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GameStop, Variance Swaps, and Related Failures of Hedge Fund Risk Management

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Northfield Webinar

March 2021

Introduction

- Recently there have been some highly publicized failures of hedge fund risk management. These events resulted in very large losses for hedge fund investors. Hedge fund activity at multiple firms (including Fidelity) has been discontinued.
- In this presentation, we will describe persistent weaknesses in the way that hedge funds have managed risk in their portfolios and illustrate how such failures could have been avoided.
- The common theme of these problems is the improper assessment of how particular investments create either increased uncertainty or higher moments in the distribution of fund returns.
  - Good risk management focuses on what we don't expect to happen but still might. *When crossing a street, you only get hit by cars you don't see coming.*

Misunderstanding Liquidity

- The first thematic failure connecting these events is an implicit assumption that liquidity is always more than sufficient and therefore risk management practices can assume that hedging relationships (e.g. a long/short portfolio) *will be rebalanced continuously.*

- While the assumption of continuous rebalancing leads to elegant closed-form math for pricing many derivatives, reliance on this assumption leads to biased estimation of risk.
  - All risk computations assume that the portfolio position weights are known. *We don't know what the weights will be between now and the next rebalancing, so traditional risk estimates are downward biased.*
  - If you can only rebalance a market neutral portfolio periodically, the maximum loss is 100% of the value of the long side, but the maximum loss on the short side is unbounded. This means that distribution of fund returns will have negative skew and positive kurtosis.

Strategies Embedding Higher Moments

- The second failure is the intentional adoption of strategies (e.g. selling variance swaps) that have negative skew so that the fund returns on average are higher but where extreme losses are far more frequent than would be expected under a normal distribution (although still relatively rare).
- Even without variance swaps many other strategies popular with hedge funds build in implicit "short vol"
  - These include many forms of derivative strategies
  - Distressed and high yield debt
  - Deep equity value tilts
- Being "short volatility" increases returns most of the time, but when you lose, you lose a lot.

Ignorance of Boundary Conditions

- The third issue is the persistent failure to account for the implications of boundary conditions associated with observable market data.
- For example, the implied volatility of some GME options reached over 500% annualized at certain recent points.
- The annualized variance of 250,000%^{2} means that the expectation of the geometric mean return for GME would be about **negative** ***5% per trading day***.
- Hedge funds often assume volatility is mean reverting, so a 500% GME vol was not sustainable so saw this is an alpha opportunity, but failed to incorporate the implied drift in option valuation calculations
  - Under the continuous rebalancing assumption of Black Scholes, the drift term *drops out most of the time.*

Hedge Fund Strategies and Time

- Prior to the development of derivative markets in the 1970s, risk and return were presumed to coincident in time. With derivatives or strategies that mimic derivative behavior, we can **separate return and risk in time.**

- We can accept risk today for return tomorrow *or obtain return today in exchange for risk tomorrow*. Obviously, return today for risk tomorrow (also known as "short vol") sounds rather appealing to financial market participants with short time horizons

- These strategies *always* look appealing when evaluated on a historical basis, because the survival of the strategy so far indicates that the day of reckoning has not yet arrived. *It is like farming in the fertile soil under a volcano and hoping no eruption comes during your tenancy.*

Creating the *Appearance* of Hedge Fund Skill

- This idea that "short vol" strategies give hedge funds the appearance of skill has been well recognized in the financial literature.
  - A Northfield client conference featured a presentation by Weisman on this issue in 2001, https://www.northinfo.com/documents/166.pdf (see slide 25) where it was demonstrated that a simulated "no skill" option strategy could have an 86% chance of *doubling the return of the risk free rate* in any year.
  - The likelihood was that such strategies would suffer catastrophic losses in very volatile periods, and so the expected cumulative return over long periods would be no better than the risk free rate.
  - However, for a hedge fund manager receiving performance based fees, the economic outcomes would be very favorable to the manager, and unfavorable to investors.

- A broad study of how this effect biased investor perceptions of hedge fund performance upward was provided in Bondarenko (2004).

Hedge Funds Aren't the Only Volatility Traders

- One hedge fund that was long volatility (and so endured many years of small losses) reported a return of more than **4000%** in the first quarter of 2020.
  - On the other hand, we are aware of one multi-strategy hedge fund that lost **400%** on their volatility trading activities over the same period.
  - It should be noted that many seemingly "vanilla" strategies have some lesser degree of volatility dependence. Even popular equity strategies like "value" and "momentum" have these properties as described in diBartolomeo (2007), https://www.northinfo.com/documents/234.pdf.

- Several large asset owners experienced very large losses associated with "short vol" strategies during the COVID-19 pandemic
  - It has been publicly reported that Canadian retirement plan AIMCO lost $2 Billion on volatility bets.

Understanding Variance Swaps

- At the high end of volatility strategies is participation in *variance swaps*.
  - These instruments are not really investments but rather are pure hedging contracts (i.e. bets). Unlike identifiable financial instruments or commodities, the underlying "volatility" is not deliverable in any form.
  - Like credit default swaps, they are not really insurance either, as there is no concept of insurable interest (e.g. I can't buy fire insurance on your house).
- What is unique about variance swaps is that the size of the bet is effectively known to the parties making the bet only after the fact.
  - It is similar to gambling on sports like American football. Scores vary widely with some games low scoring (e.g. 7-0) and others high scoring (45-37).
  - The situation is like betting on the outcome of such games, but *where value of the bet is set as the square of the total points scored.*
  - In the former case, the financial transfer from loser to winner of the bet would be $49, while in the latter case it would be around $6500, **a magnitude increase of more than 100 times.**

Analyzing Variance Swaps

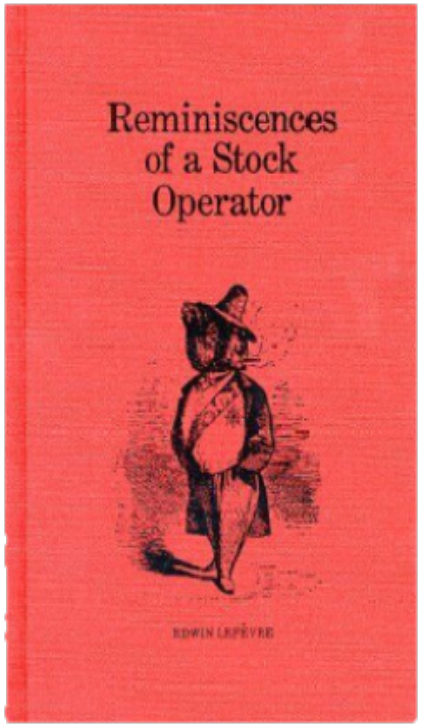
- There are several textbook analytical methods for pricing variance swaps by replicating them with combinations of traditional derivatives.
  - Seminal papers are Carr and Madan (1998), Derman, Demeterfi, Kamal and Zou (1999), and Carr and Lee (2009).
  - However, all of these computational methods have underlying assumptions about the nature of financial market behavior.
  - Some of the models are only appropriate for swaps where the future payoff will be based on how much volatility is *realized* in a specific financial market over a particular time period.
  - Other models are appropriate when payoffs are based only how much volatility is *expected* to occur over some future time period.
  - As such, traded volatility contracts such as the CBOE VIX (or BVI for Bitcoin) are not necessarily efficient to hedge variance swaps that are tied to volatility realizations.

GME, AMC and Other HF Misadventures

- The recent trading activity by a loosely coordinated group of retail investors in GameStop, AMC Entertainment, and other presumably speculative assets has garnered a great deal of attention from both the financial press and from securities regulators.
  - This set of securities saw meteoric rises in price followed by equally spectacular declines. It has been widely reported that a number of prominent hedge funds (and their investors) have sustained billions of dollars in losses arising from "short squeeze" events.

- We are frankly perplexed that that risk management processes at these funds appear so primitive as to be unprepared for such occurrences.
  - Northfield risk models have contained a number of specific features that anticipate the potential for such events and *so correctly captured the rapid increase in portfolio risk in a nearly instantaneous fashion.*

A History Lesson



Manipulation of stock prices was completely legal in the USA until 1933. In those days, the term for somebody who made a living manipulating equity prices to benefit their own trading *was called a stock "operator".*

The most famous book on the subject was Reminiscences of a Stock Operator by Edwin Lefevre which was published as a work of fiction in 1923. In reality, the book was an autobiography of Jesse Livermore (a famous operator). He was at one point in time one of the richest men in the world. He eventually lost most of his money.

Manipulation of stock prices by spreading false information is still not specifically prohibited in many countries, and in the US for assets not covered by the US Securities Act of 1933 (commodities, currencies, crypto,). Muni bonds and US Treasuries are not covered by the 1933 Act. but the SEC has asserted some jurisdiction by saying they have rules that cover bond mutual funds.

More Liquidity Problems

- Extreme price movements do not require huge amounts of money to create. In the October 19th, 1987 stock market crash the entire US equity market went down around 23% or over *$1 TRILLION as the result of only $15 Billion trading volume,* which is a modest sum for many of our existing clients. The global loss of value impact was over $2 Trillion.
- We have repeatedly pointed out pointed out the potential for these kinds of events in The Liquidity Risk Time Bomb (northinfo.com). The recent extreme price movements are very familiar to anybody who was around in 1987.
- Many of the same basic ingredients appear in both matters: the use leverage (via margin or options), speculative traders who ignore fundamental business value, and cash flow timing dependencies between brokers, clearing firms (creating liquidity problems transaction processing), and exchanges.
- For the 1987, the definitive government study was the *Brady Commission Report*, brilliantly authored by the recently deceased Harvard professor, Robert Glauber, https://archive.org/details/reportofpresiden01unit.

Back Office Issues

- We would also assert another similarity between then and now. The people who are responsible for keeping brokerage accounts functioning smoothly appear to receive inadequate training.
- To be the "financial and operations principal" of a US brokerage house of any size, you have to pass a 145 question multiple choice test called FINRA 27.
  - One of the key regulations such a principal must know thoroughly is the "net capital rule" for brokers' financial reserves under the US Securities Exchange Act of 1934. The *details of this one rule are over 300 pages long*.
  - If your brokerage firm forwards trades to a large firm for execution in a transparent way your operations principal has to pass an even easier 95 question test called FINRA 28.
  - The operations principal within a firm is also responsible for supervision of **securities lending for shorting**, which played a prominent role at the root of the recent activity in GME and AMC as liquidity for short positions dried up (i.e. carrying costs of borrowed shares rose dramatically).
  - Nearly a half billion dollars of recent GME trades did not settle on time.

Step One: Range Based Volatility Estimation

- We will now consider key elements of Northfield risk models that allowed our models to quickly and accurately adapt to the activity in GME, AMC and other speculative events.
- The first is the use of range based volatility estimators (see Parkinson, 1980) which have been in use at Northfield since 1989. The traditional way of looking at investment volatility is the standard deviation of return which is *appropriate if and only if the distribution of returns is normal and free of autocorrelation*.
- A different way to think about volatility is to consider the range of an asset's price during a particular period. For example, we can consider the highest and lowest prices for GameStop in the past year. The high was $347.51 (January 27, 2021) and the low price was $2.80 (April 3, 2020). If we had only those two pieces of data, we could create a crude proxy for return volatility by looking at size of the low to high range as compared to the average value. The high and low are close to the average price the volatility of return is presumed low. If there is a large range the volatility of return is presumed high.

Parkinson Illustrated

- The simplest possible arithmetic would involve the distance of our two data points from the central tendency (the midpoint) as a fraction of the midpoint value.

$$\text{GME Annual Volatility} = ((H - L)/2) / (H + L)/2 = (H - L) / (H + L) = 98.4\%$$

- The actual Parkinson method used in Northfield models is more algebraically complex.
  - Under the assumption that the asset returns are independently and identically distributed (IID), *there is an exact transform from the range measure to the expected standard deviation of return.*
  - More elaborate methods involving open and closing prices as well as high and low are provided several related papers including Garman and Klass (1980).
  - If the transformed range volatility does not match the observed standard deviation of return over the observations of the sample period, we use the higher value and adjust asset specific risk upward to force agreement.

Parkinson Impacts Longer Term Models

- These adjustments to asset specific risk are applied even to our long term risk models.
  - For example, in our **US Fundamental Model** at 12/31/2020 the *annual* asset specific volatility of GME was forecast at 79% and moved to 93% at 1/31/2021.
  - This is an increase of 17% over the month of January despite the fact that this is just one month of a five-year sample period from which historical volatility values are typically observed.
  - These values are extremely large indicating that almost all of the risk of GME is asset specific and the distribution of future returns is likely to be uncorrelated with broad market movements.

Using Option Implied Volatility Directly

- For risk management horizons that are much shorter (days rather years), our **Short Term Model** has (since 1997) utilized daily changes in option implied volatility to condition the forecasts of individual security volatility.
  - A second procedure maps these many changes across factors thereby allocating the adjustments to both factor and idiosyncratic effects.
  - The full methodology is presented in https://www.northinfo.com/Documents/534.pdf which was subsequently published as diBartolomeo and Warrick (2005).

- For GME, the short term estimate of *annualized* asset specific risk started at 89%, peaked at 801% annually on February first, and ended February at about 300%.
  - Ignoring largely irrelevant factor effects, the perceived volatility of GME rose roughly *nine times* through the month of January.
  - In the case of GME is it was widely publicized that the leveraged nature of options was a key mechanism used by retail investors.

Rapid Adaptation without Options

- However, not all assets that might be subject to future unusual conditions have options traded on them.
  - To address this need Northfield released the aforementioned *Risk Systems That Read®* in 2017.
  - The RSTR process uses a machine learning analysis of financial news text in place of implied option volatility.
  - The basic method is covered in https://www.northinfo.com/Documents/313.pdf which was subsequently published as diBartolomeo, Mitra and Mitra (QF, 2009).
  - Our "near horizon" models are meant for relatively short risk forecast horizons with a standard calibration of looking ahead two weeks, which is intermediate to the short term and traditional horizons.

GME in RSTR®

- We expect adaptation much faster than the long term models, but not quite as fast the Short Term model in that GME is directly optionable.
  - In the period prior to the unusual activity, financial press coverage of GME was modest resulting in an estimated *annualized* specific risk of about 36% as of January 1st, 2021 for the two week forward horizon.
  - By January 27th (when GME hit its highest closing price) that value had quadrupled to 144% exactly in keeping with expectations. As attention on the GME situation has dissipated, the annualized specific risk fell to a forecast value of 85% as of the end of February 2021.
  - It should be noted that the *Risk Systems That Read®* process is applicable across the entire range of the **Everything, Everywhere** model including equities, fixed income, funds, ETFs, and illiquid alternatives such as private equity and real estate.
  - *The RSTR enhanced risk estimates can be blended with risk forecasts from the related longer horizon model to create customized risk horizons appropriate to the alpha decay and turnover of actively managed funds,*

Incorporating Higher Moments

- The fourth aspect of our processes to consider is that the effects of both skew and kurtosis at the individual security level have been built into the computational processes for portfolio risk.
  - We know that the price of a corporate bond is bounded above by the price of an otherwise comparable bond with no credit risk (e.g. for US investors a Treasury bond).
  - However, the value of such a bond might fall a much further in the event of a credit default. This asymmetric nature in the return distribution is often ignored by risk systems but is explicitly incorporated into Northfield portfolio risk calculations where we deem appropriate as described in https://www.northinfo.com/documents/901.pdf.
  - *The two keys are the use of "mixtures of normal distributions" (see Robertson and Fryer, 1969) and Cornish and Fisher (1938).* For investors in hedge funds, one obvious application of these methods is to assess risk in long/short portfolios, where the maximum loss on the long side of the portfolio is bounded but the potential loss on short positions is unlimited, creating an extreme left tail (negative skew).

Conclusions

- Hedge fund investors have sustained billions of dollars in losses related to persistent failures of risk management at hedge funds.
  - In the case of "short vol" strategies, return distributions will always exhibit negative skew, effectively increasing risk of negative tail events
  - *Positions in variance swaps exaggerate this effect as the size of "bet" increases with loss creating an **unbounded** concave payoff.*
- The analytical nuances (range volatility, option data, and text analytics) that have long existed in Northfield models make our models well prepared for extreme events.
- Our computational processes explicitly address non-normal return distributions rather than assuming that investors are sufficiently diversified that returns will be normal. *In the case of leveraged hedge funds, this assumption is never plausible.*