Long-Term Capital Management: A Short-Lived Wonder

The Fund That Was Promised

Founded in 1994 by a dream team of experienced practitioners and acclaimed financial academics, LTCM not only earned excellent returns for its investors (185% by end of '97)[1], but also seemed to do so without incurring much risk (volatility comparable to unhedged position in S&P 500)[1]. Yet in 1998, LTCM would lose $4.4 billion of its $4.7 billion in capital and be bailed out by a consortium of Wall Street banks.[2] What was the fund's brilliant risk management doing wrong and how can such disaster be avoided?

- *LTCM's models depended on unrealistic assumptions and focused on a short period of historical data. Its "diversified" portfolio was collectively exposed to credit, liquidity, and volatility risks.*
- *Though LTCM was close to becoming insolvent, its desperate need for liquid capital to avoid defaults meant that it was suffering primarily a liquidity crisis.*
- *Based on regression analysis, we find that the fund is vulnerable under stressed economic conditions, which may materialize during the current pandemic.*
- *The absence of a CCP exacerbated LTCM's liquidity strain, but its presence could not have saved the fund from the fundamentally flawed bets.*
- *We recommend the fund to adopt a risk governance structure that includes a CRO and a Risk Committee, each endowed with sufficient supervisory power.*

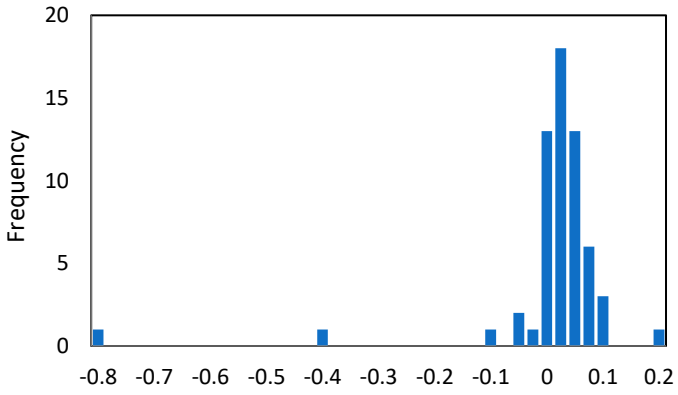
Hidden Risks in Trading Strategies

LTCM's core strategies were convergence and relative value trades, which involved taking supposedly offsetting positions in closely related securities. Such hedging allowed the portfolio to be insensitive to the *direction* of interest rates and stock prices. Profit was realized once security mispricing was recognized by broader market and eliminated over time by rational arbitrage capital. However, in the short run, LTCM was subject to the market's caprice in the form of credit, liquidity, and volatility risks.

False Diversification: To achieve diversification, LTCM held positions across financial instruments in the developed and emerging markets. Nonetheless, such diversification was a mere illusion, as almost all of their trades were bets on credit spread and volatility converging to the "true value" suggested by quant models. Moreover, LTCM was not the only Wall Street firm making such bets. By 1998, most of its tricks were out of the bag and imitated by the proprietary trading desks of large banks. Therefore, when market panicked, traders liquidated those same positions and rushed to the safest assets in a flight-to-quality. Correlation essentially went to unity. Due to the large size of its holdings, LTCM could not unwind its positions fast enough without suffering detrimental markdown.

Problematic Model Assumptions: Believing its model's outcome that equity option was overpriced, LTCM shorted a massive amount of options on major stock indexes in 1998.[1] However, the model's assumption of "constant stock price volatility" was faulty in practice. Also, selling volatility exposed the portfolio to huge downside risk, as the distribution is highly skewed (Fig.1). In addition, LTCM neglected some key nuances when using VaR to measure its risks. For example, the very size of the portfolio meant LTCM was not a price-taker, as assumed by traditional VaR. Moreover, risk of downward bias when estimating VaR increases as the portfolio becomes more complicated. The true VaR could be twice the estimated value with 200 observations of 100 assets.[3] In addition, models were trained on historical data, leading to erroneous assumptions that history will repeat itself. However, crisis usually happens because of unseen events. Therefore, it is of great importance to simulate scenarios along with performing historical risk assessments.

Figure 1: Distribution of LTCM Monthly Return



Source: Perold - Long-Term Capital Management, L.P. (A)[1]

Myopic Historical Inputs: When building its model, LTCM focused on financial data of the five most recent years, during which there were few market disruptions and volatility was low by historical standards.[5] The fund thus underestimated the risks of the portfolio. For instance, LTCM had an exposure of $240 million in US swap spread with an assumption of 15 bp annual volatility. Yet between April and August 1998, the swap spread surged from 48 to 76 bp, an unlikely event according to its model. However, LTCM should have noticed that similar swings happened in 1987 and in 1992. When these model flaws are considered, losing $1.7 billion in August 1998 was no longer an 8.3 sigma event as an LTCM apologist may argue, but something much more inevitable.

Paralyzed by Illiquidity

On September 22nd, the eve of LTCM's bailout by the banking consortium, the fund's equity was down to $773M after trading hours.[2] With an asset size of $110B[2], the fund's leverage reached 142 to 1. Even a 1% loss in asset could

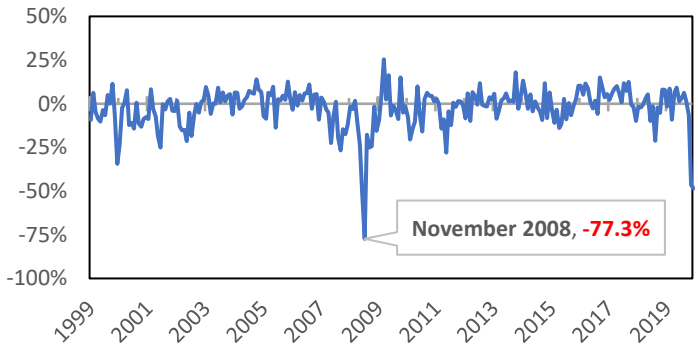
have wiped out the fund. Thus, there is no doubt that LTCM was at serious risk of insolvency. However, what the fund was confronting was first and foremost a liquidity crisis. The fund's most pressing problem was to keep at least $500M in its prime broker Bear Stearns to maintain the clearing service[2], without which LTCM could not operate as a going concern. Even a single default would trigger the cross-default provision and lead to defaults on all of LTCM's seven thousand derivative contracts.[6] The fund needed cash, *immediately*. Therefore, the $470M revolving credit that the fund received from the loan syndicate was all poured into the Bear Stearns account.[2] The liquidity problem was so severe that the company had to "borrow" $38M from its portfolio just to pay the employees' salaries.[2] It was a desperate loan riddled with conflicts of interest.

Other market participants were also aware of the liquidity nature of LTCM's crisis. Traders betted against LTCM not because of certain beliefs in the trades' fundamental values, but because they expected the fund to collapse from a short squeeze very quickly.[7] On the other hand, Warren Buffett and the consortium were willing to buy out the fund because they saw significant equity value if the fund could survive the short-term tempest. Over the long run, LTCM's positions would profit from market conditions reverting to historical means. The banks were correct. One year after the bailout, the fund earned a 10% return and the consortium was able to recover its $3.65B capital injection.[2]

Would LTCM Survive Today?

Even though LTCM failed, there are funds on the Street applying similar strategies. To assess the likelihood of those funds imploding today, we first examined the exposure of LTCM's portfolio by regressing its net monthly returns from March 1994 to April 1999 (the period of the fund's operation) on a list of risk factors. The resulting model is then used to predict hypothetical returns of LTCM, had it continued operating from May 1999 to January 2020 (Fig.2).

Figure 2: Hypothetical Monthly Return of LTCM



The multiple regression model used is

$$NetMonthlyReturn_t = 0.108 - 1.31\Delta Baa10Y_{t-1} - 0.00647VIX_{t-1} + 1.26\Delta MSCI_{W\,t-1} + 0.549\Delta SPX_{t-1} - 0.338\Delta Treasury10Y_{t-1} - 0.304\Delta DXY_{t-1}$$

where Δ represents monthly proportional change in a variable, $Baa10Y$ is the Baa rated corporate bond spread, VIX is the CBOE volatility index, $MSCI\_W$ is MSCI World Index, SPX is the S&P 500 Index, $Treasury10Y$ is the 10-year Treasury yield, and DXY is the U.S. Dollar Index. They are proxies for credit risk, volatility risk, foreign stock market risk, domestic stock market risk, interest rate risk, and exchange rate risk, respectively. Detailed regression analysis is shown in Appx.1.

Not surprisingly, LTCM's relative value strategy was not significantly sensitive to *delta* risks in bond market, domestic stock market, and dollar exchange rate. However, it was heavily exposed to *vega* and credit risk (Appx.1). In the simulation of hypothetical returns, the maximum monthly loss is 77.3%, which would have happened in November 2008. The returns' distribution is skewed to the left with fat tail (Appx.3). Proper risk management also requires examination of stressed conditions outside of historical levels. Thus, we performed sensitivity analysis on monthly returns based on hypothetical VIX levels and changes in corporate credit spread (Table 1), while holding other risk factors at long-term averages. Results show that the fund can lose 100% of its capital in one month if there is a 44% change in credit spread and VIX reaches 82.

Table 1: Sensitivity Analysis on Returns Under Extreme Stress

$\Delta Baa10Y_{t-1}$ \ VIX_{t-1}	66	74	82	90	98
38%	-82%	-87%	-92%	-97%	-102%
44%	-89%	-95%	-100%	-105%	-110%
50%	-97%	-103%	-108%	-113%	-118%
56%	-105%	-110%	-116%	-121%	-126%
62%	-113%	-118%	-123%	-129%	-134%

One near-term scenario that can cause the implosion of a fund like LTCM would be a global market shock induced by a worldwide shutdown of economic activities due to fear of coronavirus. Such shutdown has been the reality in many developed countries for almost a month. However, the economic impacts may be even more severe in developing economies, where people lack social safety net or adequate access to healthcare. For example, China's PMI dropped to 35.7 in February from 50.0 in January.[8] The resulting reduction in global demand and disruption in supply chains may lead to defaults of heavily indebted international corporations. New waves of stock price decline may occur. Unemployment rate will reach new high. Sudden hikes of VIX and credit spread are very likely results. Even if the fund is not directly exposed to emerging markets, it will still bankrupt as liquidity dries up from the inevitable flight to quality. Moreover, crowding in quant strategies increases contagion within the industry. Asset liquidation by one troubled fund could create ripple effect on other funds. Given the high correlation, the result might be severe chaos, not unlike what happened to hedge funds in August 2007.[9]

Caught in Its Own Web

To maintain the secrecy of its trades and attain the best

prices, LTCM often transacted with dozens of counterparties at one time (Appx.4). Its most important counterparty was Bear Stearns, which served as the fund's prime broker and performed much of its custodial, recordkeeping, clearance, and financing services. Along with Merrill Lynch, Bear also cleared futures contracts for LTCM. In doing so, they guaranteed LTCM's positions, thus carrying significant credit exposure to the fund.[10] LTCM also engaged in OTC transactions with about fifty counterparties, most of which were large financial institutions.[2] Another key group of counterparties was those that conducted repo and reverse repo with LTCM. Lastly, a syndicate of banks led by Chase provided a $900 million line of credit for the fund.

In our macro stress test, we focused on consequences of sharp hikes in credit spread and volatility. Counterparties with which LTCM shorted Treasury or equity options would make profit off the fund under such conditions (Appx.5). However, they were also concerned about LTCM's default risk. Should LTCM fail to pay, its counterparties would have trouble paying off their own creditors. As a result, many counterparties aggressively marked down LTCM's collateral to get hold of more of the fund's asset.[11] Such "mark-to-worst" put immense strain on the fund's liquid asset, deepening its losses. Also, LTCM at times transacted with multiple legally distinct entities within the same dealer. When a dealer started worrying about the fund's credit, an entity within the dealer might withhold the collateral that it should transfer to LTCM until LTCM pays the collateral it owed to another entity within the same dealer.[12] Such action invalidated, to an extent, the netting function of the fund's two-way mark-to-market. It caused Bear to worry about its own credit exposure and demand greater margin.

The adoption of a central clearing counterparty (CCP) would have alleviated the situation by reducing the fear over counterparty credit risk. CCPs bring the benefit of novation and multilateral netting. Since they become the shared counterparty for both sides of a contract, the winning side is not concerned over losing side defaulting. CCPs also have layers of bankruptcy prevention mechanisms to insulate the default of a clearing member.[13] Thus, attempts to mark-to-worst or withhold collateral would not have occurred.

However, the primary purposes of CCPs are to increase market efficiency and reduce systemic risk, not to save any specific hedge fund from its bad bets. Significant losses would still accrue even if a CCP decreases counterparties' incentives to exploit the fund's vulnerability. Traders, whether they were LTCM's counterparties or not, could still trade against the fund's positions in hope of profiting off the fund's liquidation.[11] What a CCP might accomplish, however, was to nullify the need for a bailout coordinated by Fed. CCPs have protocols for auctioning off assets of a failed clearing member and loss mutualization mechanisms that can prevent one fund's failure from causing critical harm to its counterparties.[13] Thus, they decrease the moral hazard of large banks and hedge funds.

Improving Risk Governance

The demise of LTCM can be explained with evidence grounded in financial theory, such as the fund's failure to recognize the extent to which its portfolio was collectively exposed to liquidity, volatility, and credit risks.[4] More fundamentally though, LTCM's collapse was the result of a weak risk governance structure that allowed such negligence to persist. The fund's trading decisions were made in an investment committee setting,[2] which can be dominated by a few strong personalities and is conducive to groupthink.[14] Its Board of Directors was filled mostly with insiders and had no real supervisory power.[15] Therefore, we recommend that LTCM strengthen its Board and establish a Risk Committee within. It should also hire a Chief Risk Officer, who would lead a team of analysts to separately cover market, credit, model, and liquidity risks (Appx.5).

The CRO, who is independent of the business units, would work in conjunction with the Risk Committee and General Partners in leading the risk management effort. Her team of analysts should take a proactive approach by working closely with fund managers and evaluating trades' impacts on the portfolio before the trades are executed. Each analyst may be tasked with monitoring a specific category of risk to ensure that no risk exposure is neglected in the process of hedging away others. To do so, the analysts should run quantitative models and conduct regular stress tests. The results are reported to the CRO, who has the authority to approve exceptions to risk limits or veto risky trades.[16] Furthermore, the CRO and the Risk Committee should ensure that the compensation packages for trading teams do not encourage excessive or unnecessary risk-taking.

The Risk Committee consists of selected members of the Board with the duty to supervise the compliance of the risk framework. Members should be experienced practitioners who are more than capable of understanding the funds' complex strategies and positions. Their responsibilities include working with the General Partners to establish risk tolerance, communicate risk budget, and monitor the performance of the CRO, while overseeing the exposures to reputational, operational, legal, and solvency risks.

The key relationship that will determine the overall success of this governance structure is the interplay among the CRO, the Risk Committee, and the General Partners. Power within a hedge fund tends to fall disproportionally on the General Partners, but an adequate degree of checks and balances is necessary for a risk management system to work.[17] The CRO and the Risk Committee must be delegated sufficient power to reject investment decisions that may bring undue risks to the fund. Of course, conflicts can arise between fund managers, whose compensation is tied closely to short-term performance, and risk management personnel, whose priority is the longevity of the fund. To alleviate such conflicts, the General Partners should set the "tone at the top" by promoting open communication and recognizing the importance of the risk function. ■

Appendix

LONG-TERM CAPITAL MANAGEMENT: A SHORT-LIVED WONDER

Appendix 1: Multiple Regression Analysis on LTCM's Net Monthly Returns (March 1994 – April 1999)

	Coefficient	Std. Error	p-value
(Intercept)	0.108	0.0296	< 0.001
$\Delta Baa10Y_{t-1}$	-1.31	0.276	< 0.001***
VIX_{t-1}	-0.00647	0.00142	< 0.001***
$\Delta MSCI\_W_{t-1}$	1.26	0.263	< 0.001***
ΔSPX_{t-1}	0.549	0.241	0.027*
$\Delta Treasury10Y_{t-1}$	-0.338	0.276	0.226
ΔDXY_{t-1}	-0.304	0.511	0.554

Significance codes: 0.1%: ***, 1%: **, 5%: *

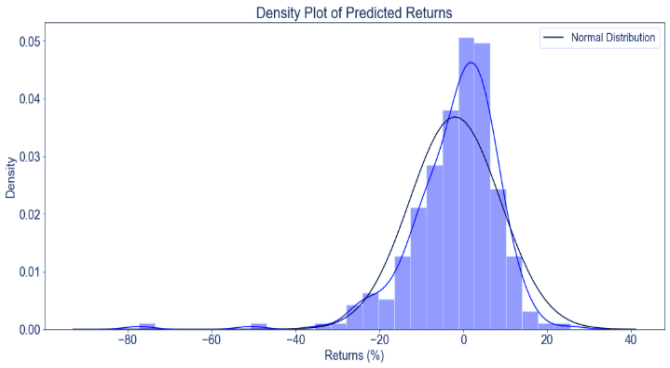
Multiple R-squared: 0.758 Adjusted R-squared: 0.731

Appendix 2: Summary of Extrapolation on Returns

May 1999 - Jan 2020	ΔBaa10Y	VIX	Return*
Min	-20.8%	9.5	-77.3%
Max	40.1%	59.9	25.4%
Average	0.135%	19.6	-2.0%
Std. Deviation	6.25%	7.8	10.9%

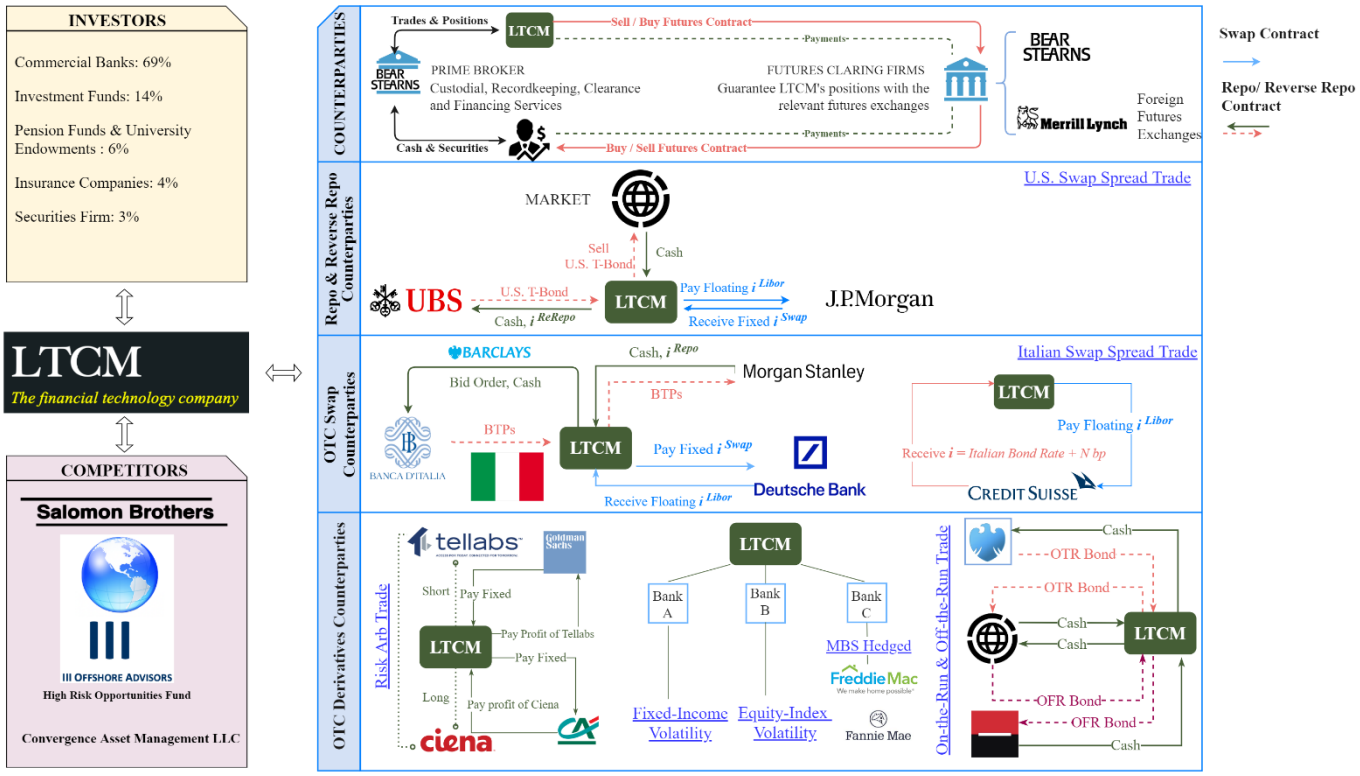
** Hypothetical Net Return of LTCM (Monthly)*

Appendix 3: Distribution of Extrapolated Returns



Note that our model is not meant to be an exact representation of LTCM's exposures, which were never something static or straightforward. The fund's set of trading strategies, along with the associated leverage level, evolved over time, as a response to the decreased profitability stemmed from imitation and crowding. For instance, in 1996 it started entering much riskier trades such as merger arbitrage, where it had little expertise.[2] Another shortcoming is that our independent variables are only broad representations of risk factors, making them particularly lacking when describing the complex holdings of LTCM. However, the fund's core investment philosophy, along with its glaring flaws, had been consistent. Therefore, we believe our model can serve as a helpful first step in elucidating the risk factors that may explain the fund's gains and losses.

Appendix 4: Selected Subset of LTCM's Counterparty Relationships



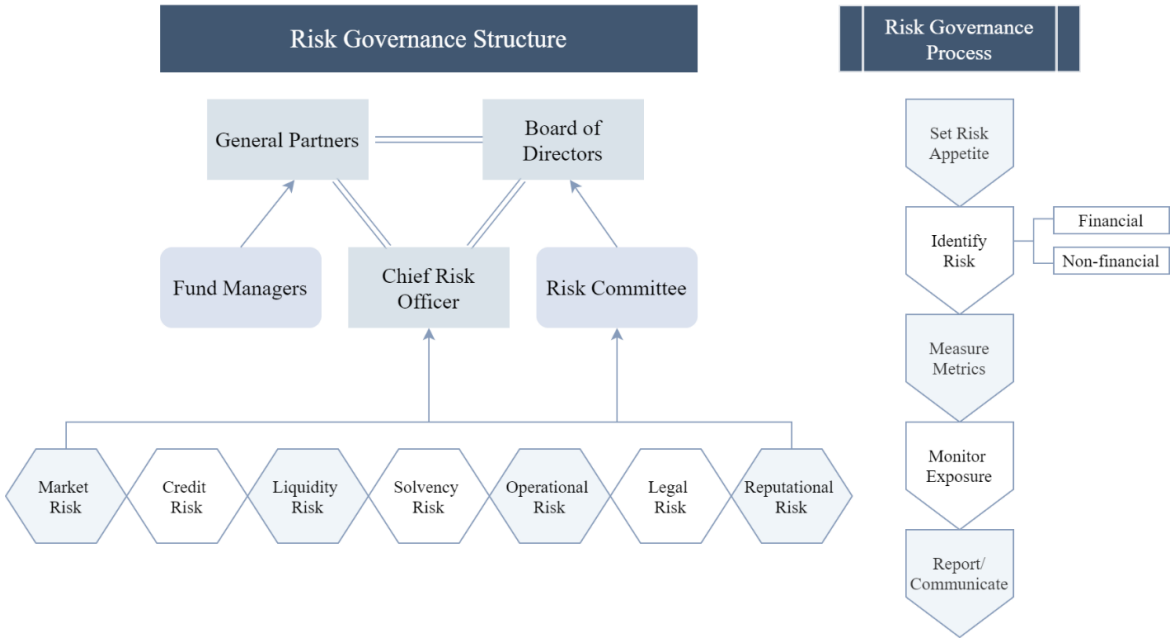
Source: Lowenstein - When Genius Failed (2000)[2], Chincarini - The Crisis of Crowding (2012)[18]

Appendix 5: Expected Losses of Selected Trades Under Stressed Economic Conditions

Trade	Trade Direction	Exposure in 1998 ($M per bp)	Inflation Adjusted Exposure ($M per bp)	Hypothetical Entry Position (bp)	YTD Maximum Loss ($M)	Historical Worst Case ($M)	Historical Worst Case Condition	
							Spread / VIX	Time
Convergence Trades								
U.S. Swap Spread	Short	5	7.94	-3.0	(115)	(659)	80	May 2008
Italian Swap Trade	Short	0.1	0.16	218	(12)	(12)	294	Apr 2018
Relative Value Trades								
Equity Volatility	Short	30	47.61	18	(1,324)	(1,689)	54	Nov 2008
U.S. Mortgage	Short	10	15.87	161	(784)	(1,641)	264	Dec 2008
Box Spread in Japan	Short	3	4.76	10	(60)	(218)	56	May 2010
Total					(2,295)	(4,218)		

Source: Yahoo Finance, Chincarini - The Crisis of Crowding (2012)[18]

Appendix 6: Proposed Risk Governance Structure for LTCM



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