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Will the U.S. Stock Market Crash? Actually, the Key Question is What is the Probability?

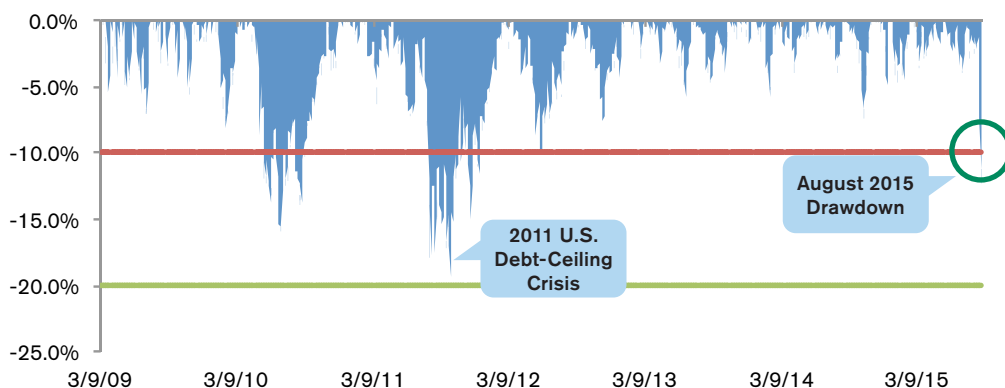
The long-anticipated correction in the U.S. stock market has arrived. The S&P 500® Index closed at 1893 on August 24 — a decline of 11 percent from its May 21 closing high of 2130. As seen in Graph 1 below, prior to this decline, the S&P 500® had steadily moved higher for the past four years without a 10 percent correction, one of the longest streaks on record.

With the sharp decline in prices (10 percent of which occurred over five trading days), questions such as, “Are we headed for a stock market crash?” and, “Is this a start of a bear market?” have arisen.

This issue of *Investment Insight* explains why it can be more fruitful for investors to assess the *probability* of a market crash than to ask simply whether one will occur. It also discusses how analysis of pricing trends in the stock-index option market can provide a clearer picture of the likelihood of a crash.

Segal Rogerscasey Canada believes that strong risk management is the essence of successful investment philosophy and that understanding market movements is critical, as is asking the right questions.

Graph 1: S&P 500® Index Drawdowns from Market High since March 9, 2009, Closing Low of 676



Source: Bloomberg

Is the U.S. Stock Market Going to Crash?

Much fame and fortune can be garnered by predicting the next market crash. In a world inundated with investment professionals, making a brash market prediction only to see the prophecy fulfilled can lead to significant notoriety, if only in the intermediate term. The upside is the booty of assets under management or a wave of newsletter subscribers. And the payoff is asymmetrical, as the “missed calls” are quickly forgotten.

While acting upon predictions of market crashes may be a misguided pursuit for long-term wealth accumulation, understanding the risk embedded in an investment portfolio and managing those risks is the essence of successful investing.

What Is the Probability of a Market Crash?

Whether U.S. stocks are headed for a market crash is not the right question, for the answer is not a binary “yes” or “no.” Rather the question is, what is the probability of a market crash and how is that different from what is priced into the market?

Stock prices change daily on a continuum of new information and fundamentals, investor sentiment and fluctuating risk aversion (fear and greed). While the science of finance has made large strides over the last 60 years, including the growth of behavioral economics, markets are social phenomena whose complex interactions will always present a challenge in the quest for understanding “where is the market headed?” The probability of a market crash is never 0 percent or 100 percent but some value in between. While Segal Rogerscasey Canada eschews predicting a market crash, we do not throw our hands up and claim “no one knows anything” either.

A key role for investment markets is to provide price discovery. More than 40 years ago, two seminal papers in finance were published: “The Pricing of Options and Corporate Liabilities” by Fischer Black and Myron Scholes and “Theory of Rational Option Prices” by Robert Merton. The enhanced understanding of options gleaned from these papers led to the creation of the Chicago Board Options Exchange (CBOE) and the deep liquid trading of options.

Why are option contracts important? Options are one of the few investment instruments that explicitly embed in their value the valuation of risk. Stocks, bonds, futures and other assets are all priced on expectations: of dividends and earnings, coupons and inflation, time value of money and risk premiums.

Options have the unique input of risk (quantified as volatility). The classic actuarial pricing model for contingent claims can be used to derive the ubiquitous Black Scholes Merton formula, pictured below, with the critical insight that expected stock returns must be replaced with the risk-free rate.

$$C(S,t) = N(d_1)S - N(d_2)Ke^{-r(T-t)}$$

$$d_1 = \frac{1}{\sigma\sqrt{T-t}} \left[\ln\left(\frac{S}{K}\right) + \left(r + \frac{\sigma^2}{2}\right)(T-t) \right]$$

$$d_2 = \frac{1}{\sigma\sqrt{T-t}} \left[\ln\left(\frac{S}{K}\right) + \left(r - \frac{\sigma^2}{2}\right)(T-t) \right]$$

$$= d_1 - \sigma\sqrt{T-t}$$

$$\sigma \text{ (sigma) = Risk}$$

While the famous Black Scholes Merton formula is an eloquent derivation made of simplifying market assumptions that are known to be violated in the real world, the notion that options are financial insurance and that insurance is about risk is insightful.

“Options are one of the few investment instruments that explicitly embed in their value the valuation of risk. ... quantified as volatility.”

S&P 500® Options and the Probability of a Market Crash

The S&P 500® is a benchmark for U.S. stock market investors. It is a capitalization-based index, consistent with modern portfolio theory, representing more than 80 percent of the public U.S. stock market. It is widely followed, with over \$7.8 trillion in assets under management benchmarked to it. Importantly, it has a well-developed option market.

S&P 500® stock index options, or SPX, trade on the CBOE in depth. The protection levels, or strikes, vary from deep market crashes to ebullient upside possibilities. The typical time horizons span from a week to three years. In other words, there is a deep, liquid market continuously trading the various likelihoods of future price outcomes of the U.S. stock market.

Option prices provide information about the likelihood of various stock-market price outcomes. As shown in Table 1 below, the larger the anticipated decline through October from the S&P 500®'s August 28 closing price, the lower the mid-price cost of put option insurance, *i.e.* the lower the probability of the anticipated decline. The probability can be derived using basic mathematics applied to the price data.¹

“There is a deep, liquid market continuously trading the various likelihoods of future price outcomes of the U.S. stock market.”

Table 1: Downside S&P 500® Index Put Option Insurance through October 2015, Based on August 28 Close

Strike*	Mid Price**	Open Interest (# of Contracts Existing)***	Notional Exposure \$ Millions****	Decline from 8/28 Closing Price
1,500	4	12,985	1,948	-25%
1,525	5	4,261	650	-23%
1,550	5	11,477	1,779	-22%
1,575	6	2,218	349	-21%
1,600	7	18,918	3,027	-20%
1,625	8	6,790	1,103	-18%
1,650	9	12,361	2,040	-17%
1,675	10	18,370	3,077	-16%
1,700	12	50,436	8,574	-15%
1,725	13	10,469	1,806	-13%
1,750	15	21,847	3,823	-12%
1,775	18	12,225	2,170	-11%
1,800	20	37,429	6,737	-10%
1,825	23	24,276	4,430	-8%
1,850	27	25,519	4,721	-7%
1,875	31	8,601	1,613	-6%
1,900	36	57,847	10,991	-4%
1,925	42	16,276	3,133	-3%
1,950	49	39,156	7,635	-2%
1,975	57	23,030	4,548	-1%

Source: OptionsXpress

* “Strike” is the price level upon which further declines are offset by the put insurance.
 ** “Mid-Price” is the average of the bid and ask prices.
 *** “Open Interest” represents the number of contracts existing for each option contract.
 **** “Notional Exposure” represents aggregate dollars of protection (Strike x Open Interest x 100).

¹ “Prices of State-contingent Claims Implicit in Option Prices” by Douglas T. Breeden and Robert H. Litzenberger was one of the first papers to use option prices to derive a risk neutral distribution.

Changes in the probability of a particular stock-market outcome are reflected in the related option prices. As seen in Table 2 below, during the recent market correction, there was a sharp increase in volume and open interest for a 1750 put option, which would protect an investor from market declines in excess of 12 percent from the August 28 closing price.

Table 2: Historical Prices for a Put Option of the S&P 500® Index at the 1750 Level with an October 2015 Expiration

Date	Underlying Close	Open	High	Low	Close	Volume	Open Interest
08/28/2015	1988.87	16.40	19.00	14.72	15.40	5,517	21,847
08/27/2015	1987.66	17.30	21.37	13.20	15.00	9,263	19,299
08/26/2015	1940.51	28.00	39.00	24.00	24.65	3,404	17,993
08/25/2015	1867.61	24.75	44.40	21.85	41.50	1,082	18,179
08/24/2015	1893.21	98.40	98.40	23.70	40.50	15,568	6,510
08/21/2015	1970.89	9.20	18.05	7.30	18.05	522	6,322
08/20/2015	2035.73	3.60	6.15	3.40	6.15	1,685	4,780
08/19/2015	2079.61	2.41	3.10	2.25	2.50	761	4,369
08/18/2015	2096.92	2.30	2.30	2.00	2.25	121	4,369
08/17/2015	2102.44	3.00	3.00	2.05	2.35	613	3,871
08/14/2015	2091.54	2.56	2.56	2.50	2.50	4	3,871
08/13/2015	2083.39	3.00	3.20	2.45	2.66	822	3,388
08/12/2015	2086.05	4.08	4.75	3.00	3.00	708	2,904
08/11/2015	2084.07	2.40	3.30	2.40	3.24	130	2,804

Source: OptionsXpress

“Using option prices as a starting point, one can invert the pricing formulae and back out the ‘implied volatility.’”

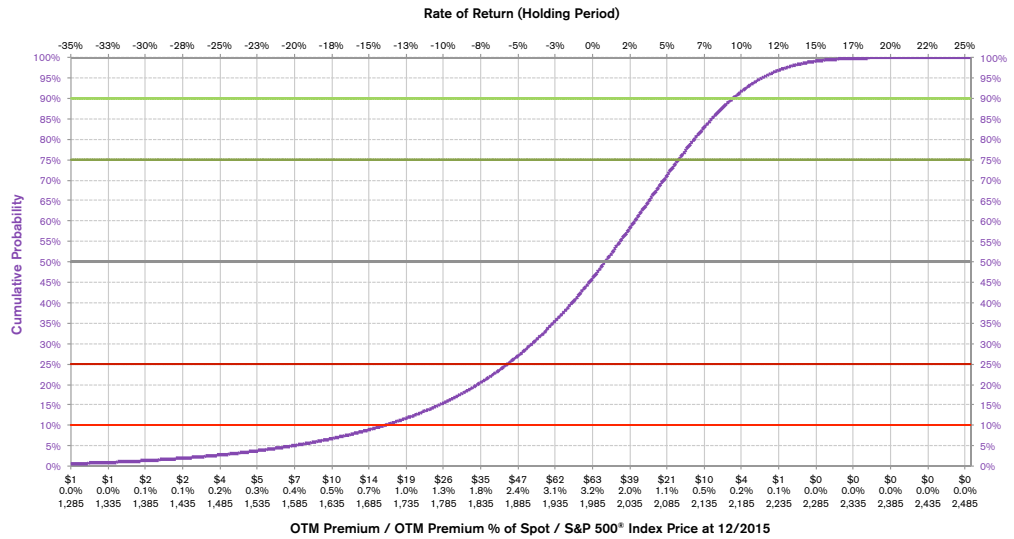
In answering the question of what is the probability of a market crash or bear market, a key first step is looking at the option market and understanding what is the likelihood priced in by traders putting money on the line, or “skin in the game.”

Using option prices as a starting point, one can invert the pricing formulae and back out the “implied volatility.” The CBOE volatility index, or VIX, is a widely disseminated outcome of this process for general risk over the next 30 days. This process can be applied along the whole spectrum of outcomes, including options whose payoff is contingent on a dramatic price decline or “market crash.” Graphs 3 and 4 on the next page show the probability data, derived from option prices, that was used to determine the likelihoods of the market-decline scenarios shown in Table 3, also on the next page.²

It is important to understand that these initial probabilities have conservatism built into them and thus overstate the likelihood of declines. Segal Rogerscasey Canada’s next step is to use its proprietary models to determine its subjective views on the likelihoods and then optimize the investment solution. Note, at times, it certainly could be optimal to be a provider of insurance rather than a buyer. It comes down to the value proposition between Segal Rogerscasey Canada’s views and the market’s.

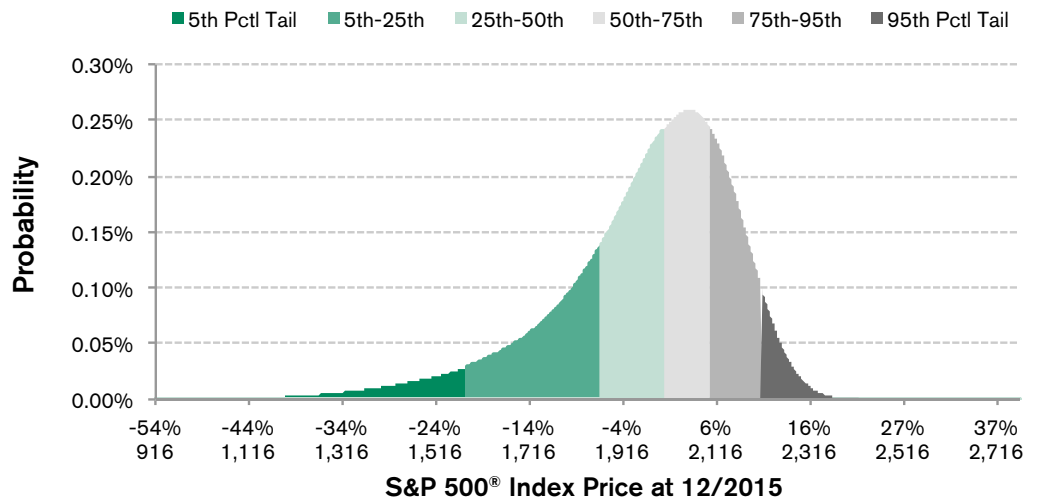
² Using option-based risk neutral distributions to enhance trading is widely practiced. For example, Interactive Brokers developed a Probability Lab trading tool for its traders: <https://www.interactivebrokers.com/en/index.php?f=5910&ns=T>. Outside of the trading community, risk neutral distributions are also prevalent. The Minneapolis Federal Reserve publishes a biweekly risk report based on option distributions for various equity indices, financial stocks, commodities and interest rates. <https://www.minneapolisfed.org/banking/mpd/weekly-commentary-on-future-asset-values>

Graph 2: Market-Implied Probability Matrix



Source: Segal Rogerscasey using data from OptionsXpress

Graph 3: S&P 500® Index Price Outcome Probabilities



Source: Segal Rogerscasey using data from OptionsXpress

Table 3: Probabilities of Two Market-Decline Scenarios through December 2015

	Close	% Decline in Price from S&P 500® Index's 8/28/2015 Close at 1989	% Decline in Price from S&P 500® Index's 5/21/2015 High of 2130	Market-Implied Probability	Segal Rogerscasey Probability
12/18/2015	1590	20%	25%	5.3%, or 1-in-20	3.3%, or 1-in-30
12/18/2015	1790	10%	16%	16.0%, or 1-in-6.25	14.0%, or 1-in-7

Source: Segal Rogerscasey using data from OptionsXpress

Conclusion

The key risk questions investors should be asking themselves are:

- What is the probability of a market crash or of investment losses in general?
- And how are those probabilities related to market-implied values?

If an investor's subjective downside probabilities are higher than what is priced into the market, downside protection should be considered. This could take the basic form of shifting equity exposure to the lower end of the investor's rebalancing range. With the prevailing valuation levels for most asset classes and the heightened sensitivity of our clients to market drawdowns, Segal Rogerscasey Canada believes a more formal implementation of a risk-mitigation strategy may be merited. These strategies encompass standalone products as well as implementations that complement existing portfolio structures. Risk-mitigation strategies will be the focus of a 2015 Segal Rogerscasey Canada publication.

Risk-taking is part of the nature of investing. Business cycles, recessions, unanticipated spikes in inflation and unemployment as well as temporary panics will be with us as long as we have free markets. Predicting these events in binary, "yes"-or-"no" fashion is a fool's errand, and the track records of successful predictions are fleeting.

But monitoring the various market risks on an ongoing basis and taking precautions when merited can provide peace of mind over the short term and add significant value to a portfolio. While Segal Rogerscasey Canada focuses on the long-term for clients, smoothing the ride is an essential ingredient. ■

“Monitoring the various market risks on an ongoing basis and taking precautions when merited can add significant value to a portfolio.”

Questions? Contact Us.

For more information about our views on U.S. stock market volatility, contact your Segal Rogerscasey Canada consultant or one of the following investment professionals:

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