Examination of VaR after long term capital management

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by

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Abstract

The 1998 failure of Long-Term Capital Management ('LTCM'), a very large and prominent Greenwich, Connecticut based hedge fund, is said to have nearly brought down the world financial system. Over the years, few financial debacles such as LTCM, have been so often written about or discussed without a firm conclusion on what went wrong. What brought the "genius" managers of LTCM to their knees? Was it hubris, or was it something more? Various commentators have jumped on LTCM's significant leverage ratio or engaged in second-guessing of management's decision in 1997 to return $2.7 billion of investor capital to increase leverage, and thereby, returns. Others have faulted the lack of transparency at LTCM or faulted regulators for a lack of oversight, criticized regulators for arranging the bailout, while others still have pinpointed the debacle on the failure of LTCM's risk management prowess. This paper avoids the blame and identifies the multiple factors, both management risk management blunders, as well as inherent flaws in the risk metric used by LTCM – Value at Risk (VaR) – a commonly used risk metric in the financial industry today.

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Introduction

The 1998 failure of Long-Term Capital Management ('LTCM'), a very large and prominent Greenwich, Connecticut based hedge fund, is said to have nearly brought down the world financial system.[1] LTCM had its roots in a highly profitable bond-arbitrage group at Salomon Brothers run by John Meriwether.[2] LTCM was founded by Meriwether in 1994 after he was forced to leave Salomon Brothers following the 1991 Paul Mozer inspired bond scandal.[3] The core of LTCM's management was comprised of numerous alumni from the bond-arbitrage group at Salomon Brothers and notable academics such as Myron Scholes, winner of the 1997 Nobel Prize in Economics with Robert C. Merton.[4] On September 23, 1998 the New York Federal Reserve ('the Fed') organized a $3.65 billion private rescue of LTCM.[5] At the time of rescue, the fund reportedly had 60,000 trades on its books.[6] The balance sheet consisted of over $50 billion of long positions and short positions of an equivalent magnitude; total futures positions of over $500 billion; over-the-counter ('OTC') swaps positions of over $750 billion, as well as, options and other OTC derivatives with a notional value of over $150 billion.[7] The Fed intervened because it was concerned about the possibly dire consequences for world financial markets if it allowed the hedge fund to fail.[8] The markets feared a liquidation of LTCM, with well over a trillion dollars in positions, would have forced dealers to sell off tens of billions of dollars of securities and to cover their numerous derivatives trades with LTCM and since most lenders had required very low haircuts (margin), there was a potential for losses to accrue while the collateral was being liquidated. Adding even more uncertainty to the mix, the LTCM fund was organized in the Cayman Islands and there was uncertainty as to whether the lenders could have liquidated their collateral.[9]

So, where did it all go wrong? What brought these geniuses to their knees? Various commentators have jumped on LTCM's significant leverage ratio or engaged in second-guessing of management's decision in 1997 to return $2.7 billion of investor capital to increase leverage, and thereby, returns.[10] Others have faulted the lack of transparency at LTCM or faulted regulators for a lack of oversight, criticized regulators for arranging the bailout, while others still have pinpointed the debacle on the failure of LTCM's risk management prowess.[11]

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[1] Lowenstein, R., *When Genius Failed: The Rise and Fall of Long Term Capital Management* (Random House: New York, 2000).
[2] *id.*
[3] *id.*
[4] Dunbar, N., *Inventing Money: The story of Long-Term Capital Management and the legends behind it*. (New York, 2000); *see also* Dunbar, N., "Meriwether's Meltdown", Risk (October, 1998) 32-36.
[5] Edwards, Franklin R., "Hedge Funds and the Collapse of Long-Term Capital Management," Journal of Economic Perspectives, (1999) 13, No. 2, 189-210; *see also* Trillion Dollar Bet, Dir. Malcolm Clark, Videocassette, BBC/WGBH Boston, 1999.
[6] *See* President's Working Group on Financial Markets, Hedge Funds, leverage and the Lessons of Long Term Capital Management, Washington D.C. (1999); *see also* House Committee on Banking and Financial Services. 1999. Hedge Funds, Leverage, and the Lessons of Long-Term Capital Management: Report of the President's Working Group on Capital Markets (April); *see also* House Committee on Banking and Financial Services. 1999. Hearings on the President's Working Group Study on Hedge Funds, 106th Congress, 1st session, Serial no. 106–19.
[7] *id.*
[8] House Committee on Banking and Financial Services. 1998. Testimony of Alan Greenspan at the Hearing on Hedge Fund Operations: before the House Committee on Banking and Financial Services, 105th Congress, 2nd session, (October 1), Serial 105–80.
[9] Under the U.S. Bankruptcy Code, in such a scenario, liquidation is explicitly permitted.
[10] Lowenstein, n.1 *supra*; Dunbar (2000), n.4 *supra*.
[11] *id.* Compare Lowenstein and Dunbar.

This blame game can go on forever and, thus, this paper excludes these issues and narrows its focus to cover LTCM's use (or mis-use) of Value-at-Risk ('VaR') to arrive at a minimum capital level sufficient to withstand the significant market stresses of late 1998 and its surprising lack of trading common sense. Part I of this paper provides a brief background of the LTCM methodology and explains the fund's core strategies. The background and overview provided in this section is essential for the following sections since the key focus of this paper is the appropriate capital base for the fund. Part II provides background information on VaR and leads to the LTCM-specific analysis in Part III, which focuses on the fund's risk management practices and illustrates the shortcomings of VaR, as implemented by LTCM. Finally, Part IV offers some concluding observations.

I.
Long Term Capital Management

A. Background

Prior to the start of LTCM, John Meriwether was the head of a highly profitable bond-arbitrage group at Salomon Brothers.[12] In 1991, due to fallout from the Paul Mozer bond scandal, the firm's Chief Executive, John Gutfreund and later Meriwether were forced out.[13] In 1993, Meriwether created Long-Term Capital as a hedge fund and recruited several Salomon bond traders and two future Nobel Prize winners, Myron Scholes and Robert C. Merton.[14] Other principals in the firm included Eric Rosenfeld, Greg Hawkins, Larry Hilibrand, William Krasker, Dick Leahy, Victor Haghani, James McEntee, Robert Shustak, and David W. Mullins Jr. The company consisted of Long-Term Capital Management (LTCM), a company incorporated in Delaware but based in Greenwich, Connecticut. LTCM managed trades in Long-Term Capital Portfolio LP, a partnership formed under the laws of the Cayman Islands.[15] The fund's operation was designed to have extremely low overhead; trades were conducted through a prime brokerage account at Bear Stearns and client relations were handled by Merrill Lynch.[16]

In laymen's terms, a hedge fund is a private investment partnership that can take, *inter alia*, long and short positions in various markets and is accessible only to large investors.[17] Meriwether chose to start a hedge fund to avoid the financial regulation imposed on more traditional investment vehicles, such as mutual funds, as established by the Investment Company Act of 1940—funds which accepted stakes from one hundred or fewer individuals with more than one million dollars in net worth each were exempt from most of the regulations that bound other investment companies.[18] By early 1994, LTCM has raised just a little over $1 billion in capital and the capital grew steadily to more than $7 billion by 1997.[19] By early 1998, according to various media accounts, since no public record of their trades exist, the total assets of LTCM amounted to more than $125 billion; this

[12] Lowenstein (2000), n.1 *supra*.
[13] *Ibid* (*Lowenstein*); *see also* Lewis, M., *Liar's Poker* (Penguin Books: New York, 2000).
[14] *Ibid* (*Lowenstein*); *see also* Lewis, M., "How the Eggheads Cracked," *New York Times Magazine*, January (1999).
[15] *id.*
[16] Lowenstein (2000), n.1 supra.
[17] Jorion, P., "Risk Management Lessons from Long-Term Capital Management" (1999)(noting that the term "hedge" is somewhat of a misnomer, if not entirely misleading; a hedge fund is almost never a "hedge" and investment in such vehicles carries significant risk.)
[18] *id.*
[19] *id.*

represents the total assets of the fund, most of it borrowed.[20] Commensurate with its performance, by 1997 the total fees of LTCM had grown to about $1.5 billion and LTCM's sixteen partners had invested roughly $1.9 billion of their own money in the fund.[21]

B. Basic Funding Structure of LTCM

LTCM was in the business of engaging in trading strategies to exploit market pricing discrepancies. Because the firm employed strategies designed to make money over long horizons--from six months to two years or more--it adopted a long--term financing structure purportedly designed to allow it to withstand short-term market fluctuations. In many of its trades, the firm was in effect a seller of liquidity.[22] LTCM generally sought to hedge the risk--exposure components of its positions that were not expected to add incremental value to portfolio performance and to increase the value-added component of its risk exposures by borrowing to increase the size of its positions.[23] The fund's positions were diversified across many markets; although the structure of this diversification would later prove to be fatal as it underestimated liquidity risks and correlations between different markets.

C. Leverage

In September 1997, when, after three and a half years of high investment returns,[24] LTCM's fund capital had grown to $6.7 billion, LTCM considered whether it was a prudent and opportune moment to return capital to investors.[25] In 1997, LTCM's returns were down to only 17%.[26] By contrast, in 1997 U.S. stocks gained approximately 37%.[27] Since LTCM marketed itself as having a level of risk no greater than that of U.S. equities, such performance was embarrassing. Indeed, why would anyone pay LTCM's sky-high management fees if, for the same risk, they could earn greater returns in U.S. stocks? No one. Thus, to achieve the high returns its investors and the firm partners had become accustomed to, the firm had to increase leverage. Towards this end, LTCM returned $2.7 billion of capital to investors in 1997 while keeping total assets at $125 billion.[28] Consequently their leverage ratio rose from approximately 18 to 1 to approximately 25 to 1. However, as ludicrous as the level of assets compared to equity sounds, these figures belie the fact that, including the fund's numerous off-balance-sheet positions, the notional principal amount added up to well over $1 trillion.[29] However, for our purposes, this scary notional amount is meaningless and what matters is the total risk of the fund.[30]

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[20] *id.*
[21] *id.*
[22] Lowenstein (2000), n.1 *supra*.
[23] *id.*
[24] Jorion (1999), n.17 *supra*.
[25] *id.*
[26] *id.*
[27] *id.*
[28] *id.*
[29] *id.*
[30] *id.*

D. Strategy

So, how was LTCM able to achieve such leverage? LTCM was able to leverage its balance sheet through the sale-repurchase agreements with various commercial and investment banks.[31] Typically, in such "repo" agreements, LTCM would sell some of its assets in exchange for cash and a promise to repurchase them back at a fixed price on some future date.[32] In most cases, banks usually require collateral that is worth slightly more than the cash loaned, e.g. a haircut, designed to provide a buffer against decreases in the collateral value.[33] However, for a variety of reasons, the fund was able to obtain next-to-zero haircuts and this left the banks exposed to the risk that LTCM could default at the same time as the collateral lost value.[34]

The bread and butter trades of LTCM can best be described as "convergence-arbitrage" trades, i.e., trying to take advantage of small differences in prices among near-identical bonds.[35] Popular LTCM trades included betting that the 10 year USD swap spread (the difference between the 10 year US Dollar Swap Rate and 10 year US Treasury Rate) would narrow; betting that the spread between on-the-run and off-the-run 30 year Treasury yields would converge; betting that European interest rates within the nascent European Monetary System would converge, as well as bets on equity volatility and various merger arbitrage transactions.

1. Discussion of Various (but not all) LTCM's Trades

According to publicly available sources – since most of LTCM's individual trades are still not available for public inspection, its total losses of approximately $4.6 billion can be summarized as follows:

- $1.6 bn in swaps;
- $1.3 bn in equity volatility;
- $430 mn in Russia and other emerging markets;
- $371 mn in directional trades in developed countries;
- $286 mn in equity pairs (such as VW, Shell discussed below);
- $215 mn in yield curve arbitrage;
- $203 mn in S&P 500 stocks;
- $100 mn in junk bond arbitrage; and
- no substantial losses in merger arbitrage.[36]

As show in the following paragraphs, while each of these investment categories may give the appearance of an overall well-diversified portfolio, in fact, they all share a rather common trait: they all depend on liquidity.

2. On-the-Run vs. Off-the-Run

LTCM's primary strategy is now popularly known as convergence arbitrage, which involves the short sale of "on-the-run" Treasury securities and purchase of "off-the-run" Treasury securities.[37] That is to say, you borrow

[31] Fabozzi, F.J., ed., *The Handbook of Fixed Income Securities* (6th edn., McGrawhill: New York, 2005); *see also* Hull, J.C., *Options Futures and Other Derivatives* (5th edn., Prentice Hall, 2002).
[32] *id.*
[33] *id.*
[34] *id.*
[35] Lowenstein (2000), n.1 *supra*.
[36] *id.*

newly issued (on-the-run) government bonds from an investment banking partner and sell the instruments in the market while buying older (off-the-run) government bonds, counting on a past trend of convergence. The off-the-run bond becomes slightly less liquid, allowing the price to trade at a discount.[38] When the price trades at a discount, the yield-to-maturity increases, displaying a negative relationship.[39] The on-the-run bond, however, begins in the same manner as the off-the-run, *ceteris paribus*. Since the price adjustments of bonds are progressively diminishing, these bonds converge, but, never meet.[40]

Profits on a short sale are achieved when the price of the underlying asset falls.[41] Since you borrowed the asset to sell, you must return it at a later date, betting the price falls so it may be repurchased at a lower price.[42] Buying an asset, also known as "going long," bets that the value of the asset will appreciate over time.[43] On-the-run bonds are typically traded at a premium since they are freshly issued, therefore more attractive to investors.[44] The off-the-run bonds traded by LTCM were bought 6-months past issue, and often sold at a discount.[45] The yield-to-maturity differences between these two instruments is known as a spread.[46] This spread converges, lowering the price of the on-the-run bond and raising the price of the off-the-run bond.[47] This price adjustment is the result of the on-the-run bonds becoming off-the-run bonds, in accordance with Malkiel's Bond theorem and liquidity preferences.[48] Almost no capital was necessary for these transactions.[49] When bonds are shorted, the proceeds from the borrowed sale are received by the shorting firm and can be used to purchase alternate securities, such as off-the-run bonds, before the on-the-run bonds are repurchased.[50]

There are various drawbacks, however, to this seemingly flawless arbitrage system. Short-sales require margin payment to ensure they will be able to make good on the loan following a sharp market downturn. This money is used as collateral; however, Meriwether, known for his ability to receive favourable contracts, often limited this effect.[51] Furthermore, bond convergence arbitrage isn't true arbitrage by the traditional definition. Arbitrage is defined as the mis-pricing of equivalent assets between two markets.[52] Mis-pricing implies that an arbitrage transaction is risk free; however, spreads may widen, creating magnified losses. Lastly, since convergence arbitrage profits from minor price adjustment, the realized gain is often minor relative to the initial investment.[53] For this reason leverage is needed. Leverage takes the form of loans and repurchase agreements. Through this

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[37] *id.*
[38] *id.*
[39] *id.*
[40] *id.*
[41] Fabozzi (2005), n.31, *supra* and Hull (2002), n.31 *supra*.
[42] *id.*
[43] *id.*
[44] *id.*
[45] Lowenstein (2000), n.1 *supra*.
[46] Fabozzi (2005), n.31, *supra* and Hull (2002), n.31 *supra*.
[47] *id.*
[48] Malkiel, B., McCue, K., *A Random Walk Down Wall Street*, (W.W. Norton & Company: New York, 1996).
[49] *See* Lowenstein (2000), n.1 *supr*a (describing LTCM's arrangements with counterparties); *see also* Jorion (1999), n.17 *supra* (same). For general understanding of how these transactions work *see* Fabozzi (2005), n.31 *supra* and Hull (2002), n.31 *supra*.
[50] *Ibid.* (*Lowenstein*).
[51] *id.*; see also Jorion (1999), n.17'
[52] Fabozzi (2005), n.31 *supra*; and Hull (2002), n.31 *supra*.
[53] *id.*

method a $1,000 investment could be leveraged up to 30 times over, mimicking a $30,000 dollar investment, allowing the investor to realize gains or losses 30 times the initial investment. Although this method can lead to previously unattainable profits, it also significantly increases risk.

3. Merger Arbitrage and Other Equity Trades

Further pressures for expanding to alternative investments came from the realization of LTCM's strategy by investment banks, leading to a narrowing of spreads and a decrease in convergence profits. Pressured to find new trades, the fund often used strategies outside the expertise of the former Solomon Arbitrage Group partners and could only be considered speculation.[54] Further pressure came from the fund's growing size. As the size of the fund grew, trades became increasing large and unwieldy, so much so that Long-Term once accounted for roughly 20% of the open interest in the French option markets.[55] Merger arbitrage became a popular tactic. Merger arbitrage is betting that a particular merger will actually take place; risks include whether the proposed merger will be approved by the relevant regulatory authority, such as the Justice Department, whether shareholders will approve the deal; or, more generally, whether the buyer will be able to complete the deal (e.g. arrange financing) effectively driving the stock to the buyout price.

Speculating on the spread between common and preferred stock also became a tactic of LTCM. Common and preferred stock are the same except that preferred stock does not have voting right but pays a dividend in annuity form. When the prices of common and preferred stock diverged too widely, LTCM would short the overpriced stock and go long on the under-priced stock.[56] (Lowenstein, 2000, 99).

4. Interest Rate Swaps and Equity Volatility

Among Long-Term's largest positions became interest rate swaps and equity volatility. These two assets amounted for $2.9 billion of Long-Term's losses.[57] Equity volatility does not refer to any specific investment but rather to a strategy for investment. According to the Black-Scholes model, in 1998 the fund foresaw equity volatility of 15%; however, options were trading at 20% volatility.[58] An increase in volatility is positively related to the options price; therefore LTCM began shorting $1.3 billion dollars' worth of equity volatility in early 1998.[59] This became a terrible fault under the conditions of the impending storm.[60]

Furthermore, Long-Term began shorting $1.9 billion worth of interest rate swaps.[61] Interest rate swaps bet on whether the spread between the LIBOR (London Interbank Offer Rate) and government securities will narrow.[62] Under stable economic conditions, the spread tends to narrow; however, the opposite effect is seen under conditions of volatility.[63] These two derivative trades quickly became the primary positions held by LTCM.

[54] Lowenstein (2000), n.1 *supra*.
[55] Trillion (1999), n.5 *supra*.
[56] Lowenstein (2000), n.1 *supra*.
[57] *id.*
[58] *id.*
[59] *id.*
[60] *id.*
[61] *id.*
[62] *id.*
[63] *id.*

Because a derivatives price is derived from the price of an underlying asset, it is merely a contracted right to that asset at a future date.[64] Since the asset is often not held by the selling party, derivative contracts can be bought for a fraction of the underlying value with promise of repayment on the expiry date.[65] For this reason, derivative contracts are naturally leveraged, only maintained by an underlying margin.[66] A margin is similar to a down payment.[67] Furthermore, Long-Term frequently used large amounts of external leverage to buy these contracts which were naturally leveraged.[68] Ultimately, this resulted in $1.29 trillion dollars in positions at the height of the fund's trading.[69]

With many assets weighted in convergence arbitrage an adequate analysis of the nature of risk behind this trade must be considered. As cited in Owen Lamont and Richard Thaler's research, The Law of One Price in Financial Markets, LTCM had noteworthy positions in the assets with dual share classes.[70] A particular trade used in their research was the Royal Dutch Shell Company.[71] Shell is a British firm traded in London while Royal Dutch shares are traded in Amsterdam. The merger agreement allowed for dual shares in different markets, with Royal Dutch to control 60% of the cash flows and Shell to control 40%.[72] Moreover, in a perfect market Royal Dutch shares should trade 1.5 times higher than Shell shares. According to Lamont and Thaler, the market continuously violates the law of one price, that is, that all assets should have one price that is consistent with that of a comparable asset.[73] In 1981 the spread between these two classes was 15% too low while in 1996 the spread was 30% too high.[74] But, what does this say about LTCM's strategy? With LTCM in convergence positions in common/preferred stock, dual share classes, bond convergence and interest rate swaps, the partners were betting on rationality in markets, however, panic quickly can distort proper market pricing. Lamont and Thaler's theory also reveals that LTCM's positions were not true arbitrage. Arbitrage is a risk-free investment of mispriced assets.[75] These assets may have been theoretically mispriced in a perfect market, however, historical research indicates this strategy is only arbitrage in short-term, which may not have suited the interest of LTCM.[76]

[64] Hull (2002), n.31 *supra*.
[65] id.
[66] id.
[67] id.
[68] Lowenstein (2000), n.31 *supra*.
[69] Trillion (1999), n.5 *supra*.
[70] Lamont, O.A., Thaler, R.H., *Anomalies: The Law of One Price in Financial Markets* (2003) 17(4) Journal of Economic Progress 191-2002.
[71] *id.*
[72] *id.*
[73] *id.*
[74] *id.*
[75] *id.*
[76] *id.*

II.

LTCM's and VaR

A. Value At Risk

VaR can be defined as the worst loss that can happen under normal market conditions over a specified horizon at a specified confidence interval level.[77] VaR measures the shortfall from the qualtile of the distribution of trading revenues.[78] By way of background, VaR was developed as a practical first-order gauge of financial risk.[79] Its primary purpose was to communicate risks to stakeholders.[80] More recently, it has developed into a common benchmark to compare and control risk across risk-taking units and, thus, determine the amount of equity capital necessary to support a trading activity.[81] VaR measures are based on two quantitative parameters: the confidence level and the horizon.[82] The choice of these parameters depends on the application.[83] If VaR is simply used to report or compare risk, the parameters can be arbitrarily chosen, as long as they are consistent.[84] However, if VaR is used as the basis for setting the amount of equity capital, the parameters must be chosen with extreme care.[85] In other words, the confidence interval level must be high enough that the probability of exceeding VaR is very low.[86] Turning to the horizon, it must be related to the liquidity of assets, or the time necessary for an orderly liquidation or, in the further alternative, the horizon should cover the time necessary to raise additional funds or for corrective action.[87] However, these approaches which underpin the use of VaR by financial institutions veil the fundamental and intrinsic flaws of the VaR approach to risk management.

B. Was VaR the Culprit?

At the time of LTCM's failure, the fund's reliance on VaR was named as the number one culprit. But is this charge accurate? To answer this question, we must answer an antecedent question: what are the problems with VaR?

1. Financial Assets Do Not Exhibit Normal Distribution (Gaussian Distribution)

VaR models (along with a lot of other risk measurement tools, such as the Black-Scholes options pricing model) assumes that asset prices follow a "normal" distribution, or the classical bell curve.[88] That sort of distribution is also known as Gaussian. But it is well known that financial assets do not exhibit normal distributions.[89] The distribution of prices in financial markets are subject to both "skewness" and "kurtosis."[90] Skewness means results are not symmetrical around the mean:

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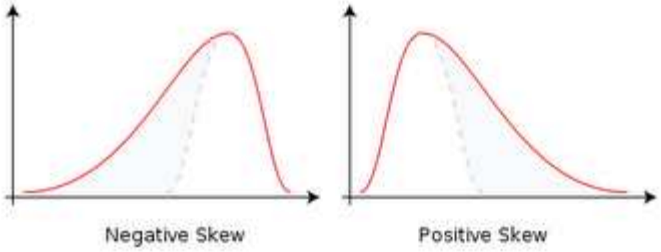
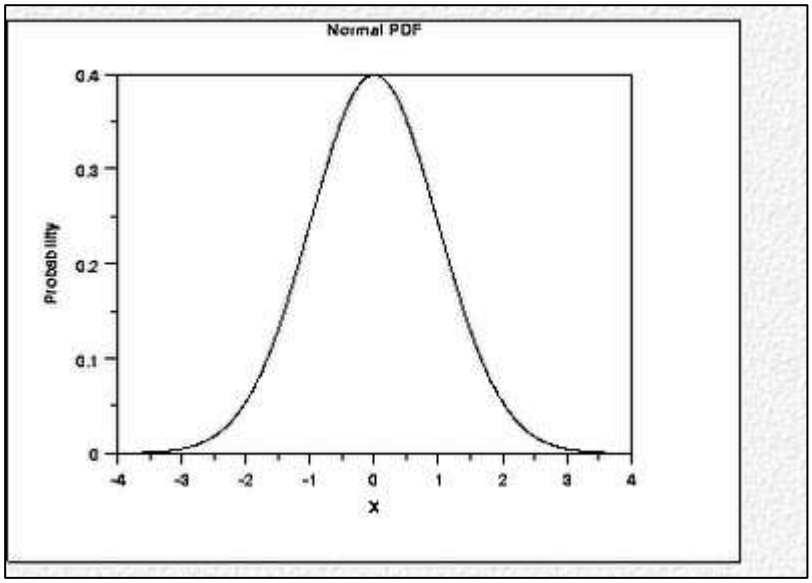
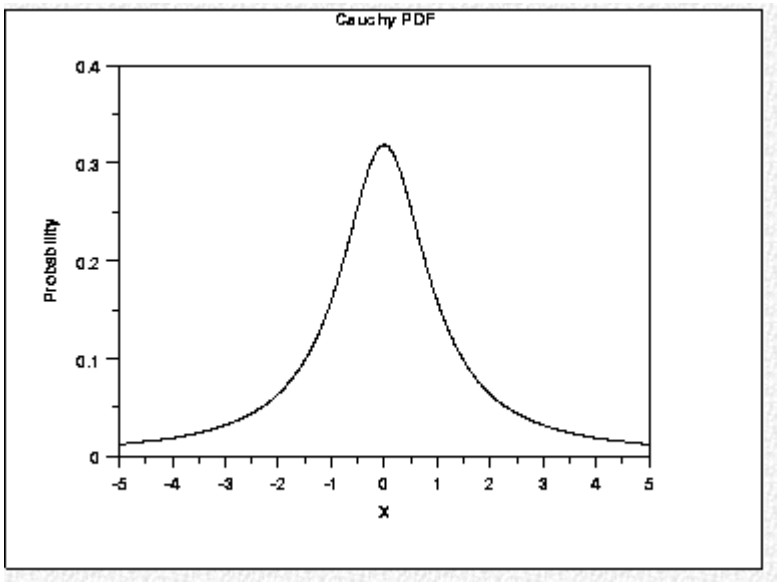
[77] Butler, C., *Mastering Value At Risk: A Step-by-Step Guide to Understanding and Applying VaR* (Pearson Education Limited: Harlow, 1998).
[78] *id.*
[79] *id.*
[80] *id.*
[81] *id.*
[82] *id.*
[83] *id.*
[84] *id.*
[85] *id.*
[86] *id.*
[87] Jorion (1999), n.17 *supra*.
[88] *id.*
[89] *id.*
[90] Hull (2002), n.31 *supra*.



Stocks and bonds are subject to negative skewness (longer tails of negative outcomes) while commodities exhibit positive skewness (and that factor, in addition to their low correlation with financial asset returns, makes them a useful addition to a model portfolio).[91] Kurtosis is also known informally as "fat tails."[92] That means that events far away from the mean are more likely to happen that a normal distribution would suggest.[93] The first chart below is a normal distribution, the second, a so-called Cauchy distribution, which has fat tails:



[91] *id.*
[92] *id.*
[93] *id.*



The notion that financial markets do not exhibit Gaussian distributions is not new.[94] Indeed, at around the time when the ideas of financial economists were being developed and taking hold (and key to their work was the idea that security prices were normally distributed), mathematician Benoit Mandelbrot learned that cotton had an unusually long price history (100 years of daily prices).[95] Mandelbrot cut the data, and no matter what time period one used, the results were not normally distributed.[96] His findings were initially dismissed, but they have been confirmed repeatedly.[97] Yet the math on which risk management and portfolio construction rests assumes a normal distribution! A similar problem can be observed when traders try to "game" a VaR system.[98] For example, if a risk manager uses a VaR system for risk control or performance evaluation, traders may have an incentive to evade their risk limits.[99] Examples of such evasion include when currency traders take large positions in pegged currencies, which have low historical volatility but high devaluation risk.[100] Or, traders take delta neutral short straddle position (such as Nick Leeson of the Barring's fame).[101] In such instances, there is a resulting downward bias in the risk measure.[102]

2. Fundamental Misconception About VaR: If Only More Data?

For 20 years numerous investors have been complaining about measurements of portfolio risk that use the Gaussian distribution, or bell curve. Every four or five years, they are told, their portfolios suffer from a once-in-50-years event. However, doesn't common sense lead one to believe that something is off here?

On the one hand, reverting back to our earlier discussion, models based on the Gaussian distribution are a pretty good way of managing day-to-day trading positions since, from one day to the next, risks will tend to be

[94] *id.*
[95] Mandelbrot, B.B., *The Variation of Certain Speculative Prices* (1963) 36(4) Journal of Business 394-419.
[96] *id.*
[97] *id.*
[98] Jorion (1999), n.17 *supra*.
[99] *id.*
[100] *id.*
[101] Leeson, N., *Rogue Trader* (Warner Books: London, 1997).
[102] Jorion (1999), n.17 *supra*.

normally distributed. Also, they give a simple, one-number measure of risk, which makes it easier for the traders' managers to make decisions. In this line of thought, it is argued that the "tails risk" becomes significant over longer periods of time. In other words, as one trader put it:

> Traders who maintain good liquidity and fast reaction times can handle tails risk. A once-in-10-years-comet- wiping-out-the-dinosaurs disaster is a problem for the investor, not the manager-mammal who collects his compensation annually... He has what they call a "résumé put," not a term you will find in offering memoranda...[103]

On the other hand, this line of thought belies the fact that the models misrepresent the nature of risk. Moreover, this line of reasoning still assumes that VaR is still purportedly good at measuring the risk of what happens 99% of the time while conceding what happens in that remaining 1% could be catastrophic. That in fact understates the flaws of VaR.

The fundamental misconception about VaR is that, if only, the risk manager used a series of financial data over longer period of time, the model would have been right.[104] This line of argument is belied by what was noted by Mandelbrot's observation: the risks are simply not normally distributed. In other words, more data will not fix this intrinsic failing. While the noisiest of the VaR critics will hammer home this point repeatedly, e.g. our very own NYU Professor Nassim Nicolas Taleb, their dismissive and lack of sufficient explanation on this point has been muzzled by an obsession in the academic and regulatory community that insists on the soundness of VaR.[105]

3. One Size Fits All Approach to VaR

Building on the above flaw, the next overlooked or, less mentioned critique of VaR, is the industry's "one size fits all" approach to VaR. The same normal distribution is assumed for all asset types, when in reality, different types of investments exhibit different types of skewness.[106] The fact that VaR allows for comparisons across investment types via force-fitting is simply overlooked. No single construct can be adequate. Accordingly, large firms must rely on multiple tools and financial regulators should abandon their over reliance on VaR as a proxy for risk; however, given its popularity and global use as the go-to-risk metric this seems unlikely. However, this false confidence in VaR has meant that it has become a crutch. Rather than attempting to develop sufficient competence to enable them to have a better understanding of the issues and techniques involved in risk management and measurement (which would clearly require some staffers to have high-level math skills), regulators instead take false comfort in a single number that greatly understates the risk they should be most worried about, that of a major blow-up.[107]

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[103] Personally communicated to me by Jack DiMaio in August 2004 at a dinner in Greenwich, Connecticut. Mr. DiMaio is a partner at DiMaio & Nassert, LLC and former trader at Credit Suisse First Boston.
[104] Jorion (1999), n.17 *supra*.
[105] *See e.g.*, Taleb, N.N., *Fooled by Randomness* (Random House: New York, 2004).
[106] Taleb, N., *The Jorion-Taleb Debate*, Derivatives Strategy (April 1997).
[107] *id.*

III.

Did LTCM's Reliance on VaR Doom it to Failure?

Turning back to LTCM, what impact if any did VaR have on its demise? As noted above, the notional value of some of its hundreds of billions of dollars of OTC of derivatives positions, and even the $125 billion in assets, is meaningless. Indeed, what mattered at the end of the day was the overall volatility of the fund. According to its marketing materials, i.e., its representations to potential investors to induce them to invest in the fund, it asserted that "the portfolio [is] managed so that its target risk [is] no larger than the risk of an unleveraged position in the S&P 500."[108] Of course, for a fund charging sky-high fees, one cannot blame them for a bit of "marketing freedom," however, this statement involved unrealistic assumptions and well established biases that were probably known to the fund's principals.[109]

The annual average volatility of the S&P 500 over 1978 to 1997 was 15%.[110] Using simple arithmetic, we can apply this number to the fund's capital ($4.7 billion) and arrive at a daily volatility of $4,700 x 0.15/√252 = $44 million.[111] The fund's investor letters state that the fund's daily volatility was around $45 million. Now, what do these figures mean? Broadly speaking, or at least in theory, it meant that LTCM targeted its positions so as to maximize expected returns subject to the constraint that the fund's perceived risk was no greater than that of the stock market.[112]

Since LTCM acted much as the same as a commercial bank, looking at the capital requirements under the Basle framework is a good starting point. These rules specify that capital should be at least 3 times the 99% confidence interval level VaR over 10 business days. Once again, *assuming* a normal distribution and the associated multiplier 2.33, the daily 99% VaR of LTCM's portfolio was $105 million.[113] Under the Basle framework, this would have translated into a capital level of 3 x $105 million x √10 = $993 million, which is significantly less than LTCM's $4.7 billion in equity.[114] So, what's wrong with this picture?

Firstly, the ten-day period required for commercial banks is entirely unrealistic for a hedge fund. For one thing, commercial banks are closely supervised by their regulator(s), who can step in at the first sign of trouble and, thus, the 10-day period can be interpreted as the normal reaction time should such a hypothetical bank run into difficulties. However, for a hedge fund, the horizon should correspond to the period required to raise additional funds and this period, usually in times of great or significant stress, will likely be substantially longer than the 10-day period applicable to commercial banks.[115]

Secondly, this approach assumes that volatility is constant, when in fact, it rarely is. This approach also assumes that the distribution of profit and losses are symmetrical, which as noted by Merton in discussing long positions

[108] Jorion (1999), n.17 *supra*.
[109] *id.*
[110] *id.*
[111] *id.*
[112] *id.*
[113] *id.*
[114] *id.* (citing Basle Committee on Banking Supervision (1995), *An Internal Model-Based Approach to Market Risk Capital Requirements,* Basle, Switzerland: BIS.)
[115] *id.*

in credit sensitive instruments is incorrect.[116] Merton summarizes that long positions in credit-sensitive instruments can be interpreted as short positions in options, which have limited upside potential (e.g. the premium) and large downside risk (e.g. default).[117] Moreover, even if the distributions were symmetrical, it is unlikely their tails could be sufficiently captured by a normal distribution model. Indeed, recent time-series models establish that most financial series have fatter tails than provided for by normal distribution, even when accounting for time-variation in risk. Moreover, various academic commentators have argued that, even after fitting a time-varying GARCH process, conditional standardized returns are better approximated by a Student t-distribution than by a normal distribution.[118] By way of example, academic studies of the study of LTCM's risk management, using the same data to optimize a portfolio and compute its VAR, demonstrates the biased risk forecasts would have shown up in the realized returns. In sum, extrapolating the $105 million daily VaR figure derived above to a monthly figure leads to $339 million. Next, assuming an annual profit of 18%, the expected profit would have been $71 million over a month. Consequently, at a 99% VaR confidence interval level, the worst loss over a month should have been $268 million. However, since LTCM's own figures reveal that in May and June 1998 its portfolio lost $310 million and $450 million, respectively, the daily VaR limit must have been breached on a number of occasions. Indeed, back-testing of its portfolio reveals that in the period prior to the market upheaval of 1998, the fund's daily VaR breached $200 million. Thus, this leads to the unmistakeable conclusion that the target volatility reported to investors, and used by management in its risk assessment, was unrealistically low. Viewed in light of this information, the true Basle minimum capital would increase to $2.2 billion, just barely sufficient since LTCM lost approximately $1.7 billion in August 2008.[119]

Third, and somewhat surprisingly, LTCM seems to have overlooked the correlation and impact of volatility, as well as liquidity on its various purportedly "diversified" positions. For example, it seems to have taken no account of the fact that a sharp increase in equity volatility, or a sovereign default, or other such scenario would likely correlate with adverse events in other, unrelated markets, such as was seen with the overall widening of fixed income spreads (i.e. corporate bond spreads, MBS spreads, swap spreads, merger arbitrage spreads etc.), and increase in fixed income volatility.[120]

Fourth, LTCM's risk management model appears to have taken little, if any, account of the correlation between markets and/or positions when liquidity disappears. This is truly surprising since even the most novice traders, for example, stay at home day traders, would be able to figure out that a sharp rise in equity volatility would likely impact merger arbitrage spreads or related convergence trades. LTCM was basically punting on a massive scale and thus deviating considerably from what had been its historical approach. In addition, LTCM was taking very large positions in a lot of markets, yet was making no provisions for liquidity risk. In other words, there was no way it could exit most of its positions without having a price impact. That is a basic mistake that even a penny stock trader would avoid after his first few days trading, however, LTCM perpetrated it in breathtakingly cavalier fashion. Thus, while LTCM managed to maintain the image of having sophisticated risk management

[116] *id.*
[117] *id.*
[118] *id.*
[119] *id.*
[120] id.; *see also* Kolman, J., LTCM Speaks, *Derivatives Strategy* (April 1999), 12-17.

up to the point of its failure, it violated its own playbook and completely ignored position size versus normal trading liquidity.[121]

IV.

Conclusion

As discussed in this paper, LTCM failed because it seems to have badly mismanaged its risk and lulled itself into believing that its VaR was manageable. In fact, it made severely flawed judgments as to the diversification of its overall portfolio and underestimated its risk due to its risk concentration, reliance on short-term history and its general head-in-the sand approach to the glaring intrinsic flaws in VaR.

Finally, as noted by most academic commentators, LTCM liked to compare itself to a typical Wall Street investment bank, which was leveraged 20 to 25 times. However, as much as the firm's management would liked to have thought that LTCM was comparable to their former alma mater, Salomon Brothers, this comparison was faulty. Why? Firstly, commercial and investment banks hold significantly more diversified portfolios that span several markets and businesses. They are not just in the business of "convergence" trades. Secondly, in most instances, the banks' traders' activities actually benefit from increased volatility, since volatile markets generate greater trading volume and revenues, which provide a natural hedge against increases in volatility. Next, investment banks and commercial banks have much easier (and quicker) access to fresh funds than a hedge fund. Finally, one further thought must be mentioned. Much of the academic commentary on VaR, as well as the LTCM debacle has been interpreted as an "indictment" of sorts of the common usage of VaR in the trading industry. However, that issue as a red herring. A more appropriate question to ask would be, if commercial banks and investment banks are fully regulated, why do we permit special rules for hedge funds to act and parade around as "special" investment banks or "commercial banks" and avoid full regulation when they carry all the same risks to the system? The fact that hedge funds only cater to the ultra-wealthy is a far cry from a valid justification for the inherent risks to the overall financial system from letting highly leveraged entities run around, potentially without any regulatory oversight at all.

[121] Jorion (1999), n.17 *supra*.

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