day annualized daily standard deviation / prior 250 day annualized standard deviation.

*The equity markets were closed for 1 week following 9/11. As a result, no 1-day change is available. Similarly, no 5 trading day volatility post-event is available.

⁸ Federal Reserve Bank of St. Louis, *The Economic Impact of an Influenza Pandemic on the United States*, February 2008.

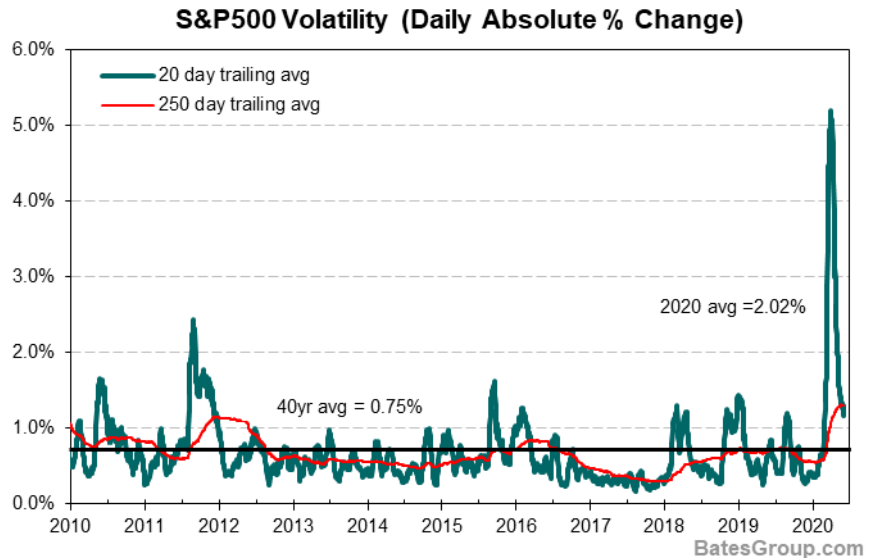
Volatility Trends

Daily Price Changes

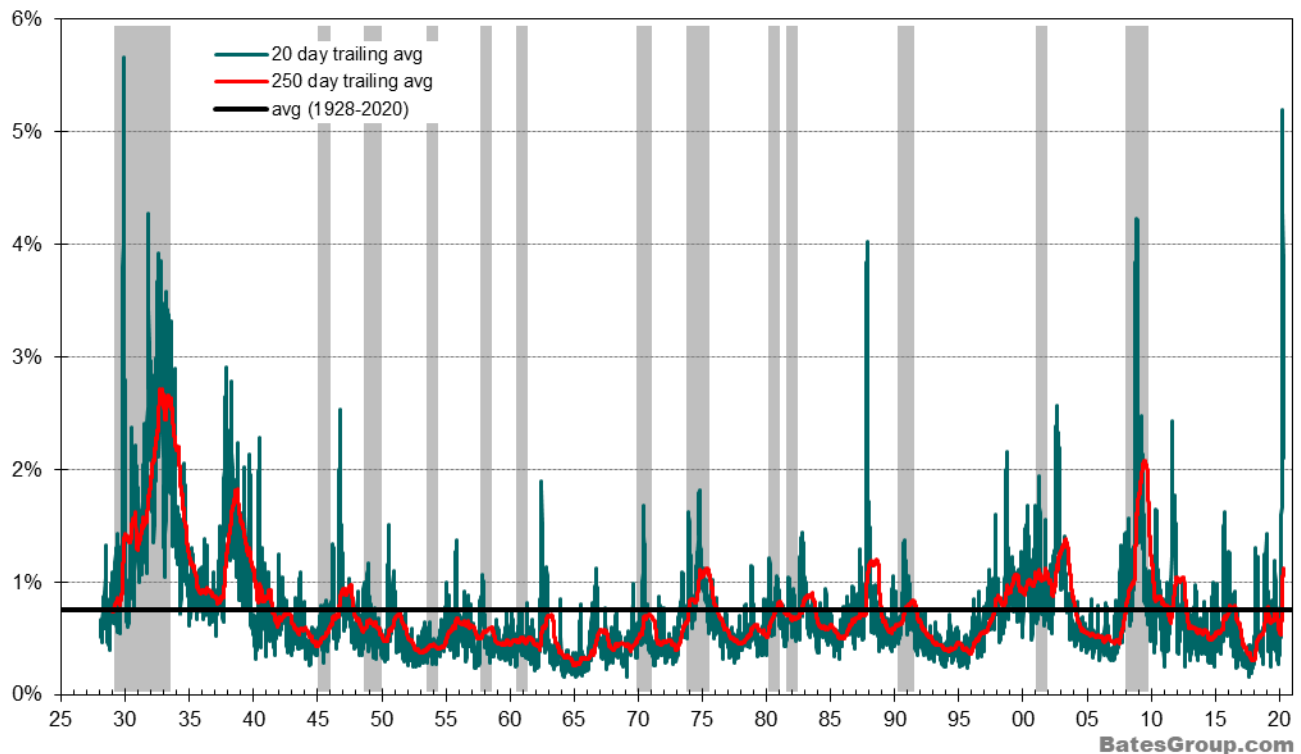
For the past decade, equity market volatility was relatively low compared to the long-term average. However, that changed in early 2020 as the potential impact of the coronavirus on the U.S. economy created considerable uncertainty in the equity markets.

In late February, volatility in the S&P 500 Index increased significantly, with a record number of days exhibiting daily price changes of ± 3.0 percent or greater. In March, the average absolute daily price change for the S&P 500 Index was ± 4.95

percent. In other words, on any given day in March, an investor could have expected to experience a 5-percent price swing in the S&P 500 Index. Year-to-date, the S&P 500 has moved up or down 2.0 percent on average. By comparison, over the past 40 years, the average daily absolute price swing was 0.75 percent.



S&P500 Index Volatility, Absolute Daily Percentage Change (1928-2020)*

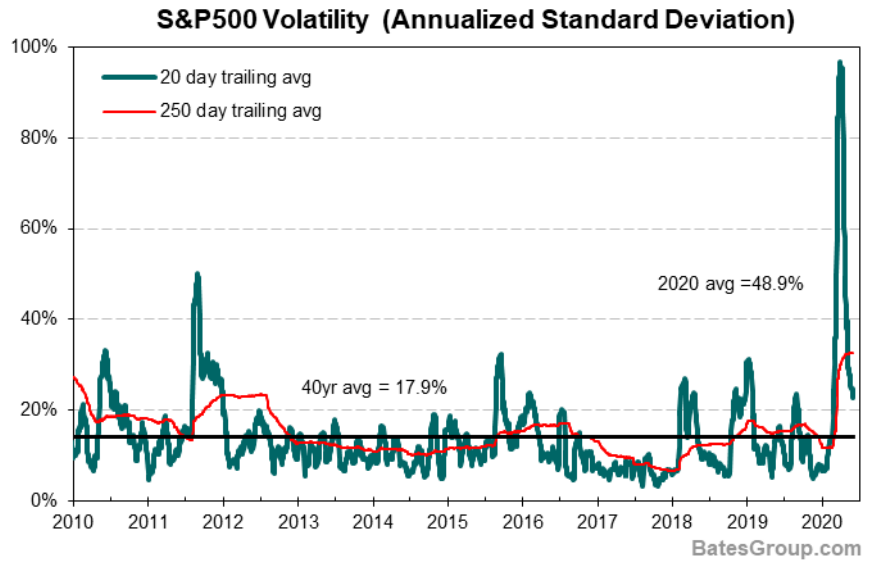


* Shaded areas represent recessions (NBER)

Standard Deviation

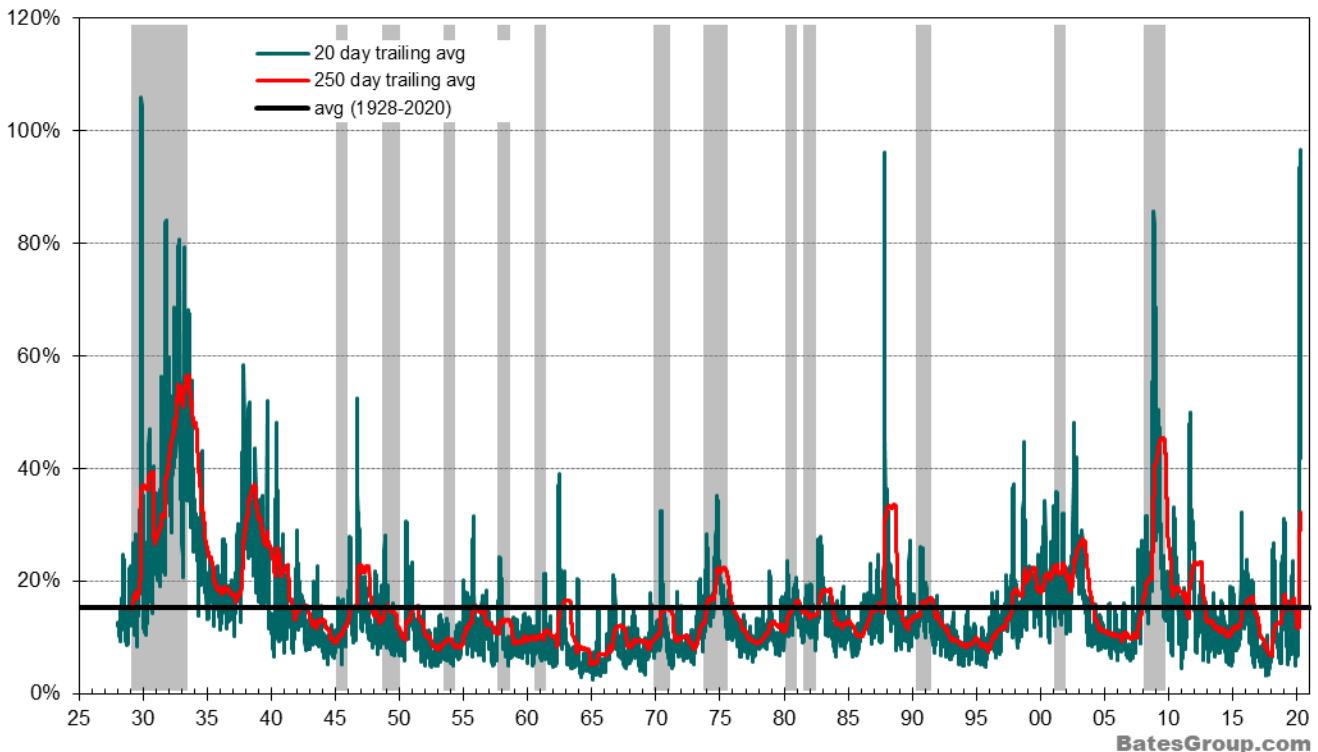
In terms of measuring the S&P’s volatility by annualized standard deviation, the index experienced a historic surge in volatility in the first 4 months of 2020. Year-to-date, the S&P 500 Index had an annualized standard deviation of 51.4 percent. That standard deviation compares to the long-term (1928 to 2020) average volatility of 18.7 percent.

March was a month of extremely high volatility for the S&P 500 Index with an annualized standard deviation of 93.1 percent.



How does the sharp spike in volatility in 2020 compare to prior market downturns? Such a dramatic rise in short-term volatility for the equity market has been experienced just four times previously in the last 100 years (*see chart below*). In fact, when measured by a 1-month annualized standard deviation, the spike in March for this year ranks as one of the steepest increases in the history of the S&P Composite Index, second only to the Stock Market Crash of 1929.

S&P500 Index Volatility, Annualized Standard Deviation (1928-2020)*



* Shaded areas represent recessions (NBER)

S&P 90/500 Index Historical Volatility Table (1928 to 2020)*

Number of Days with Percentage Moves Greater Than...

| | <-1.0% | >1.0% | Total | <-2.0% | >2.0% | Total | <-4.0% | >4.0% | Total | <-5.0% | >5.0% | Total | daily avg abs % ch | annualized stdev |
|------|--------|-------|-------|--------|-------|-------|--------|-------|-------|--------|-------|-------|-----------------------|---------------------|
| 1928 | 27 | 40 | 67 | 4 | 2 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0.73% | 14.83% |
| 1929 | 48 | 66 | 114 | 29 | 18 | 47 | 11 | 5 | 16 | 9 | 5 | 14 | 1.43% | 37.14% |
| 1930 | 70 | 58 | 128 | 32 | 18 | 50 | 4 | 3 | 7 | 1 | 0 | 1 | 1.31% | 27.21% |
| 1931 | 97 | 69 | 166 | 55 | 35 | 90 | 10 | 10 | 20 | 2 | 7 | 9 | 1.87% | 40.24% |
| 1932 | 95 | 86 | 181 | 68 | 64 | 132 | 27 | 30 | 57 | 14 | 18 | 32 | 2.59% | 53.39% |
| 1933 | 75 | 87 | 162 | 42 | 52 | 94 | 18 | 20 | 38 | 9 | 11 | 20 | 2.23% | 48.59% |
| 1934 | 59 | 61 | 120 | 27 | 26 | 53 | 3 | 2 | 5 | 1 | 1 | 2 | 1.23% | 26.01% |
| 1935 | 40 | 51 | 91 | 9 | 15 | 24 | 0 | 0 | 0 | 0 | 0 | 0 | 0.92% | 18.39% |
| 1936 | 29 | 59 | 88 | 11 | 8 | 19 | 0 | 0 | 0 | 0 | 0 | 0 | 0.86% | 17.51% |
| 1937 | 62 | 55 | 117 | 34 | 19 | 53 | 10 | 3 | 13 | 4 | 2 | 6 | 1.32% | 29.40% |
| 1938 | 67 | 74 | 141 | 27 | 44 | 71 | 5 | 9 | 14 | 4 | 1 | 5 | 1.56% | 31.70% |
| 1939 | 52 | 52 | 104 | 23 | 18 | 41 | 3 | 2 | 5 | 1 | 1 | 2 | 1.11% | 25.81% |
| 1940 | 35 | 36 | 71 | 12 | 8 | 20 | 4 | 3 | 7 | 4 | 1 | 5 | 0.86% | 21.91% |
| 1941 | 29 | 25 | 54 | 6 | 5 | 11 | 0 | 1 | 1 | 0 | 0 | 0 | 0.67% | 14.96% |
| 1942 | 26 | 33 | 59 | 2 | 5 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0.65% | 13.58% |
| 1943 | 17 | 25 | 42 | 4 | 3 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0.59% | 13.15% |
| 1944 | 8 | 8 | 16 | 1 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0.44% | 9.04% |
| 1945 | 22 | 26 | 48 | 7 | 2 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0.61% | 12.74% |
| 1946 | 37 | 40 | 77 | 14 | 15 | 29 | 4 | 2 | 6 | 2 | 0 | 2 | 0.93% | 22.74% |
| 1947 | 31 | 30 | 61 | 5 | 2 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0.68% | 14.18% |
| 1948 | 24 | 30 | 54 | 7 | 3 | 10 | 3 | 0 | 3 | 0 | 0 | 0 | 0.64% | 15.27% |
| 1949 | 16 | 18 | 34 | 4 | 2 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0.54% | 11.63% |
| 1950 | 22 | 33 | 55 | 7 | 2 | 9 | 1 | 0 | 1 | 1 | 0 | 1 | 0.66% | 14.84% |
| 1951 | 17 | 19 | 36 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0.53% | 10.74% |
| 1952 | 8 | 5 | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.37% | 7.87% |
| 1953 | 15 | 8 | 23 | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0.44% | 9.53% |
| 1954 | 6 | 11 | 17 | 1 | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0.47% | 9.37% |
| 1955 | 20 | 25 | 45 | 5 | 7 | 12 | 1 | 0 | 1 | 1 | 0 | 1 | 0.65% | 15.29% |
| 1956 | 23 | 25 | 48 | 1 | 4 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0.61% | 12.38% |
| 1957 | 24 | 17 | 41 | 5 | 3 | 8 | 0 | 1 | 1 | 0 | 0 | 0 | 0.56% | 12.94% |
| 1958 | 6 | 13 | 19 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.46% | 8.95% |
| 1959 | 14 | 10 | 24 | 1 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0.44% | 9.36% |
| 1960 | 16 | 14 | 30 | 1 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0.50% | 10.35% |
| 1961 | 7 | 14 | 21 | 2 | 1 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0.44% | 10.08% |
| 1962 | 33 | 24 | 57 | 6 | 7 | 13 | 1 | 1 | 2 | 1 | 0 | 1 | 0.70% | 16.47% |
| 1963 | 4 | 3 | 7 | 1 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0.38% | 8.59% |
| 1964 | 3 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.26% | 5.24% |
| 1965 | 8 | 1 | 9 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0.31% | 6.91% |
| 1966 | 25 | 16 | 41 | 3 | 2 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0.55% | 11.75% |
| 1967 | 9 | 10 | 19 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0.41% | 8.36% |
| 1968 | 9 | 12 | 21 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0.45% | 9.35% |
| 1969 | 17 | 8 | 25 | 1 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0.50% | 10.00% |
| 1970 | 34 | 31 | 65 | 4 | 7 | 11 | 0 | 1 | 1 | 0 | 1 | 1 | 0.69% | 15.10% |
| 1971 | 14 | 18 | 32 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0.48% | 10.17% |
| 1972 | 6 | 4 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.40% | 7.93% |
| 1973 | 43 | 35 | 78 | 6 | 9 | 15 | 0 | 0 | 0 | 0 | 0 | 0 | 0.78% | 15.76% |
| 1974 | 67 | 47 | 114 | 15 | 17 | 32 | 0 | 3 | 3 | 0 | 0 | 0 | 1.06% | 21.73% |
| 1975 | 35 | 45 | 80 | 3 | 8 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0.79% | 15.37% |
| 1976 | 14 | 25 | 39 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.57% | 11.06% |
| 1977 | 12 | 5 | 17 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.45% | 9.04% |
| 1978 | 24 | 19 | 43 | 1 | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0.61% | 12.55% |
| 1979 | 13 | 17 | 30 | 1 | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0.51% | 10.80% |

*Data based on daily closing prices. On March 4, 1957, the S&P 500 Composite Index was introduced to replace the S&P 90 Composite Index.

Number of Days with Percentage Moves Greater Than...

| | <-1.0% | >1.0% | Total | <-2.0% | >2.0% | Total | <-4.0% | >4.0% | Total | <-5.0% | >5.0% | Total | daily avg abs % ch | annualized stdev |
|-----------------|-----------|-----------|-----------|----------|----------|-----------|----------|----------|----------|----------|----------|----------|-----------------------|---------------------|
| 1980 | 37 | 43 | 80 | 7 | 4 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0.82% | 16.40% |
| 1981 | 30 | 24 | 54 | 4 | 3 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0.66% | 13.40% |
| 1982 | 38 | 44 | 82 | 6 | 11 | 17 | 0 | 1 | 1 | 0 | 0 | 0 | 0.85% | 18.18% |
| 1983 | 26 | 29 | 55 | 1 | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0.66% | 13.27% |
| 1984 | 16 | 25 | 41 | 0 | 7 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0.61% | 12.70% |
| 1985 | 7 | 21 | 28 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0.50% | 10.12% |
| 1986 | 25 | 35 | 60 | 6 | 3 | 9 | 1 | 0 | 1 | 0 | 0 | 0 | 0.67% | 14.64% |
| 1987 | 42 | 53 | 95 | 20 | 20 | 40 | 4 | 3 | 7 | 3 | 2 | 5 | 1.13% | 32.01% |
| 1988 | 31 | 37 | 68 | 5 | 11 | 16 | 2 | 0 | 2 | 1 | 0 | 1 | 0.74% | 17.02% |
| 1989 | 14 | 26 | 40 | 2 | 2 | 4 | 1 | 0 | 1 | 1 | 0 | 1 | 0.58% | 13.01% |
| 1990 | 42 | 33 | 75 | 8 | 5 | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 0.77% | 15.89% |
| 1991 | 25 | 34 | 59 | 2 | 7 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0.67% | 14.24% |
| 1992 | 11 | 17 | 28 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.46% | 9.64% |
| 1993 | 7 | 10 | 17 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0.40% | 8.57% |
| 1994 | 15 | 12 | 27 | 1 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0.46% | 9.80% |
| 1995 | 4 | 9 | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.37% | 7.78% |
| 1996 | 17 | 21 | 38 | 3 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0.56% | 11.73% |
| 1997 | 31 | 50 | 81 | 6 | 9 | 15 | 1 | 1 | 2 | 1 | 1 | 2 | 0.85% | 18.06% |
| 1998 | 32 | 47 | 79 | 12 | 11 | 23 | 1 | 2 | 3 | 1 | 1 | 2 | 0.92% | 20.21% |
| 1999 | 40 | 52 | 92 | 9 | 14 | 23 | 0 | 0 | 0 | 0 | 0 | 0 | 0.91% | 18.00% |
| 2000 | 54 | 48 | 102 | 19 | 18 | 37 | 1 | 1 | 2 | 1 | 0 | 1 | 1.06% | 22.13% |
| 2001 | 54 | 51 | 105 | 13 | 12 | 25 | 2 | 2 | 4 | 0 | 1 | 1 | 1.03% | 21.47% |
| 2002 | 72 | 53 | 125 | 29 | 23 | 52 | 1 | 5 | 6 | 0 | 2 | 2 | 1.27% | 25.94% |
| 2003 | 37 | 45 | 82 | 5 | 10 | 15 | 0 | 0 | 0 | 0 | 0 | 0 | 0.83% | 17.00% |
| 2004 | 20 | 21 | 41 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.54% | 11.05% |
| 2005 | 17 | 13 | 30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.52% | 10.24% |
| 2006 | 13 | 16 | 29 | 0 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0.47% | 10.00% |
| 2007 | 34 | 31 | 65 | 11 | 6 | 17 | 0 | 0 | 0 | 0 | 0 | 0 | 0.72% | 15.92% |
| 2008 | 75 | 59 | 134 | 41 | 31 | 72 | 15 | 13 | 28 | 11 | 7 | 18 | 1.74% | 40.79% |
| 2009 | 55 | 62 | 117 | 28 | 27 | 55 | 6 | 5 | 11 | 1 | 2 | 3 | 1.24% | 27.18% |
| 2010 | 37 | 39 | 76 | 10 | 12 | 22 | 0 | 1 | 1 | 0 | 0 | 0 | 0.80% | 17.98% |
| 2011 | 48 | 48 | 96 | 21 | 14 | 35 | 4 | 3 | 7 | 1 | 0 | 1 | 1.04% | 23.18% |
| 2012 | 21 | 29 | 50 | 3 | 3 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0.59% | 12.72% |
| 2013 | 17 | 21 | 38 | 2 | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0.54% | 11.02% |
| 2014 | 19 | 19 | 38 | 4 | 2 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0.53% | 11.33% |
| 2015 | 31 | 41 | 72 | 6 | 4 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0.72% | 15.43% |
| 2016 | 22 | 26 | 48 | 5 | 4 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0.58% | 13.04% |
| 2017 | 4 | 4 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.30% | 6.66% |
| 2018 | 32 | 32 | 64 | 15 | 5 | 20 | 1 | 1 | 2 | 0 | 0 | 0 | 0.74% | 16.98% |
| 2019 | 15 | 22 | 37 | 5 | 2 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0.57% | 12.42% |
| 2020ytd | 28 | 29 | 57 | 18 | 16 | 34 | 8 | 8 | 16 | 4 | 5 | 9 | 2.02% | 48.87% |
| 28-20avg | 29 | 31 | 60 | 9 | 8 | 17 | 2 | 2 | 3 | 1 | 1 | 2 | 0.76% | 18.73% |

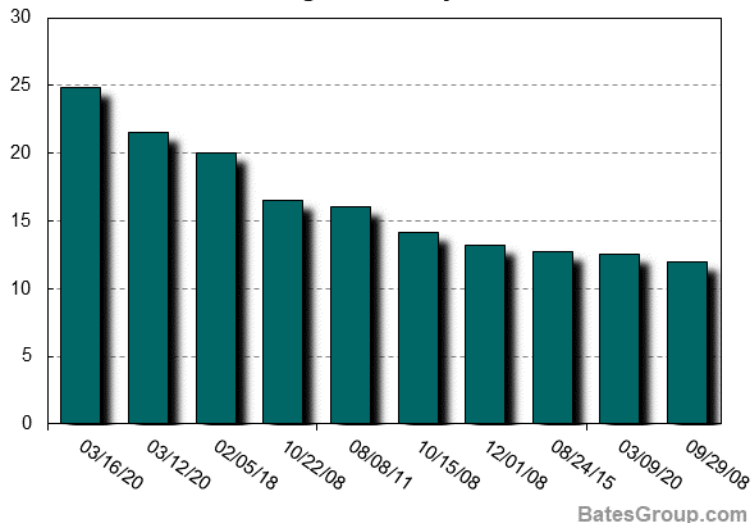
*Data based on daily closing prices. On March 4, 1957, the S&P 500 Composite Index was introduced to replace the S&P 90 Composite Index.

CBOE Volatility (VIX) Index

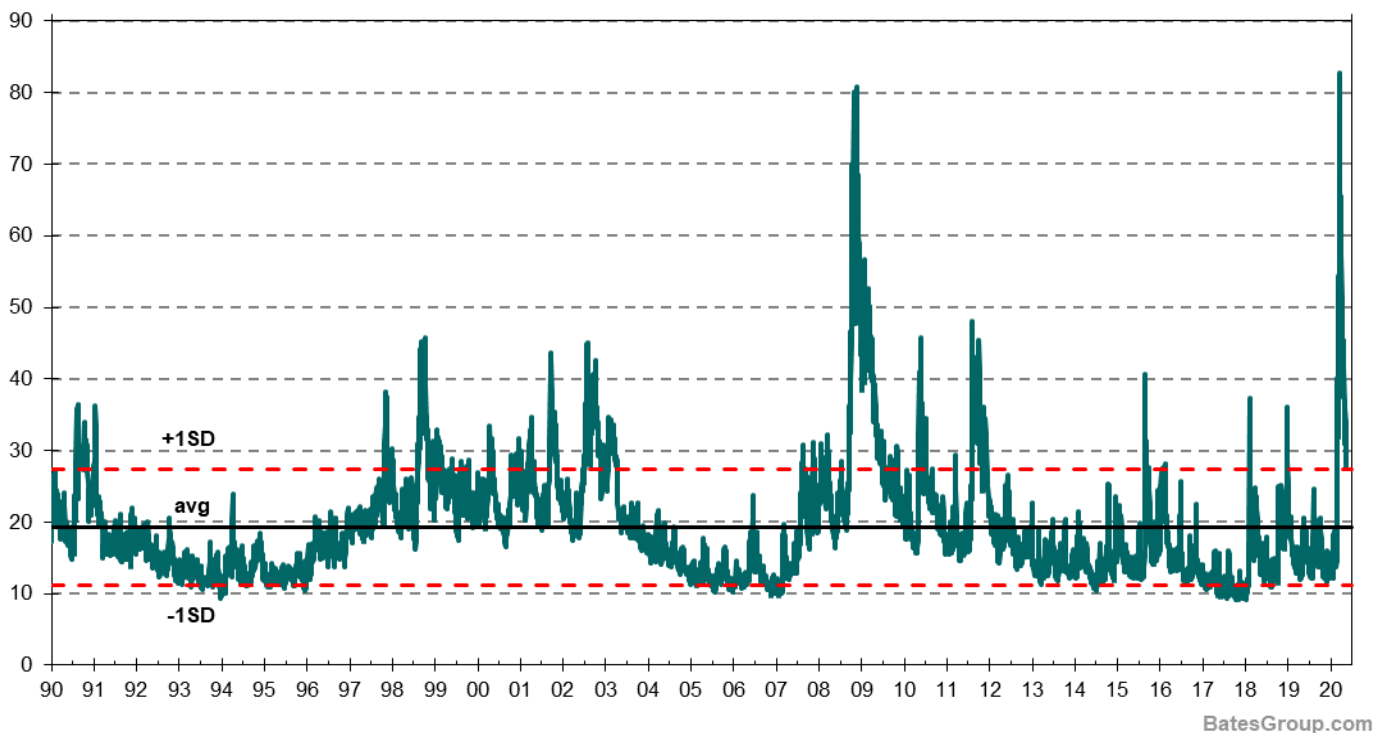
Market volatility, as measured by the CBOE Volatility (VIX) Index,⁹ surged to a record high of 82.69 on March 16, 2020, as the S&P 500 Index plunged 12 percent and the Dow Jones Industrial Average fell 3,000 points. The drop was the highest level in the history of the index and is rivaled only by the previous high set on November 20, 2008, during the height of the credit crisis. This compares to the average daily close of 19.32 for the 1990 to 2020 period (*see chart below*).

The 2 days with the greatest single-day increase in the history of the VIX occurred in March 2020. On March 12, the volatility index jumped 21.57 points as the S&P 500 Index fell 9.51 percent, and 2 trading days later, on March 16, the VIX surged another 24.86 points as the Composite Index plunged 12 percent. Both surges occurred on days when the S&P 500 Index fell 9.5 percent or more. In contrast, the 20-point rise on February 5, 2018, occurred when the S&P Index fell a moderate 4.1 percent.

VIX Index: Largest One-Day Index Moves



CBOE Volatility Index (1990-2020)



⁹ The VIX Index is a measure of investor’s expectation of future short-term market volatility and is composed of S&P 500 “call and put options” over a wide range of strike prices, with expirations between 23 and 37 days.

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