NORTHFIELD modeling financial markets worldwide

Estimation of Event Risk: Crashes, Brexit, and Whatever Comes Next

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Introduction

- The lead up to the recent "Brexit" vote created massive anxiety among investors in the UK, with lesser but still severe concerns across the European Union countries and around the world.
- Numerous financial firms circulated commentaries on this subject from their investment strategists, but almost all of this discussion is qualitative interpretation of the known facts. A few offered highly speculative risk discussions based on hypothetical stress tests with minimal foundation in either economic theory or empirical fact.
- We assert that most standard methods used to assess the risk of extreme events and other short lived phenomena are simply inadequate, and often lead counterproductive actions by investors.
- *The body of the presentation will address numerous key aspects of how event risks should be viewed, assessed and incorporated into portfolio management actions.*

The Return of Sybil The Soothsayer

- A June 10, 2016 article on Bloomberg had the headline "European Stocks Could Plunge 24% in Brexit Vote, Stress Study Shows".
  - As the underlying "stress study" was done by a Northfield competitor, we have no comment on the quality of the analysis.
  - What is concerning to us is that the public presentation of the information was misleading. What would have actually been useful to investors was a complete statement framed like this, irrespective of the numerical values within:

Our research shows that the routine likelihood of a 24% or greater decline in European stocks in any one month is about 1 in 500. Due to the Brexit issue, we believe that the likelihood of a 24% or greater decline in the month immediately following the vote is between 1 in 50 and 1 in 100. As such, the likelihood that European stocks will not fall 24% or more in the month after the Brexit vote is between 98% and 99%.

Proper Framing of Event Risk

- *Our research shows that the routine likelihood of a 24% or greater decline in European stocks in any one month is about 1 in 500. Due to the Brexit issue, we believe that the likelihood of a 24% or greater decline in the month immediately following the vote is between 1 in 50 and 1 in 100. As such, the likelihood that European stocks will not fall 24% or more in the month after the Brexit vote is between 98% and 99%.*

- Context: What is the probability of the event in routine conditions?
- Timing: When might this event occur?
- Horizon: Over what time period might this event occur?
- Alternative Outcomes: What is the probability that the event will or will not happen?
- Uncertainty: How certain are we about what we think might happen?
- If we can't articulate these points, we are not ready to say anything.

Semantics for Today

- We draw a sharp semantic distinction between "risk" and "uncertainty." (see Knight, 1927)
  - Let's define risk as the precisely known probability of unfavorable outcomes from an investment. Let's define uncertainty as our inability to precisely define that probability
- For illustration, consider two gamblers in a casino.
  - The first gambler is playing roulette, where the odds and payoffs associated with any particular bet are precisely known and do not change over time. This gambler is facing risk only.
  - Our second gambler is playing poker with both a dealer and several other players participating. This gambler is facing both risk and uncertainty. While there is some probability of losing your bet on a given hand of poker, this gambler does not know what those odds are because the odds depend on the skills and financial resources of the other players which are unknowns.

An Event Taxonomy

- There are three kinds of events that can create potential for financial loss:
  - Events that are unanticipated with respect to both the nature and timing. (October 1987 crash)
  - Events that are expected to occur at a random arrival rate (possibly rare) but we don't know when (Japanese earthquake).
  - Events where the timing is precisely known but the outcome is unknown (Brexit vote, company earnings announcements).
- We argue that a different approach is required for these three cases.
  - One procedure is clear in all cases. Ignore people that say they know what will happen. They are fools, liars, or both.

Investor Response to Event Information

- Several papers have examined the relative market response to "unanticipated" and "anticipated" information
  - Ederington and Lee (1996)
  - Kwag Shrieves and Wansley(2000)
  - Abraham and Taylor (1993)
- Jones, Lamont and Lumsdaine (1998) show a remarkable result for the US bond market
  - Total returns for long bonds and Treasury bills are not different if announcement days are removed from the data set
- Brown, Harlow and Tinic (1988) provide a framework for asymmetrical response to "good" and "bad" news
  - Good news increases projected cash flows, bad news decreases
  - All new information is a "surprise", decreasing investor confidence and increasing discount rates
  - Upward price movements are muted, while downward movements are accentuated

Unanticipated Events

- These are the "black swans" as coined by Nassim Taleb (2007), that result in can result in extreme movements of financial markets.
- The mechanism of the "tail" risk is explored in diBartolomeo (2007).
  - The assumption that security returns should be normally distributed arises from the Central Limit Theorem, which requires that what we observe is the summation of a large number of *independent events*.
  - When time horizons are very short, or there is a severe decline in liquidity the assumptions of the CLT no longer hold, resulting in fat tailed distributions which extreme events can be a random draw.
  - The preponderance of academic research suggests that the T-5 distribution is a reasonable choice for daily security returns.
  - As time horizons shorten in the limit, some have argued for the stable Paretian distribution, (see Mandelbrot, 1963) which has the a number of practical issues associated with it (infinite variance and not generally additive across portfolios).

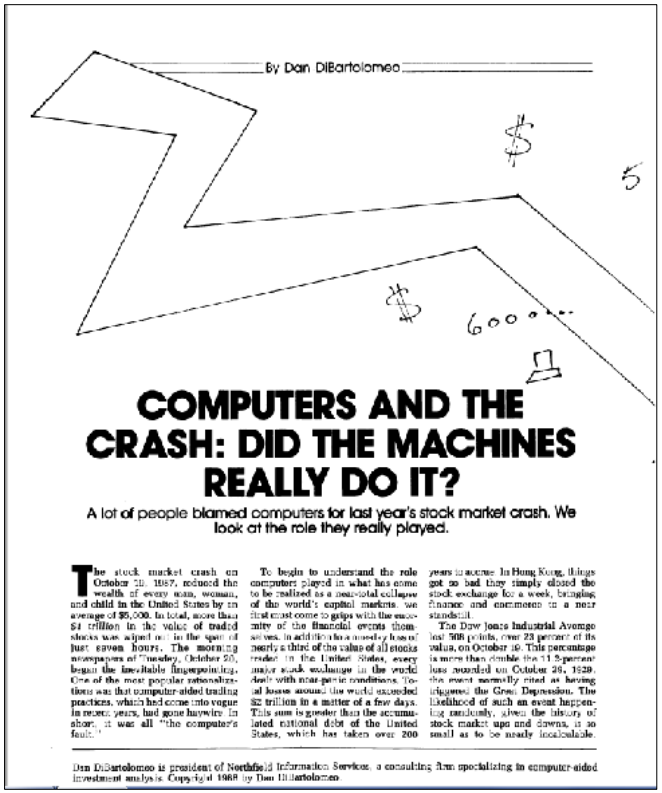
Our Key "Take Away" For Today

- *When a large event is unanticipated, investors receiving the news need time to think about what to do before they act so there is a temporary steep decline in liquidity. Extreme events occur after the information is released, as investors absorb the information at different rates and some try to trade before enough liquidity is restored.*

- *For anticipated events, investors have formulated a plan of action in advance, and so act promptly upon release of the information. Liquidity is low before the announcement as investors wait for news, but is restored rapidly so extreme events are much less likely once the information is known.*

The Crash of October 1987

- On October 19, 1987 the US stock market declined 23%, more than double the decline in 1929 that marked the start of the Great Depression.
- An investigation into the causes produced the Brady Commission report named for the incoming US Treasury Secretary. The principal investigator was Robert Glauber who went on to head NASDAQ and is currently teaching at Harvard. I've discussed the event with both personally.
- A key finding of the report was that an asymmetry in the clear trade clearing process for stock index futures had *removed large amounts of liquidity.*
- Arbel, Carvell and Postnieks (1988) found that even during the crash, low beta stocks went down less than high beta



By Dan DiBartolomeo

COMPUTERS AND THE CRASH: DID THE MACHINES REALLY DO IT?

A lot of people blamed computers for last year's stock market crash. We look at the role they really played.

The stock market crash on October 19, 1987, reduced the wealth of every man, woman, and child in the United States by an average of $5,000. In total, more than $4 trillion in the value of traded stocks was wiped out in the span of just seven hours. The morning newspapers of Tuesday, October 20, began the inevitable fingerpointing. One of the most popular rationalizations was that computer-aided trading practices, which had come into vogue in recent years, had gone haywire. In short, it was all "the computer's fault."

To begin to understand the role computers played in what has come to be realized as a near-total collapse of the world's capital markets, we first must come to grips with the enormity of the financial events themselves. In addition to a measly loss of nearly a third of the value of all stocks traded in the United States, every major stock exchange in the world dealt with near-panic conditions. Total losses around the world exceeded $2 trillion in a matter of a few days. This sum is greater than the accumulated national debt of the United States, which has taken over 200 years to accrue. In Hong Kong, things got so bad they simply closed the stock exchange for a week, bringing finance and commerce to a near standstill.

The Dow Jones Industrial Average lost 508 points, over 23 percent of its value, on October 19. This percentage is more than double the 11.5-percent loss recorded on October 28, 1929, the event normally cited as having triggered the Great Depression. The likelihood of such an event happening randomly, given the history of stock market ups and downs, is so small as to be nearly incalculable.

Dan DiBartolomeo is president of Northfield Information Services, a consulting firm specializing in computer-aided investment analysis. Copyright 1988 by Dan DiBartolomeo

Tail Probabilities

- Once the assumption of normality is gone, the likelihood of extreme events grows quickly event for distributions that would visually look normal.
- Chebyshev's inequality provides the boundary value.
- We like tracking distributional assumption leverage, the ratio of the values

Probability of a realization > n standard deviations away from mean					
	n=2	3	4	5	6
Chebyshev	1/4	1/9	1/16	1/25	1/36
Bound Same K	1/5	1/27	1/85	1/208	1/432
RV with Same K	1/6	1/33	1/114	1/289	1/614
Normal Dist	1/22	1/370	1/16000	1/1.75 MIL	1/500 MIL

Earthquakes, Tsunamis and the End of the World

- For some types of events (e.g. an earthquake in an geologically active area or a stock market crash) we assume that the cumulative probability of the event is one. *It will happen sooner or later, but we don't know when.*
- The standard process in these cases is the use of the Poisson distribution in which we forecast the frequency of an event. If λ is average number of events per period, the probability of observing K events in a period is:

$$P(k) = \lambda^K e^{-K} / K!$$

"Our story takes place between the Second War to end all wars and the third, which by eliminating mankind all together will do the trick."

The List of Adrian Messenger

How About Really, Really Big Events?

- Another thread of relevant finance literature is impact of "great anomalies".
  - Much of the empirical research literature on financial markets does not include rare but extreme events such as the collapses of Russian financial markets at the time of the Russian revolution, the German financial markets in the 1930s and the total expropriation of private enterprises at the Communist takeover in China in 1949.
  - While rare, such total market collapses have a very meaningful impact on how investors should view returns from various financial markets (Dimson, Marsh, Staunton, 2014).
  - Other studies such as Barro (NBER, 2005) and Gabaix (2006, 2012) attribute investor preferences among financial assets as predicated on their expected frequency of such extreme events.

Market Returns and Geopolitical Conflict

- We perceive geopolitical conflicts such as wars to be the strongest events. Based on the foregoing discussion we form two hypotheses:
  - H1: Long term financial market returns will be negatively correlated with geopolitical conflict *as measured by casualty rates*.
  - H2: The effect of this relationship will be even stronger for debt markets. Wars are expensive, driving up yields, and losers in war can't pay. There is no "upside" for lenders.
  - For Hypothesis 1, we can reject the null for both fixed income markets and a 60/40 portfolio. For equities alone, the result has the correct sign but is not significant. For Hypothesis 2, we can reject the null hypothesis. Bond markets are nearly linearly negatively related to the conflict measure and are substantially more negatively related to geopolitical conflict than equity markets.
  - Details of the data and analytical methods are available at: http://www.northinfo.com/Documents/646.pdf

"Even God Cannot Change the Past," but We Can Pretend

- The obvious numerical approach to estimation of single event risks are simulations based on bootstrapping. What we really want is to combine the rich distributional information of a numerical simulation with the "intuitive" nature of a set of explicit scenarios. Such a combined process is described in Meucci (2008)
- Our version of this is called Optimized Scenario Analysis.
- It is possible to "stress test" by filtering the set of past observations from which our projected sequences of events are built.
  - We could include only months from periods of economic recession, or had rising interest rates or include only months that were perceived as particularly volatile. *Meucci refers to this as "crisp conditioning".*
  - If we have a "seed sample" of N observations and we filter out P observations, the probability of any observation being drawn to fill a position in a particular path is *1/(N-P) or zero.*
  - Now we have dense simulated data in both time series and cross-section, *conditional on the stressful or benign filtering.*

Now Let's Get Flexible

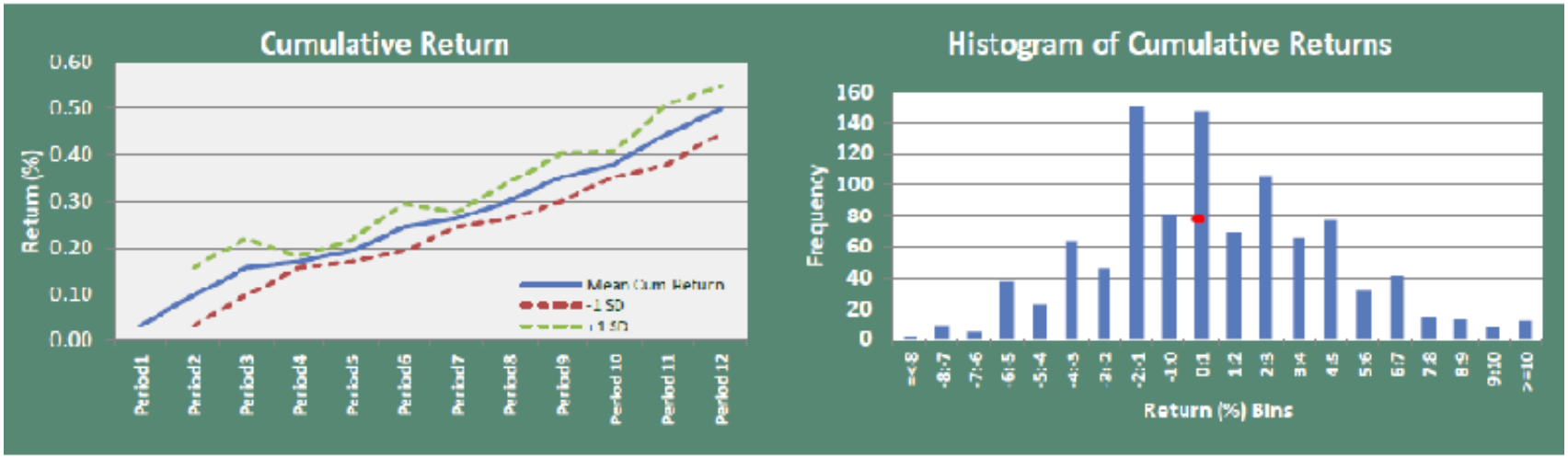
"Who is to say that truth is in the crystal and not in the mist?"
Kahlil Gibran

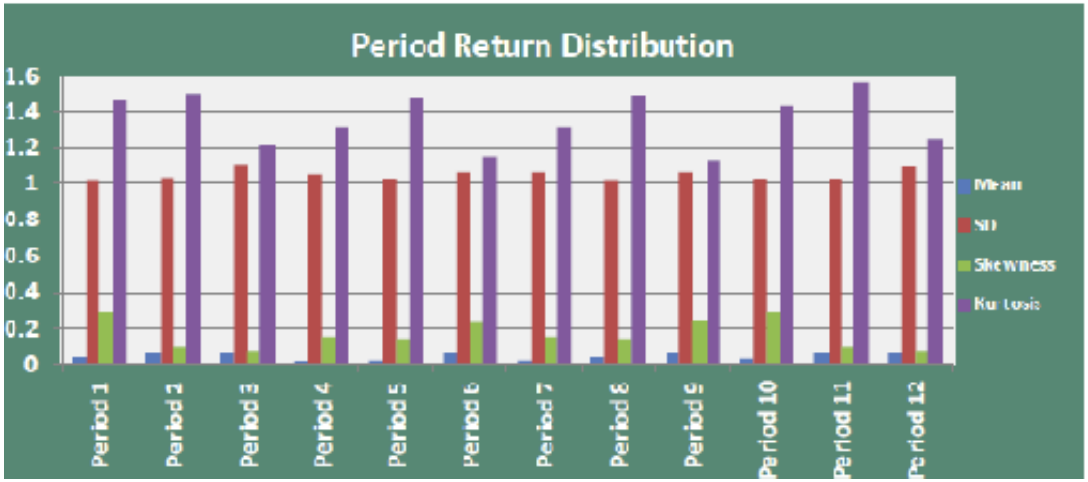
- We can set up a more flexible process where the probability of any particular observation being drawn for inclusion in a bootstrap path is explicitly defined by the user.
  - Instead of the probability of inclusion being 1/(N-P) we can choose a vector of explicit values for each observation. Meucci refers to this as *flexible conditioning*
  - Each probability p_t must be between zero and one
  - The sum of all values of p_t must equal one
  - *We can also compress the time basis of the empirical data. We can pretend that historical events that took a month took a day, hour or minute instead.* The distributional assumptions would change and so would our evaluation of the probability of tail events.

Scenario Based Flexible Conditioning

- We would like combine bootstrap simulations with explicit scenarios.
  - We can build the probability vector for inclusion of observations so as to fulfill the some explicit scenario within a confidence interval.
  - For example, we could say "Do a bootstrap simulation where ***on every path***, the 10 year interest rate rises between 297 and 303 basis points, and oil prices decline 11 to 13% over a 12 month interval".
  - Observations with increasing interest rates and declining oil prices get more weight and vice-versa.
  - We can specify any variable for which data exists for the seed sample. We are not limited to the factors of an underlying model.
  - We can generate several different scenarios and select the number of paths to be run for each to represent weights. We just do our cross-sectional statistics on the aggregated paths.
  - *The cross-sectional variation in the paths is an implicit measure of the likelihood of the scenario.* If all paths are similar we know that the only a small fraction of all feasible paths fulfill the scenario.

Optimized Scenario Analysis Output





Metric	Mean Value
Cum Ret. (%)	0.50
Std. Dev (%)	3.56
Skewness	0.30
Kurtosis	0.09
Periods with positive active returns	364
Periods with negative active returns	636

Conclusion: "We're In a Lot of Trouble"

- While it is clear that event risk can be formally estimated, it takes clear, critical thinking and a lot of effort to do well. Too many in the investment industry have been irresponsible, putting forward ill framed and ill supported speculation on the risks associated with major events. Investors need to do their own research into such matters.

- The plot of the1976 movie classic *Network* involved a TV network news show that employed bizarre methods to get ratings including nightly reports from a staff fortune teller, "Sybil the Soothsayer". Since 1976 the key news provider to the world has moved from television to the Internet and social media, but we will conclude with this prescient clip from the film (rated PG for coarse language).

- https://www.youtube.com/watch?v=HFvT_qEZJf8