Capital Structure Arbitrage

using non-Gaussian approach

Presentation by:
Ramakrishnan Chirayathumadom
Ronnie Zachariah George
Venkateshwarlu Balla
Dhiraj Bhagchandka
Neeraj Shah
Kunal Shah

Sponsor:
Evnine-Vaughan Associates, Inc.

Our Sponsor

Evnine-Vaughan Associates, Inc.

- Equities Hedge Fund
- $800 million in funds under management
- Founded by Jeremy Evnine and Richard Vaughan in 1994 in San Francisco
- The original founders of Iris Financial Engineering Holdings Ltd.

Agenda

- Capital Structure Arbitrage – Overview
- Merton model
- Non-Gaussian approach
- Data
- Algorithm,Analysis, Results
- Issues, Future Work, Conclusions

Now…

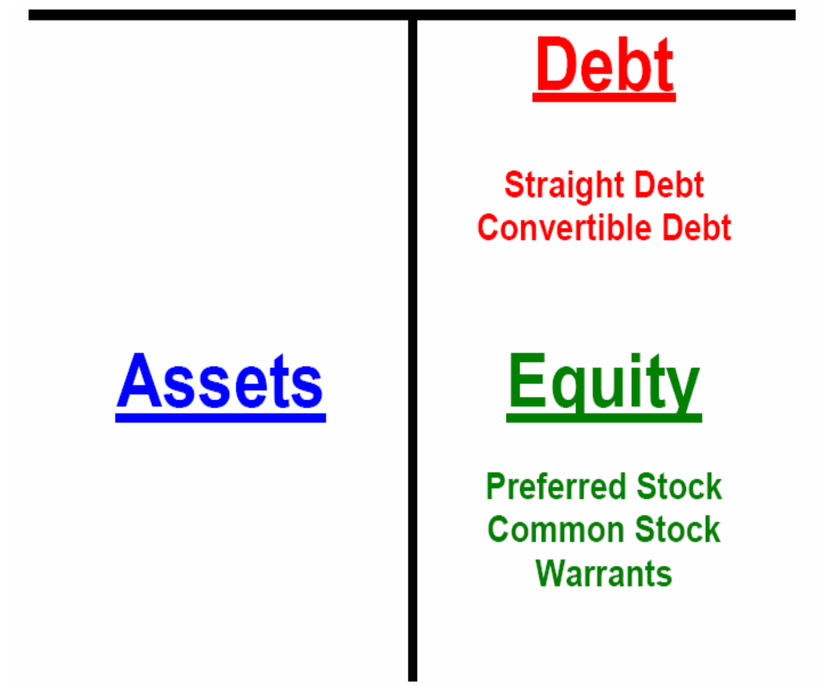
- **Capital Structure Arbitrage – Overview**
- Merton model
- Non-Gaussian approach
- Data
- Algorithm,Analysis, Results
- Issues, Future Work, Conclusions

Capital Structure Arbitrage

Capital structure of a company
- Assets = Debt + Equity
- Modigliani & Miller (1958)

- Debt
  - Priority over Equity holders
  - No observable markets
  - Different seniority levels

- Equity
  - Equity holders paid after debt repayment
  - Observable markets exist
  - Different priority levels



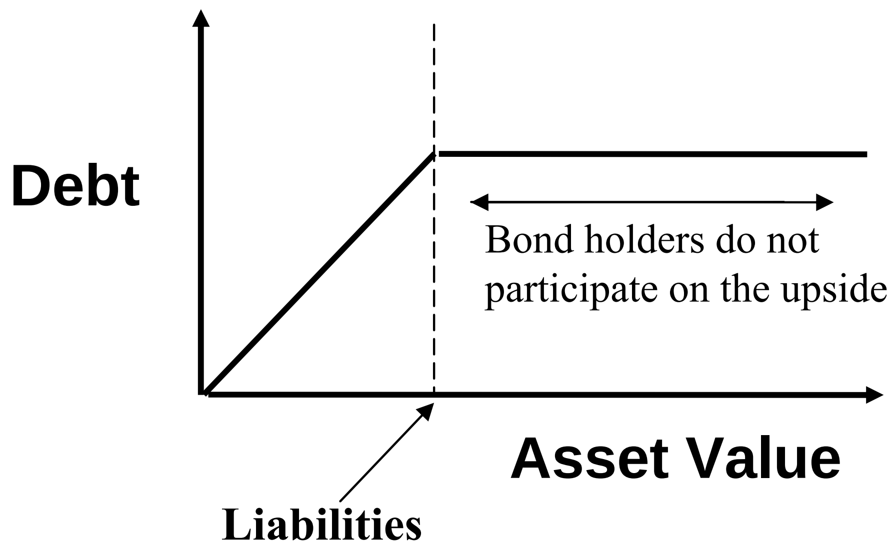
Capital Structure Arbitrage

Why does Capital Structure Arbitrage exist?

- Debt should be priced "fairly" to reflect the true state of the company. No fair market valuation of most debt instruments

- Black, Scholes (1973)

- No "correct" market valuation of the assets of the company!!!



Potential arbitrage opportunities exist if market price of debt cannot be "justified" by its capital structure

Capital Structure Arbitrage

Capital Structure Arbitrage Outline:

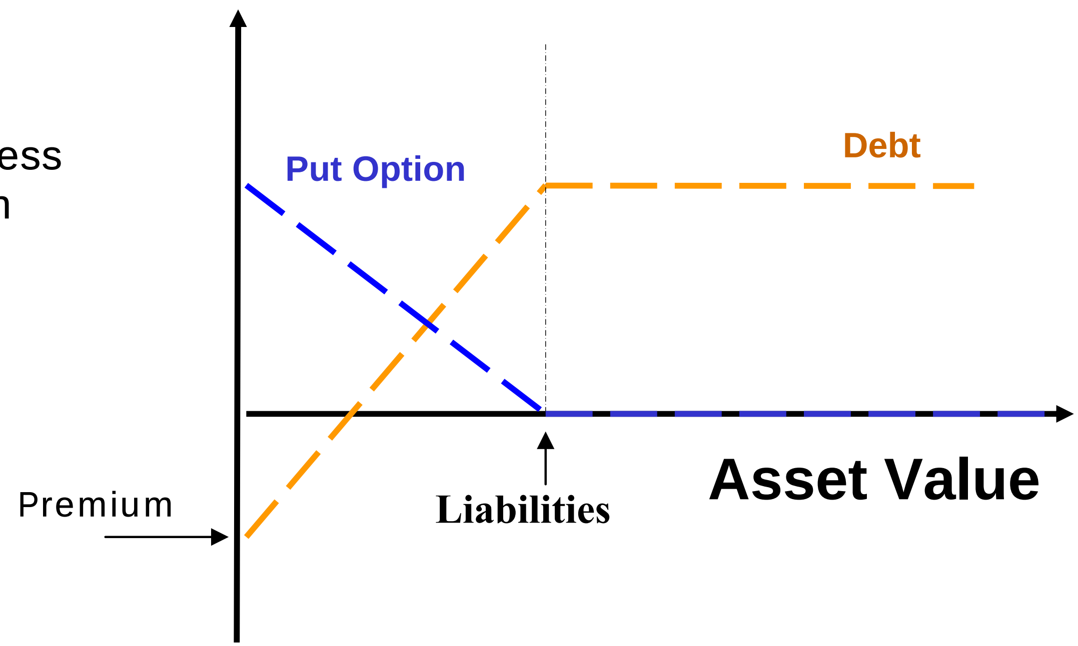
- A trader believes that debt of a company is under priced
- Trader purchases the “cheap” corporate bonds
- Hedges his position by purchasing puts on the stocks

“No Default”

- Receives yield on bond in excess of what he paid for put option

“Default”

- Receives strike price less premium



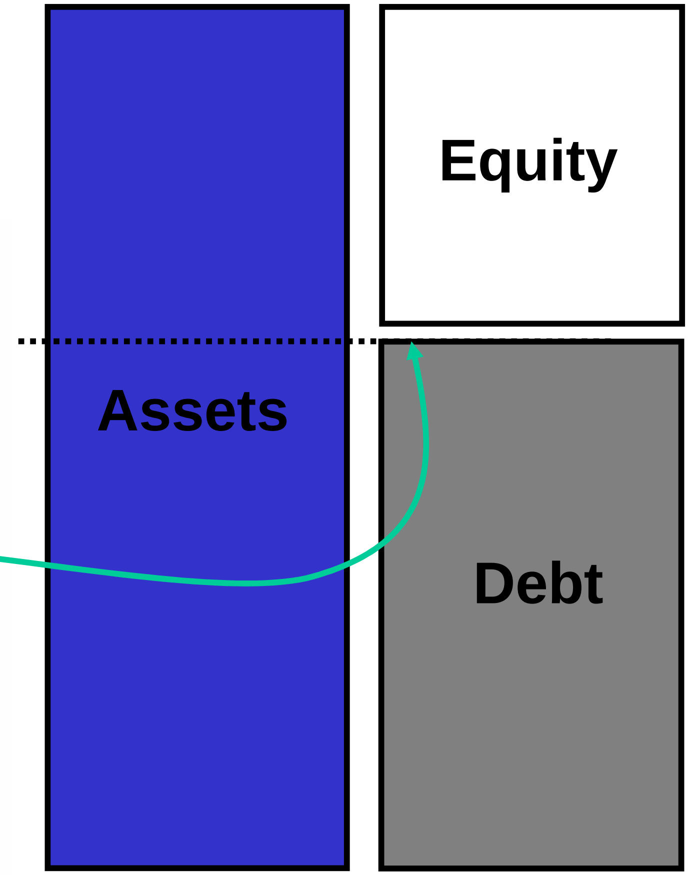
Now…

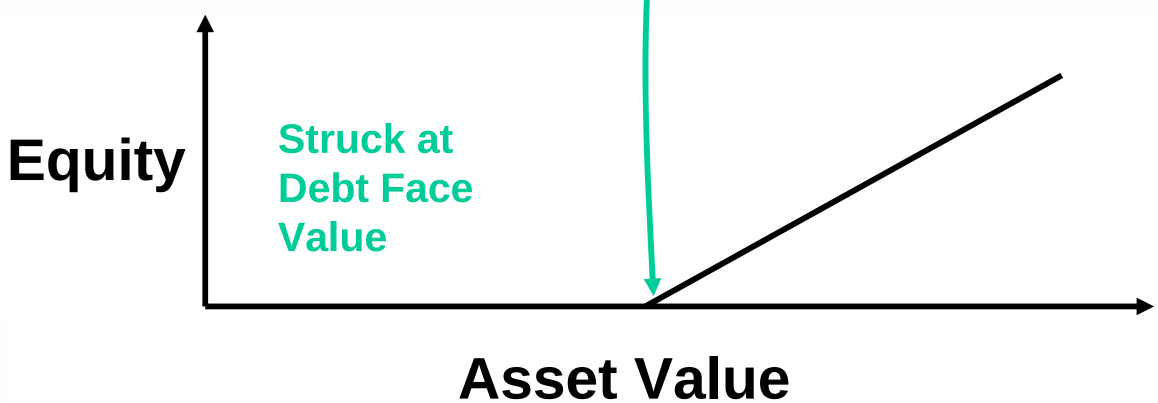
- Capital Structure Arbitrage – Overview
- **Merton model**
- Non-Gaussian approach
- Data
- Algorithm,Analysis, Results
- Issues, Future Work, Conclusions

Merton Model (1974)

- Equity is a call option on underlying assets of firm

Suppliers of Capital	Payoffs to Suppliers of Capital at Bond Maturity	
	If $A_T \leq F$	If $A_T > F$
Bondholders receive	A_T	F
Stockholders receive	0	$A_T - F$
Total capital distributed	A_T	A_T



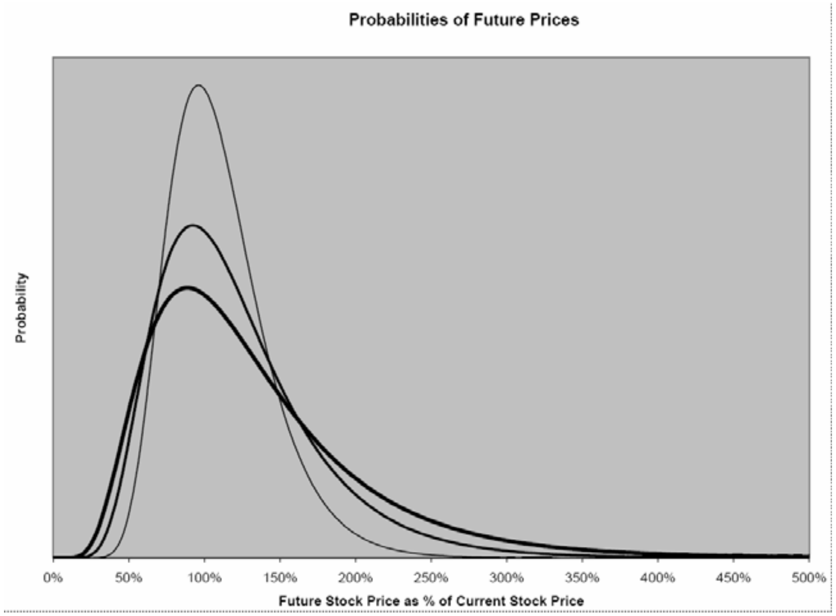


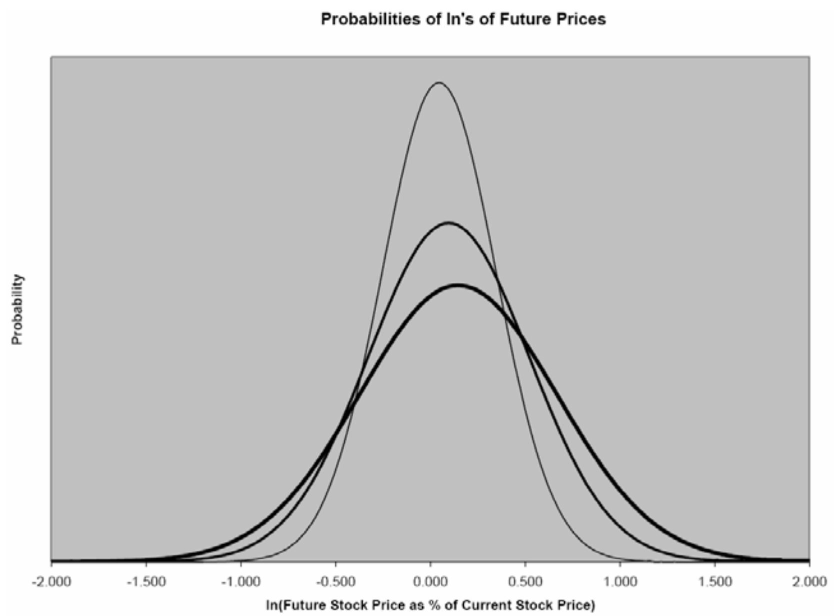
Merton Model

- Key assumptions
  - Underlying assets follow stochastic log normal process
  - Debt in terms of single zero coupon bond
  - Black-scholes valuation for European call option

- Asset Process:

$$dA = \mu A\, dt + \sigma A dz$$





Merton Model – credit spread

$$E_T = \max[A_T - D, 0]$$

$$E_0 = A_0 N(d_1) - De^{-rT} N(d_2)$$

$$B_0 = A_0 \left[N(-d_1) + L N(d_2) \right]$$

$$s = y - r = -\ln\left[N(d_2) + N(-d_1)/L \right]/T$$

$$E_0 \sigma_E = \frac{\partial E}{\partial A} A_0 \sigma_A$$

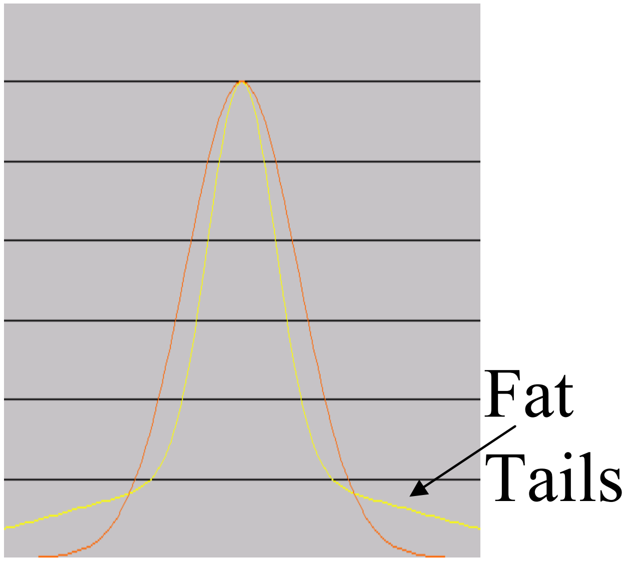
Assets = Equity + Debt

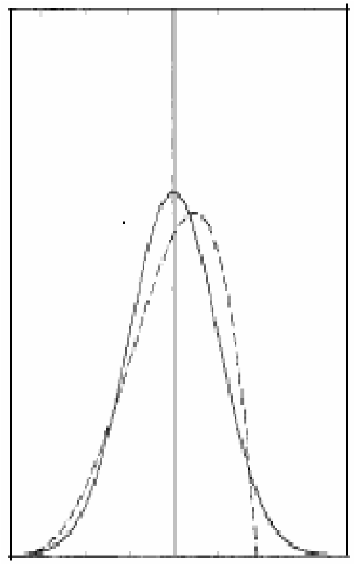
Implied credit spread!

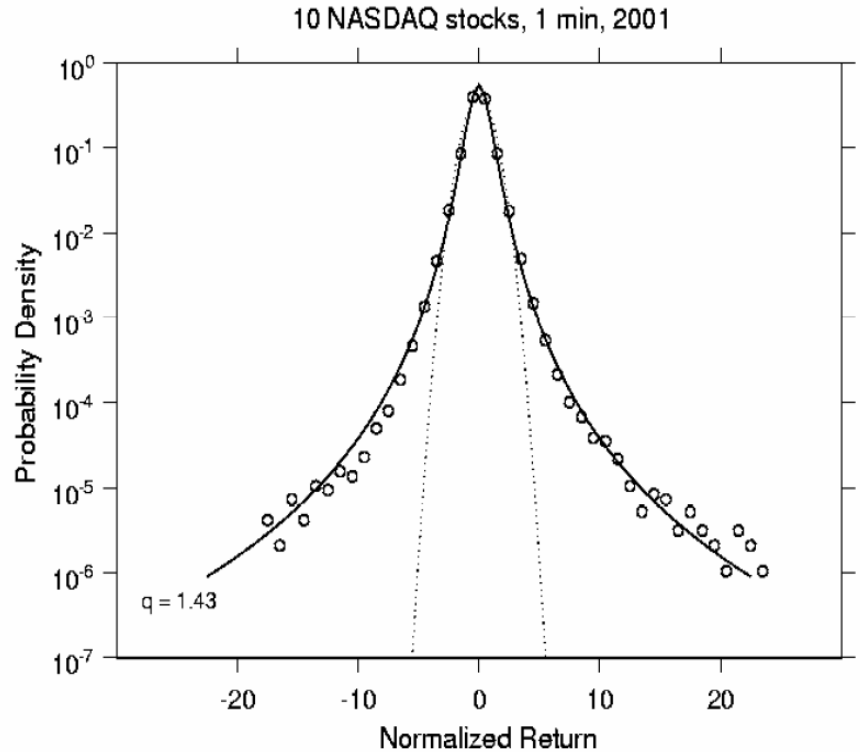
Now…

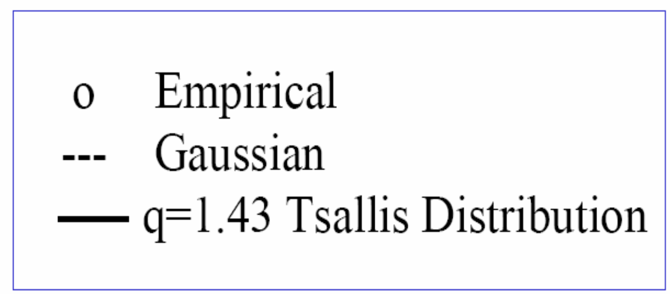
- Capital Structure Arbitrage – Overview
- Merton model
- **Non-Gaussian approach**
- Data
- Algorithm,Analysis, Results
- Issues, Future Work, Conclusions

Non-Gaussian process









- Stock distributions have fat tails as well as skew
- Special distributions:
  Tsallis fits & explains data better
- Asset is underlying to stock
  => asset process non-Gaussian

Courtesy: Lisa Borland, EVA Funds

Tsallis distribution

Asset Stochastic Process

$$dA = \mu A\, dt + \sigma A^{\alpha}\, d\Omega$$

$$d\Omega = P(\Omega)^{\frac{1-q}{2}}\, d\omega$$

Feedback term

Tsallis distribution

α is "skew"

q is "smile"

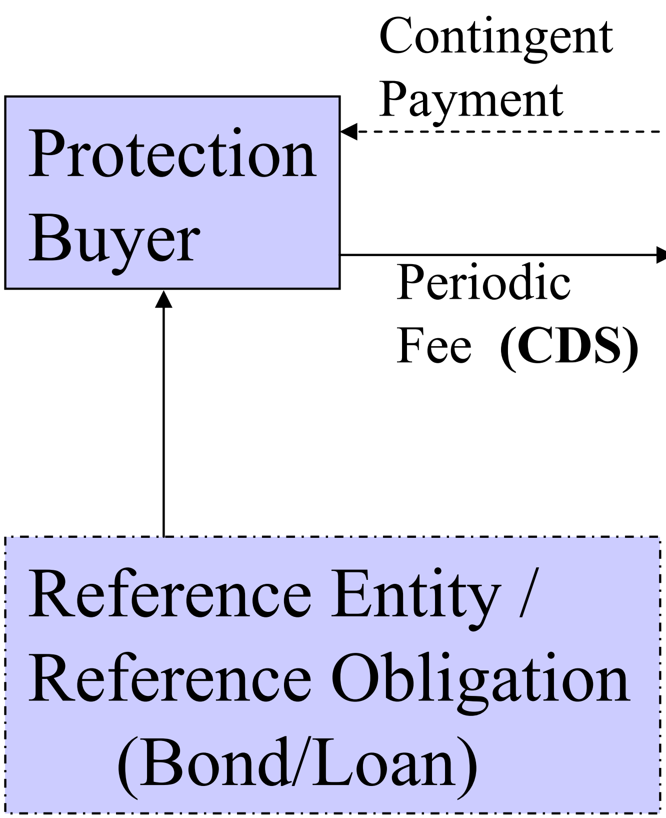
Fat tails giving higher extreme returns

Tsallis distribution becomes Gaussian with **α=1 and q=1**

$$\frac{\partial F}{\partial t} + rS\frac{\partial F}{\partial S} + \frac{1}{2}\frac{\partial^2 F}{\partial S^2}\sigma^2 S^2 P(\Omega)^{1-q} - rF = 0$$

Generalized Black-Scholes PDE

Credit Default Swaps & Arbitrage



- CDS – transaction
- CDS spread = credit spread
- Credit spread mis-pricing can be used for arbitrage

  - sell CDS at high price and buy bonds at low

  - buy CDS at low price and sell bonds at high spread
- Trading spreads: buy CDS & sell options (achieve +ve theta) etc

Now…

- Capital Structure Arbitrage – Overview
- Merton model
- Non-Gaussian approach
- **Data**
- Algorithm,Analysis, Results
- Issues, Future Work, Conclusions

Project Focus

- Implementation of the capital structure arbitrage theory in a non-Gaussian setting
- Observables – equity price, equity volatility, time to maturity, total assets, long-term debt, risk-free interest rate
- Calculated values – q and alpha values, credit spread
- CDS data for comparing the actual credit spread against the calculated credit spread

CDS Data

- Provides insurance against a default by a particular company or sovereign entity

- In theory, close to the credit spread of the yield on a n-year par yield bond issued by the reference entity over n-year par yield risk-free rate

- CDS quotes[1] for each company taken according to the time to maturity of its bonds

1. Courtesy Lombard Data Systems

Equity Data

- **CDS data**
- **Equity price**
- **Equity volatility**

- Equity prices[1] taken for the observed period
- Adjusted closing price taken for this purpose
- Historic volatility estimated using the daily stock prices of that particular quarter

1. Taken from CompuStat

Balance-sheet Data

- **CDS data**
- **Equity price**
- **Equity volatility**
- **Total assets**
- **Long-term debt**

- Book value of assets[1] compiled
- Book value of long term debt[1] obtained

1. Taken from CompuStat

Interest Rate and "T"

- **CDS data**
- **Equity price**
- **Equity volatility**
- **Total assets**
- **Long-term debt**
- **Risk-free rate**
- **"T"**

- Risk-free interest rate taken for each data-point
- 'T' – time to maturity taken as weighted average of different time to maturity for different bonds

Merging the Data

- CDS data
- Equity price
- Equity volatility
- Total assets
- Long-term debt
- Risk-free rate
- "T"

- In total, 54 companies were chosen across various sectors such as Retail, Communication, Aerospace, Finance, Energy etc
- Companies chosen with different market cap sizes
- Data for each company was taken for January 2000 to December 2003 at quarter-end points

Now…

- Capital Structure Arbitrage – Overview
- Merton model
- Non-Gaussian approach
- Data
- **Algorithm, Analysis, Results**
- Issues, Future Work, Conclusions

Algorithm

Assume a 'q' and 'α' pair

To apply the non-gaussian routine, the asset volatility is required. $\sigma_A(q, \alpha, \mathbf{k})$ is obtained by exploiting the nonlinear parity relationship [1]

$$\mathbf{E}(q, \alpha, \sigma_A, k) / A_0 = dE / dA_0 (q, \alpha, \sigma_A, k)\ \sigma_A/\sigma_E$$

where **k** are other available parameters

The Asset Value needed is more accurately calculated using the observed equity quote as $\mathbf{A_0 = E_0 / E(q, \alpha, \sigma A, k)}$

CDS Spread calculated is computed using the above parameters and compared to the CDS Spread quote.

$$q^*, \alpha^* = \arg\min \sum [\text{CDS Spread calculated} - \text{CDS Spread quote}]^2$$

over all available data points

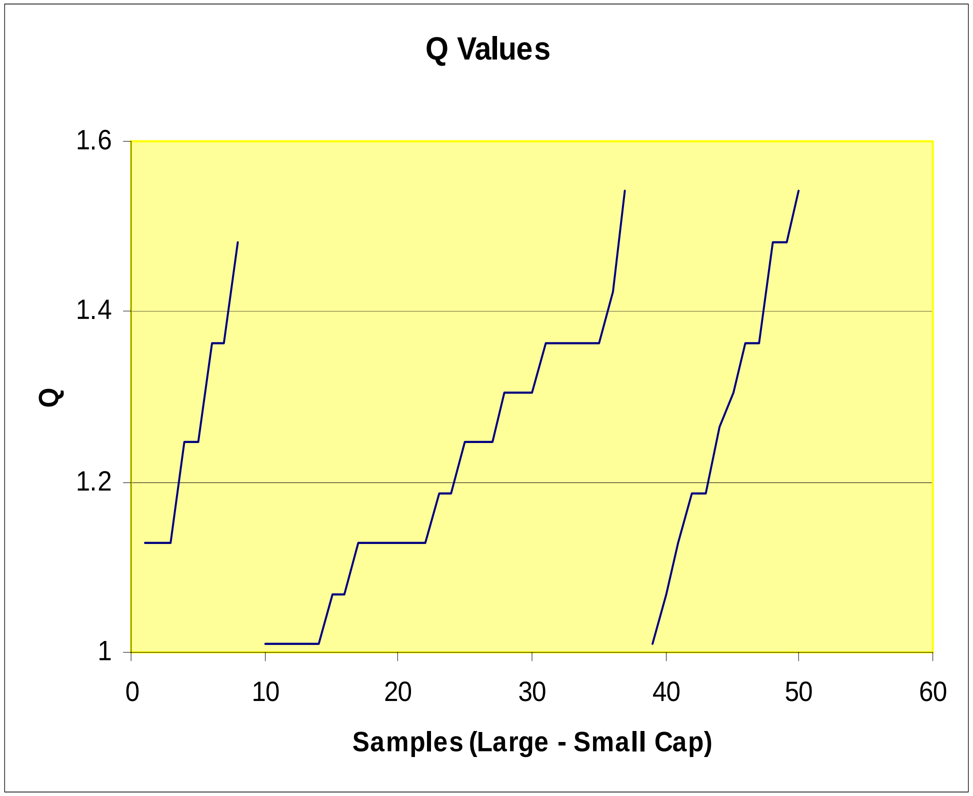
[1] *Mertons model, Credit Risk and Volatility skews* – Hull, Nelken & White (2003)

Analysis

- Analyzing all the samples, $\mathbf{q_{avg} = 1.23}$ and $\boldsymbol{\alpha_{avg}} \mathbf{= 0.3}$
  These values provide a zeroth order estimate to evaluate asset processes

- Target companies split into buckets by Market Cap and cross-segregated by sector

- q, α tested for predictability: all ranges of q are found in all size buckets

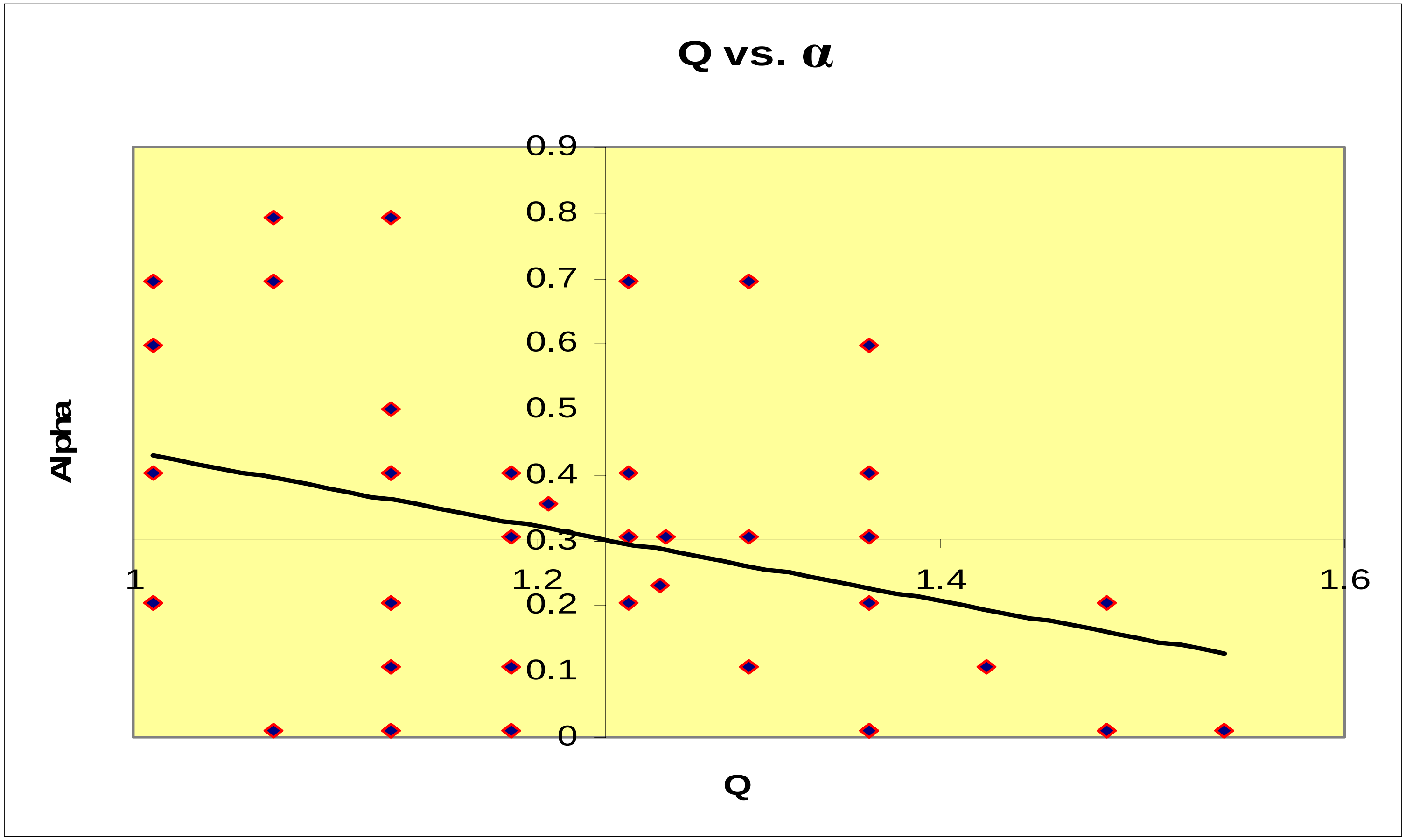


- Higher q (implying fatter tails) are less frequent in larger company observations
-

- The asset volatilities and q values are slightly lower on average than those measured directly on equity

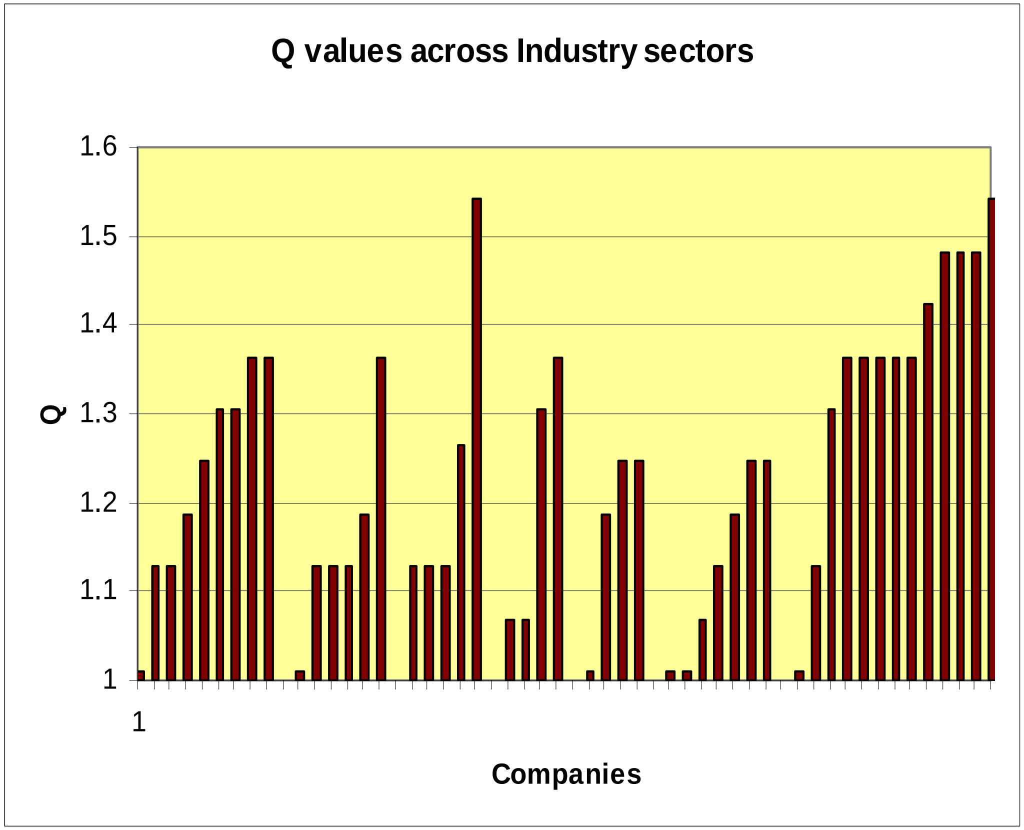
Analysis

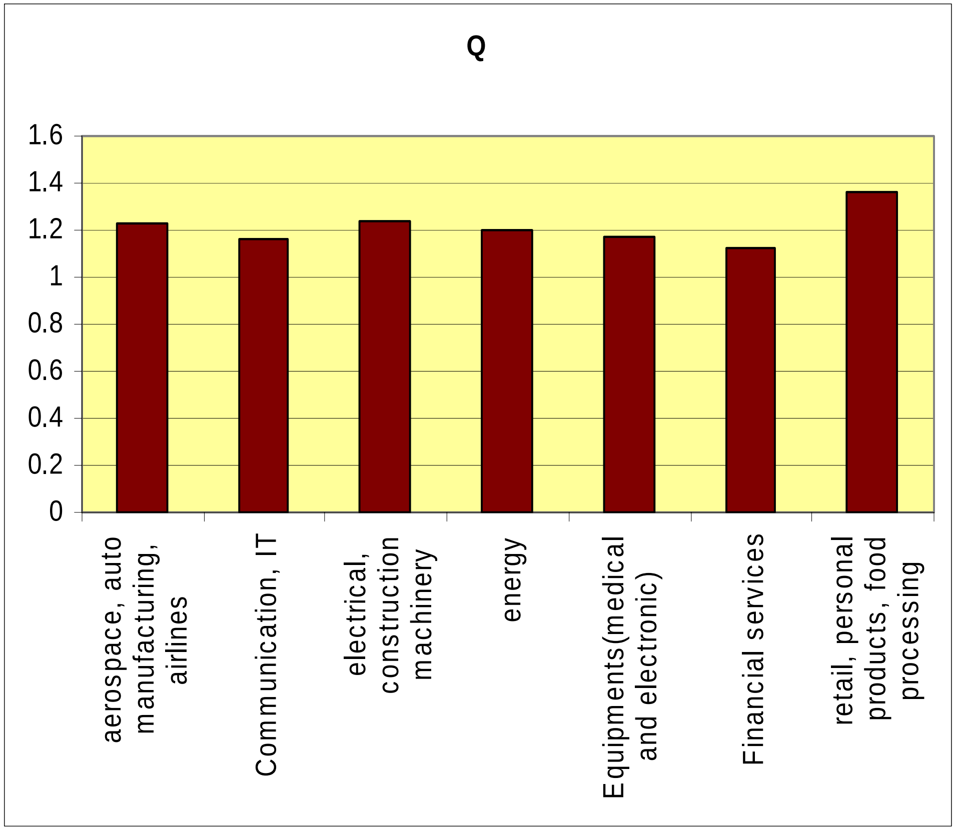
- q and α are essentially independent. These values reinforce the requirement to determine both these parameters to capture the model completely



Analysis

Sectors 1 through 7 are Aerospace, Communication, Construction, Energy, High tech equipment, Financial services and Retail



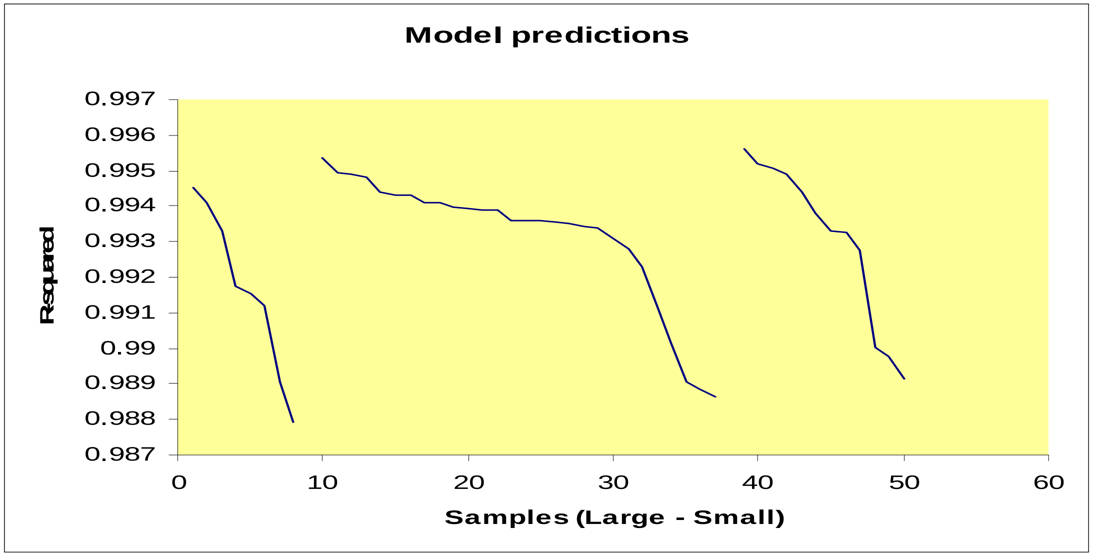


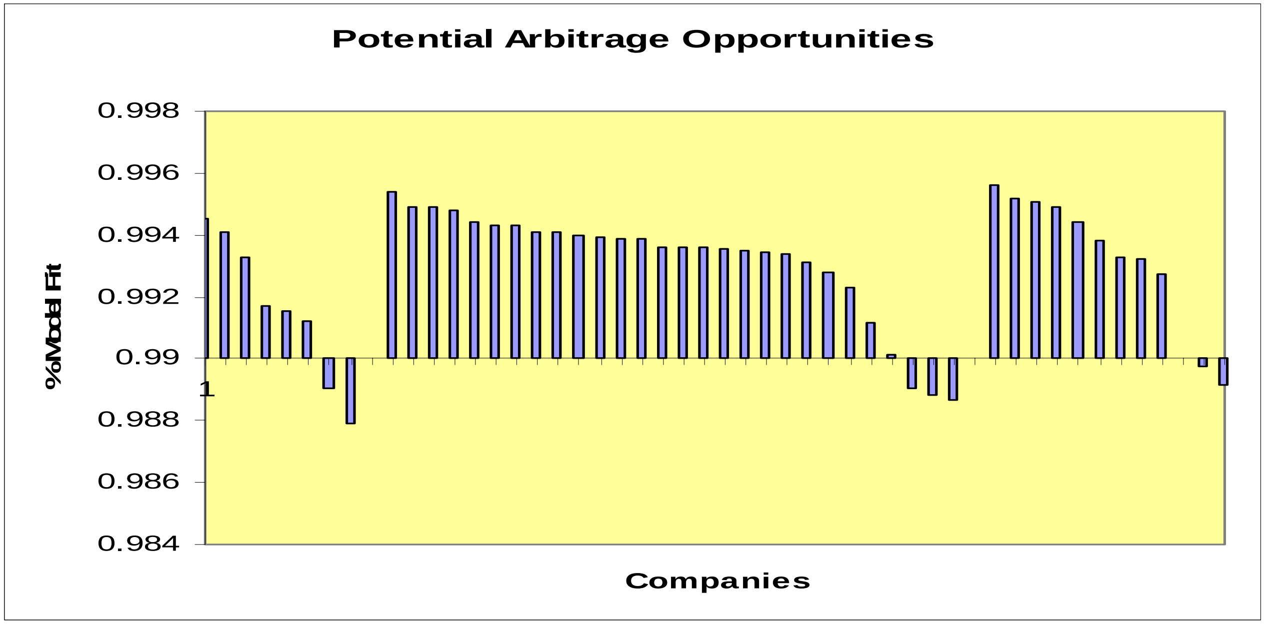
These values are fairly stable across industries

Reliability

- All samples showed very high R-squared error with the model when measured at the observed CDS spread point

- On a closer observation however, some samples were markedly "less tractable" than others:





- Here, a select few show < 99% matches

- Prime candidates for further examination

Now…

- Capital Structure Arbitrage – Overview
- Merton model
- Non-Gaussian approach
- Data
- Algorithm,Analysis, Results
- **Issues, Future Work, Conclusions**

Issues

- Code not stable for certain ranges of inputs
- CDS spread approximated by Bond Yield spread
- Equity as an Option on the Asset process can cause a departure from the lognormal distribution
- Estimation of Asset Value and Variance

Scope for future work

• Calculate various risk parameters (Greeks) numerically w.r.t to non-Gaussian model

Δ= dC/ dS **Γ = d²C/ d²S** **Θ = dC/ dT**

Vega = dC/ dσ **O = dC/ d (OAS),** oas: option adjusted spread

• Why are these important – protection against un-hedged 'calamities'

• Omicron neutral hedging[2]

• Re-create results for other choices of T

• Time stability analysis of q, alpha

[2] *Capital Structure Arbitrage Strategies: Models, Practice and Empirical Evidence* - Oliver Berndt and Bruno Stephan Veras de Melo, November 2003, Lausanne, Switzerland

Conclusions

1) The non-Gaussian model is found to be very effective in estimating the CDS spread quotes

2) Q and α need to be evaluated independently and show little correlation and the above are stable over industry sectors and company sizes

3) The model is particularly useful in calculating the Omicron risk parameter allowing for development of effective hedging strategies

Acknowledgements

Lisa Borland (EVA) *for her timely advice, encouragement and help with the code*

Jeremy Evnine (EVA) *for his useful insights on capital structure arbitrage*

Lombard Data Systems *for providing us with CDS data*

Sachin Jain *for his suggestions, help and feedback during the course of our project*

Prof. Rob Luenberger *for his advice and support*

Questions / Comments