Risk Containment for Hedge Funds

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High Net Worth Seminar
Naples, FL
Jan 24, 2008

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Investment Vehicle that Experienced Explosive Growth

- 30 fold growth in assets under management since 1990
- estimate > 2000 new funds launched in 2006
- in US equities: 5% of assets, but 30% of trading volume

  (source: sec.gov)

- Premium for top funds, e.g. Caxton 3/30, Renaissance 5/44, SAC 50% of profits

Extensive Literature

- Weisman, A. "Informationless Investing And Hedge Fund Performance Measurement Bias," *Journal of Portfolio Management*, 2002, v28(4,Summer), 80-91.
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- Jorion, P. "Risk management lessons from Long-Term Capital Management," *European Financial Management*, 2000, v6(3), 277-300.
- Chow, G. & Kritzman, M. "Value at Risk for Portfolios with Short Positions," *Journal of Portfolio Management*, 2002 v28(3,Spring), 73-81.
- Winston, K. "Long/short portfolio behavior with barriers," *Northfield Research Conference*, 2006.
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Fundamental Idea

- For both investors and managers, hedge funds (though they may be benchmarked to long-only or cash) are a totally different animal

- Non-Gaussian return distributions
- Liquidity and leverage/credit considerations
- Dynamic investment strategies

- Traditional measures of performance and risk – std dev, tracking error, β, α, Sharpe ratio – are non-descriptive

Part I: Complications for the Investor

- Lo 2001, “Risk Management for Hedge Funds: Introduction and Overview”

  Weisman 2002, “Informationless Investing And Hedge Fund Performance Measurement Bias”

- How to manufacture performance with no skill

1. No Skill α

From Lo 2001:

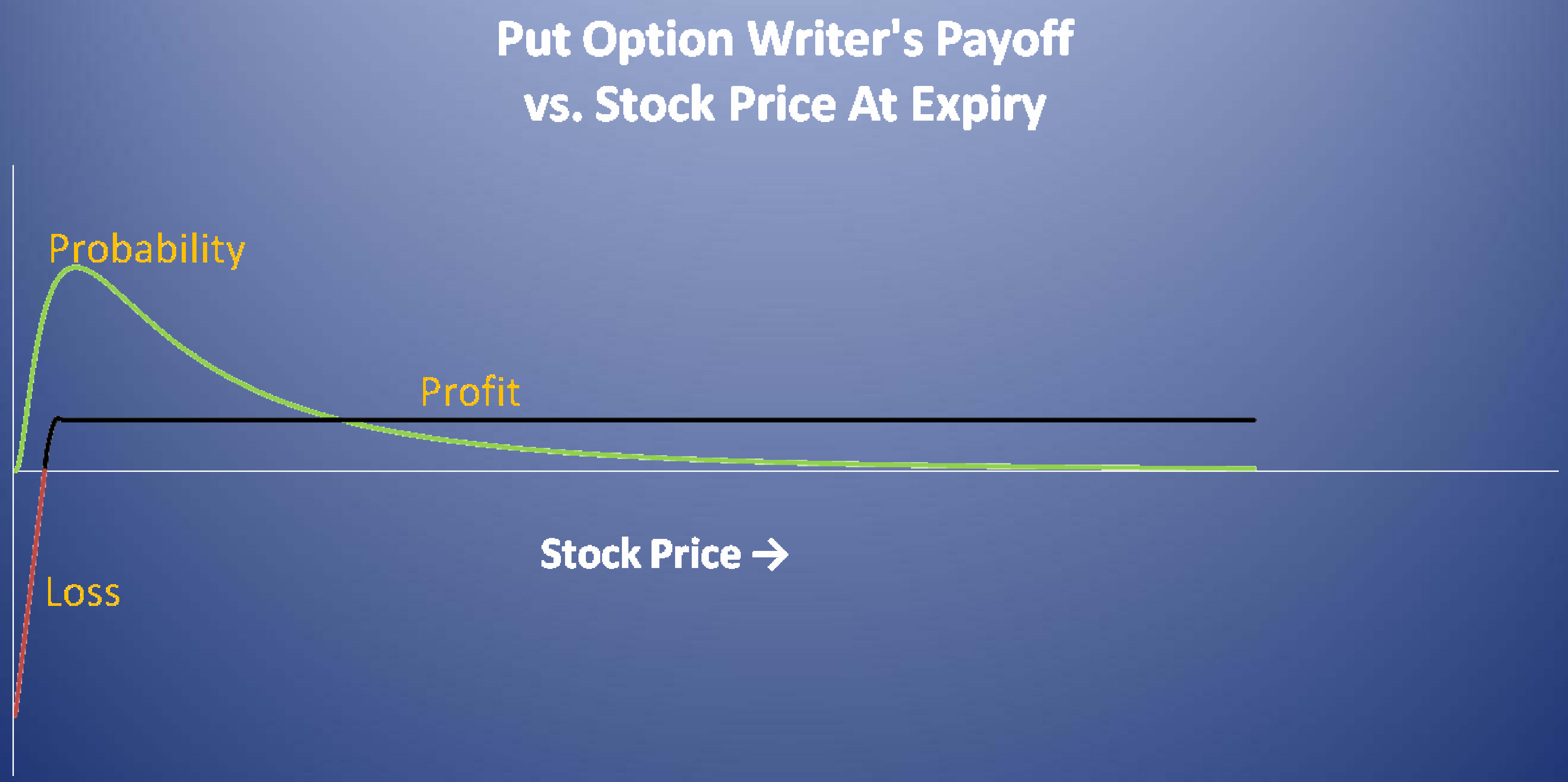
Table 3. Capital Decimation Partners, LP, January 1992–December 1999

Statistic	CDP	S&P 500
Monthly mean (%)	3.7	1.4
Monthly standard deviation (%)	5.8	3.6
Minimum month (%)	–18.3	–8.9
Maximum month (%)	27.0	14.0
Annual Sharpe ratio	1.94	0.98
Number of negative months (out of total)	6/96	36/96
Correlation with S&P 500	59.9	100.0
Total return (%)	2,721.3	367.1

The Secret: Short Volatility
(sell insurance - risk is invisible until it happens)

- Writing options
  Lo's example sells out of the money puts
- Writing synthetic options by Δ hedging (dynamically altering the mix of stock and cash)
  Executed without owning derivatives
- Issuing credit default swaps
- Betting that spreads return to typical levels
  e.g. LTCM, see Jorion 2000

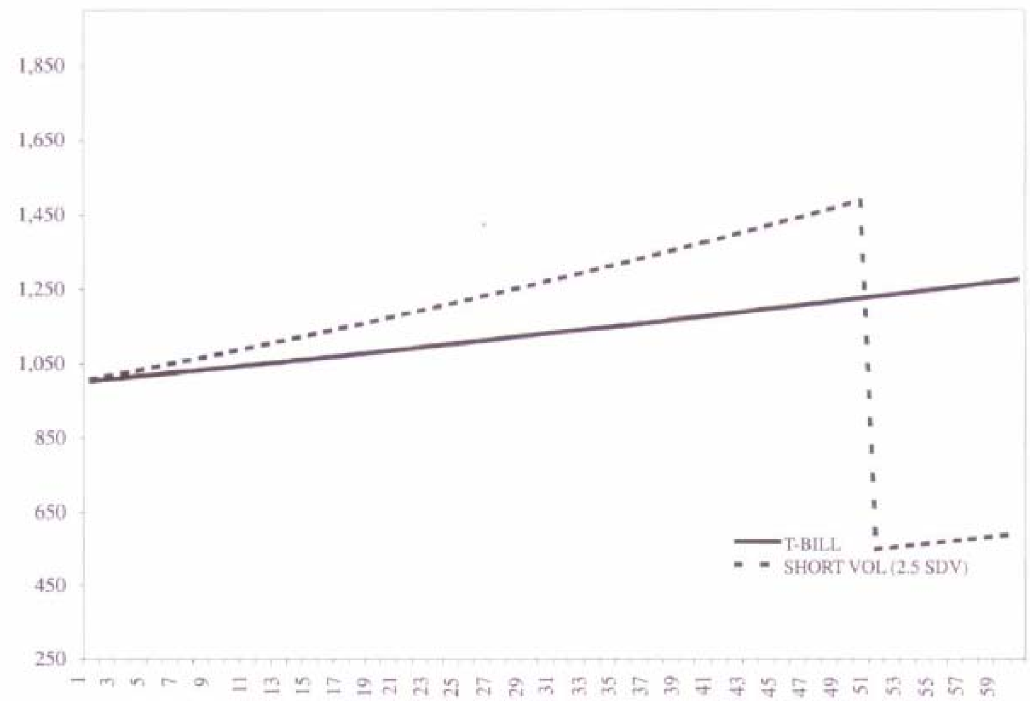
Frequent Small Gains Exchanged for Infrequent Large Losses



Performance of Short Vol Strategy

From Weisman 2002:

EXHIBIT 2
Randomly Generated Five-Year Performance—T-Bill versus Short-Volatility Strategy



2. Estimated Prices for Illiquid Securities

- Value of infrequently traded securities is estimated
- Even operating in earnest, one is likely to undershoot both losses and gains

- Underestimate volatility
- Overestimate value after a series of losses
  i.e. exactly when positions must be liquidated

- Behavior evidenced by serial correlation in returns

- A separate phenomenon: Up returns are, in general, shrunk by performance fees. → The return of the underlying investments (in particular, downside) is more volatile than indicated by reported returns

The Effect on Sharpe Ratio

Suppose the estimate is a combination of present and past true returns:

$$r_t^{estimated} = (1\text{-}w)r_t + wr_{t\text{-}1}$$
$$\sigma^2_{estimated} = [(1\text{-}w)^2 + w^2]\,\sigma^2$$

$$SR = (r\text{-}r_f) / \sigma$$

w = 50% →	Estimated SR	↑ 41%
25% →		↑ 26%
10% →		↑ 10%

3. Increasing Bets After Loss

- Weisman 2002 – St. Petersburg Investing
- If you lose $1 on the first bet, wager $2 on the next. If you lose that bet, wager $4 on the next, etc.
- Low probability of losing, but loss is extreme
- Can happen inadvertently
  - $10 long, $10 short, $10 cash
  - Lose on the shorts: $10 long, $12 short, $10 cash
  - Size of bets jumps from 200% → 275%
    $20 on net $10 → $22 on net $8

Performance of St. Petersburg Strategy

From Weisman 2002:

Theory Meets Reality

- LTCM
  90% of return explained by monthly changes in credit spread
  1/98 → 8/98, lost 52% of its value. Leverage jumped from 28:1 ↑ 55:1

- Nick Maounis, founder of Amaranth Advisors:
  "In September, 2006, a series of unusual and unpredictable market events caused the fund's natural-gas positions, including spreads, to incur dramatic losses"

  "We had not expected that we would be faced with a market that would move so aggressively against our positions without the market offering any ability to liquidate positions economically."

  "We viewed the probability of market movements such as those that took place in September as highly remote … But sometimes, even the highly improbable happens."

Addressing Short Volatility

- Bondarenko 2004
- From options on futures, price a variance contract
  $dF_t/F_t = \sigma_t\, dWt$
  $d\text{Log}F_t = dF_t/F_t - ½\, \sigma_t^2\, dt$

  $E_0^*[\int_0^T \sigma_t^2\, dt]$ = price of variance contract at time 0
  $= -2\, E_0^*[\log(F_T / F_0)] + E_0^*[\int_0^T dF_t/F_t]$
  $= -2\, E_0^*[\log(F_T / F_0)]$
  calculated via option prices' risk-neutral density
- Over the interval, sample realized variance, $\int_0^T \sigma_t^2\, dt$
- (Sampled – Priced) / Priced = the return to variance. Averaging over experiments yields the variance return premium

Empirical Value of Short Volatility

- The premium is negative, i.e. the market pays (above the value of the risk itself) to pass off variance

- Adding the time series of variance returns as a factor in style analysis
  1) reveals a fund's exposure
  2) corrects estimated alpha to account for this source of return

- Bondarenko finds hedge funds as a group earn 6.5% annually from shorting volatility

Addressing Serial Correlation

- Fit model that explicitly incorporates the structure of serial correlation

- Getmansky et al 2004

$r_t^{reported} = \Sigma_k \theta_k r_{t-k}$ $\Sigma_{k=1..K} \theta_k = 1$

$r_t = \mu + \beta m_t + \varepsilon_t$ $\varepsilon_t, m_t \sim$ IID, mean 0

$var(r_t) = \sigma^2$

Nonlinearities: Different Up and Down Market Sensitivities

From Lo 2001:

$r_t = \alpha + \beta^- m_t^- + \beta^+ m_t^+ + \varepsilon_t$

Lo also presents a model to account for phase-locking behavior

e.g. correlation across asset classes rising during catastrophic markets

Table 8. Nonlinearities in Hedge-Fund Index Returns: Monthly Data, January 1996–November 1999

Style Index	$\hat{\alpha}$	$t(\hat{\alpha})$	$\hat{\beta}^+$	$t(\hat{\beta}^+)$	$\hat{\beta}^-$	$t(\hat{\beta}^-)$	R^2
Currencies	0.93	1.97	0.05	0.34	0.13	0.81	0.01
ED—distress	1.95	7.84	–0.11	–1.50	0.58	6.95	0.36
ED—merger arb	1.35	7.99	0.04	0.91	0.27	4.78	0.27
EM—equity	3.78	2.41	0.16	0.34	1.49	2.84	0.11
EM	2.64	3.20	0.21	0.88	1.18	4.27	0.23
EM—fixed income	1.88	3.99	0.07	0.49	0.56	3.56	0.16
ED	1.61	9.35	–0.01	–0.26	0.43	7.37	0.41
Fund of funds	1.07	6.89	0.08	1.84	0.27	5.13	0.33
Futures trading	0.69	1.35	0.18	1.23	0.13	0.76	0.04
Growth	1.49	3.65	0.69	5.80	0.98	7.13	0.62
High yield	1.11	8.05	–0.08	–1.92	0.19	4.10	0.15
Macro	0.61	1.09	0.30	1.84	0.05	0.28	0.05
Opportunistic	1.35	3.95	0.33	3.31	0.52	4.53	0.37
Other	1.41	5.58	0.23	3.05	0.69	8.19	0.57
RV	1.36	12.22	–0.04	–1.27	0.15	4.02	0.15
RV—convertible	1.25	8.44	–0.01	–0.31	0.18	3.55	0.14
RV—EQLS	0.87	5.64	0.09	2.04	0.14	2.65	0.17
RV—option arb	4.48	4.29	–0.78	–2.56	0.33	0.95	0.07
RV—other—stat arb	1.40	4.38	–0.02	–0.18	0.11	0.99	0.01
Short selling	0.04	0.07	–0.67	–3.94	–1.25	–6.41	0.51
Value	1.46	4.49	0.24	2.54	0.69	6.41	0.45

Note: Regression analysis of monthly hedge-fund index returns with positive and negative returns on the S&P 500 used as separate regressors. ED = event driven; arb = arbitrage; EM = emerging market; RV = relative value; EQLS = equity long/short; stat = statistical.

Source: AlphaSimplex Group.

Part II: Complications for the Manager

- Liquidity
- Stability
- Limited Liability
  - Chow & Kritzman 2002, "Value at Risk for Portfolios with Short Positions"
  - Winston 2006, "Long/short portfolio behavior with barriers"

1. Liquidity Risk

- An example: big drops in Aug 2007

8/3	SP500 ↓ 2.7%, R2000 ↓ 3.6%
8/6-8	SP500 ↑ 4.5%, R2000 ↑ 5.3%
8/9	SP500 ↓ 3.0%, R2000 ↓ 1.4%
8/10	SP500 ↑ 0.0%, R2000 ↑ 0.5%
8/13-15	SP500 ↓ 3.2%, R2000 ↓ 4.7%
8/16-17	SP500 ↑ 2.8%, R2000 ↑ 4.5%,
8/27-28	SP500 ↓ 3.2%, R2000 ↓ 3.9%
8/29	SP500 ↑ 2.2%, R2000 ↑ 2.5%

- Over the month, SP500 up 1.3%, R2000 up 2.2%

Liquidity Risk (cont)

- Liquidity risk is concerned with the cost of trading within some short horizon and perhaps under duress
- Investment risk is concerned with changes in underlying (market perceived) value
- Conventional risk models address investment risk
- During market turbulence, counterparties demand compensation for assuming additional risk. Moreover, many of the usual liquidity providers (other hedge funds) may be under pressure to shed positions
  - Pricing reflects both an uncertainty premium and the cost of reaching for liquidity
- The manager of assets at call (leverage or panicky investors) doesn't have the option to wait and can be forced to close positions at fire sale prices

2. Stability

- In short positions, (lack of) skill doesn't stabilize itself
  - right   long: bet size ↑ short: ↓
  - wrong   long: bet size ↓ short: ↑
- Hedges are also less stable
  - Simplified example: 2 stocks, both with β ≈ 1
    one ↑ 15%, the other ↓ 15%
  - In long only, portfolio β is still ≈ 1
  - In long/short, portfolio β goes from 0 → +/- 0.3
  - Idea applies to all hedges

The fact that stocks respond similarly to external factors is no longer a safety net

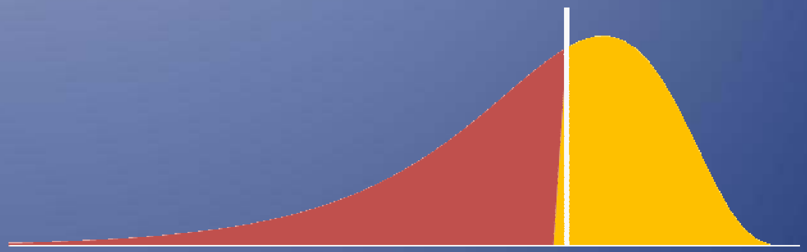
3. No More Limited Liability

Long stock or portfolio:

Limited loss, unlimited gain

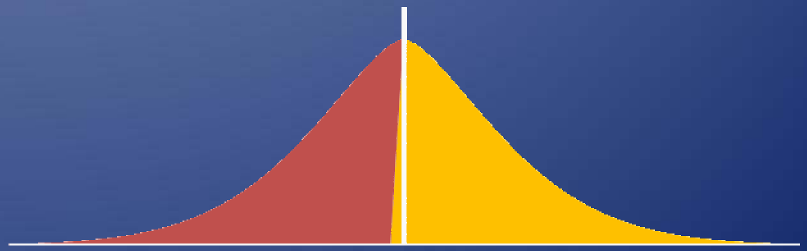
Short stock or portfolio:

Unlimited loss, limited gain



Long/short portfolio:

Unlimited gain, unlimited loss



Canonical Model Doesn't Accommodate Unlimited Downside

- Recall usual Brownian motion model:

- $dS/S = \mu\, dt + \sigma\, dW$
  $d\text{Log}S = (\mu - ½\, \sigma^2)\, dt + \sigma\, dW$

- Instantaneous return is normal,
  (1 + return) over time is lognormal:
  $S_T/S_0 = e^{[(\mu - ½\, \sigma^2)T + \sigma W_T]}$

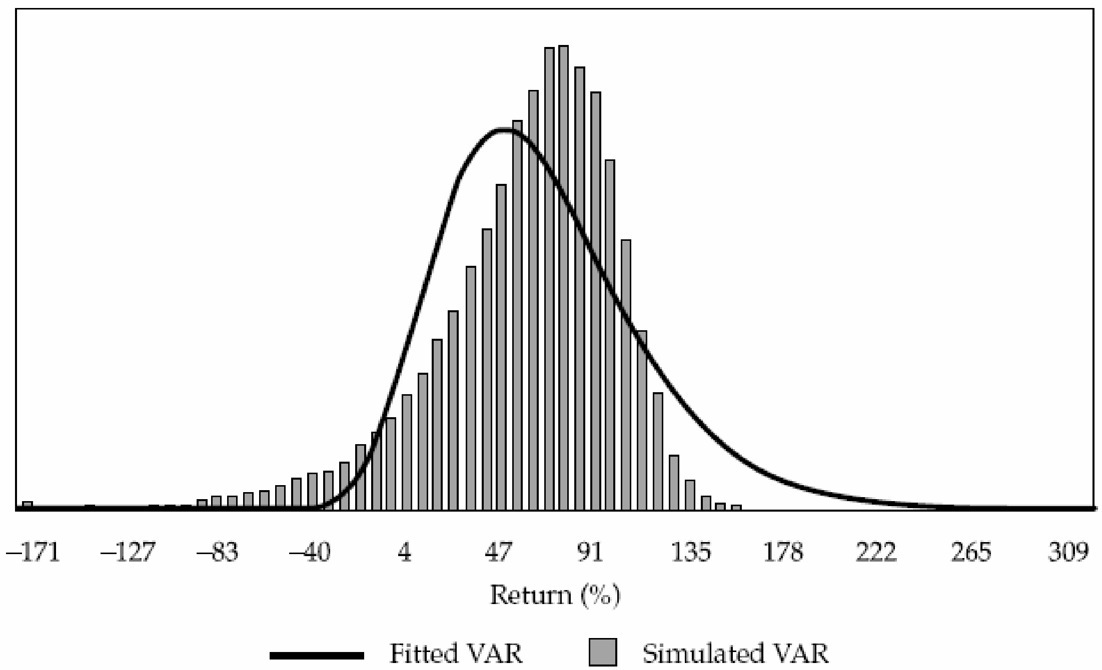
- Sum of lognormal ≠ lognormal

- Lognormal never falls below 0

Example of Breakdown: long/short VAR assuming lognormal

From Van Royen, Kritzman, Chow 2001:

Figure 7. Fitted versus Simulated VAR: Asset A 200 Percent, Asset B –100 Percent



A Better Framework for Long/Short Risk

- Model each side of a long/short portfolio by geometric Brownian motion

- $dL/L = \mu_L\, dt + \sigma_L\, dW_L$
  $dS/S = \mu_S\, dt + \sigma_S\, dW_S$ $\qquad dW_L dW_S = \rho dt$
- Dynamics of L - S describe behavior of long/short portfolio

- Answer quantitative and qualitative questions (Winston 2006)
  - "What is the expected time to hit drawdown?"
  - "What is the probability the portfolio is > $110 in 1 year without falling below a drawdown of $80 in the interim?"
  - "How does increasing short-side volatility affect the probability of ruin?"

- L - S is not a geometric Brownian motion

- See mathematical literature for options on spreads

Ways to tame the non-GBM, L – S

- Approximate L-S by a Brownian motion with the same mean and variance at time T

- Look at ratio, f = L / S
  $df = dL/S - L\, dS/S^2 + L/S^3\, d\langle S\rangle - 1/S^2\, d\langle S,L\rangle$
  $df/f = [\mu_L - \mu_S + \sigma_S^2 - \rho\sigma_L\sigma_S]\, dt + \sigma_L dW_L - \sigma_S\, dW_S$ $\rightarrow$ f is GBM

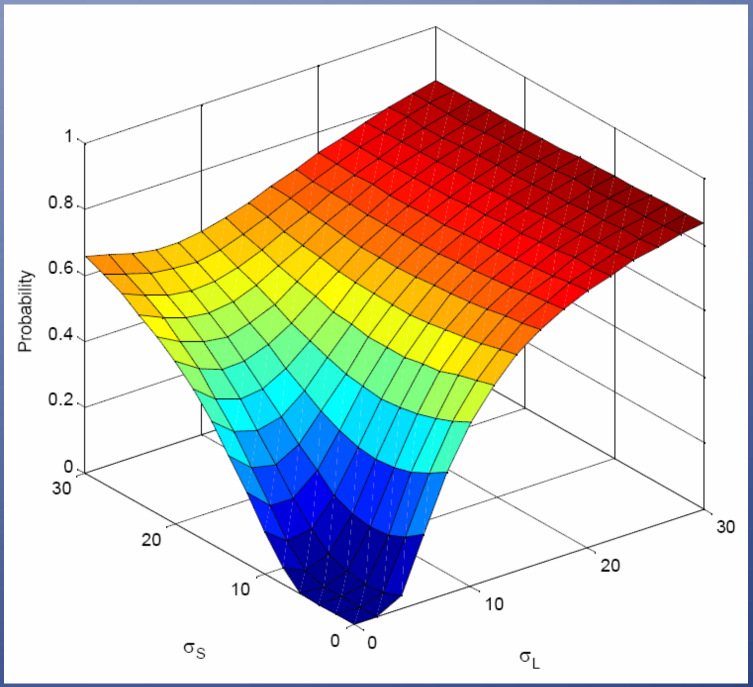
- Kirk approximation (used in Winston 2006)
  Interested in $P(L - S < \text{critical } k) = P(L/[S+k] < 1)$
  let $g(L,S) = L/[S+k]$
  will be approximating $S/(S+k)$ by $S_0/(S_0+k)$

  $dg = dL/(S+k) - L\, dS/(S+k)^2 + L/(S+k)^3\, d\langle S\rangle - 1/(S+k)^2\, d\langle S,L\rangle$
  $dg/g = dL/L - dS/S\, [S/(S+k)] + \sigma_S^2\, [S/(S+k)]^2\, dt - \rho\sigma_L\sigma_S\, [S/(S+k)]\, dt$
  $\approx dL/L - dS/S\, [S_0/(S_0+k)] + \sigma_S^2\, [S_0/(S_0+k)]^2\, dt - \rho\sigma_L\sigma_S\, [S_0/(S_0+k)]\, dt$
  which is BM

An Application of the Model

Success and failure surfaces from Winston 2006:

- •Initial leverage=3 (long=2, short=1)
- •1 year
- •300bps skill on long side, 200bps skill on short side
- •.5 correlation
- •90% drawdown absorbing barrier



Summary

- Hedge funds offer investment strategies poorly described by traditional tools and measures.

- If investors aren’t aware of the hidden risks, surely they will select for them.

  e.g. 4:00 mile is fast, 3:30 mile = a goat?

- Managers of long/short portfolios are exposed to phenomena not present in long-only. Avoiding a blow-up requires extra vigilance.