An Overview of Counterparty Credit Metrics

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Outline

- Introduction
  - Examples
- Monte Carlo Survey
- Counterparty Credit Metrics
  - Exposure
  - Credit losses
  - Credit Value Adjustment (CVA)
- Practical Issues
- Glossary, End Notes, and References

What is Counterparty Credit Risk?

"Counterparty [credit] risk is the risk that the counterparty to a trade or trades could default before the final settlement of the transaction's cashflows" (1)

"…bilateral credit risk of transactions with uncertain exposures that can vary over time with the movement of underlying market factors" (2)

"Exposure" is the replacement cost of the trade less any credit offset. If no recovery, it is the maximum of the mark-to-market or zero: max(MTM,0)

Lots of information available in the banking literature

What is Counterparty Credit Risk?

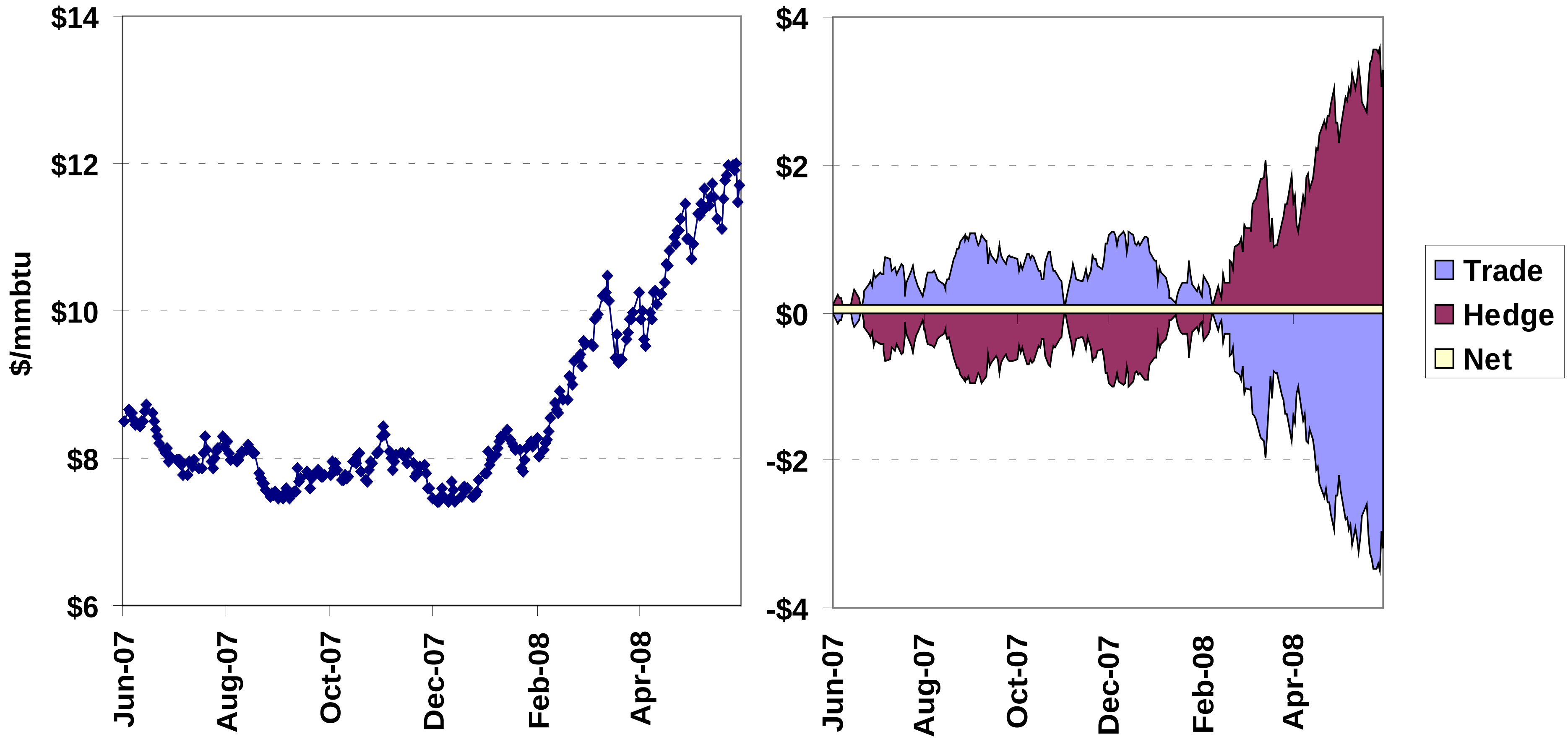
- Capital Adequacy
  - Identify collateral and margining requirements, including the effects of triggers that are a function of credit rating or the price of a credit default swap
  - Estimate the cost of funding hedges and the likelihood of a liquidity squeeze
- Risk Management and Compliance
  - Know and understand the counterparty exposure
  - Proactively identify signs of distress in individual firms or industries
  - Determine appropriate credit charge for each class of counterparty
  - "Blow-up" risk: identify scenarios that would cause the franchise to be cancelled

Examples

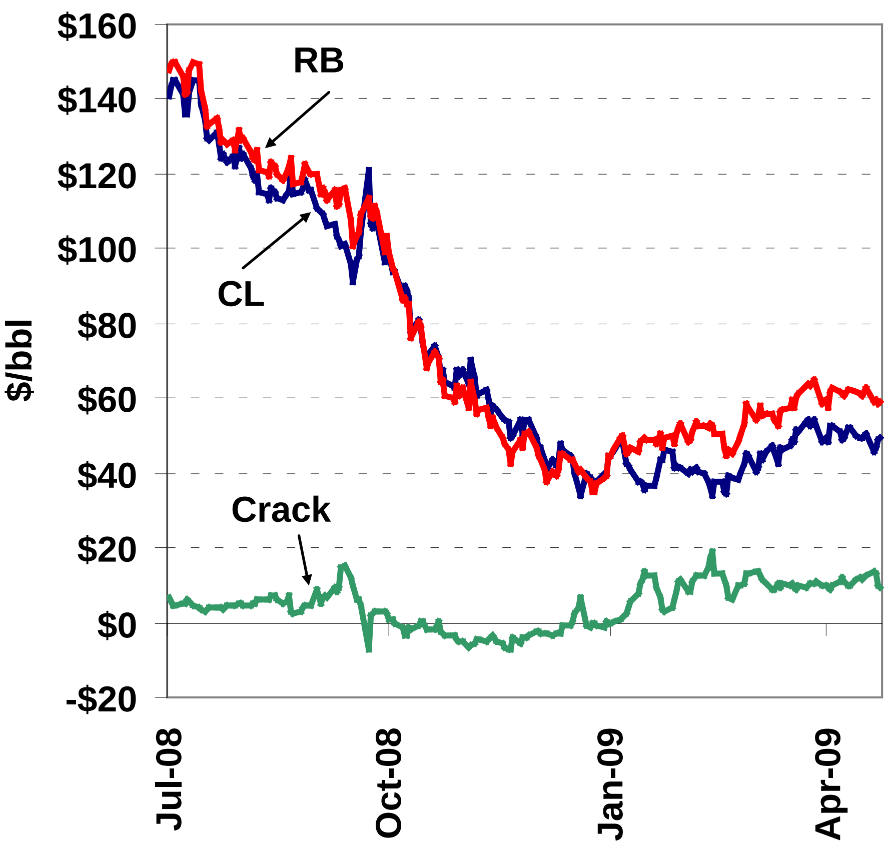
- Offsetting trade: a trader sells fixed price gas 12 months forward to a customer, and hedges by purchasing elsewhere a fixed price gas 12 months forward at a $0.10 discount

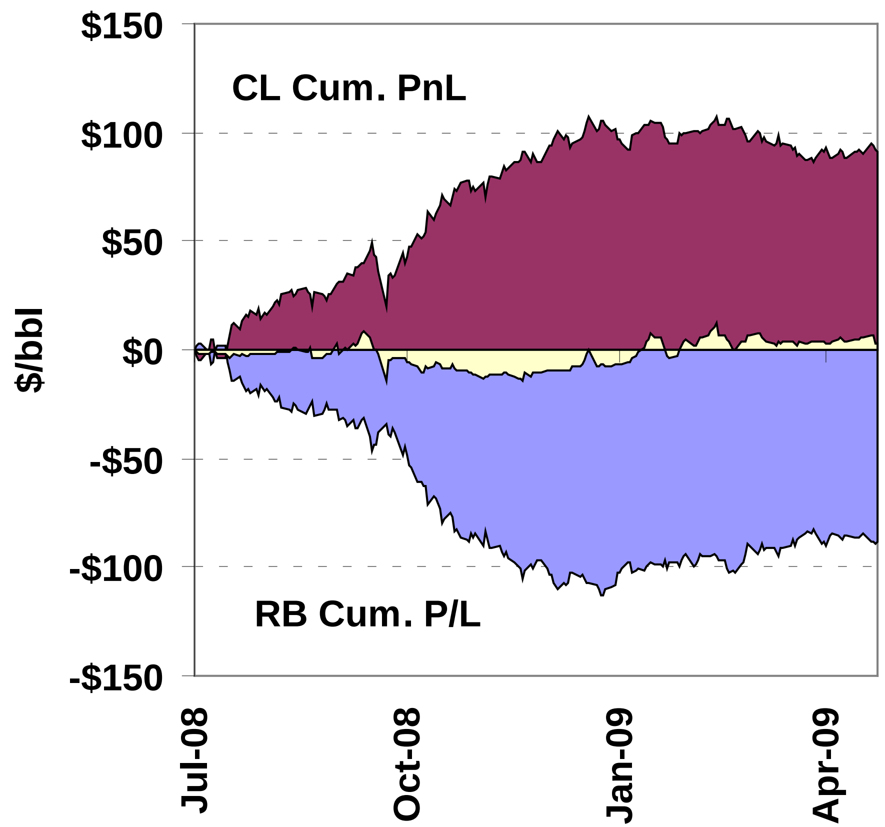
- Gasoline crack: a trader purchases gasoline and shorts crude

Example: Offsetting Trade

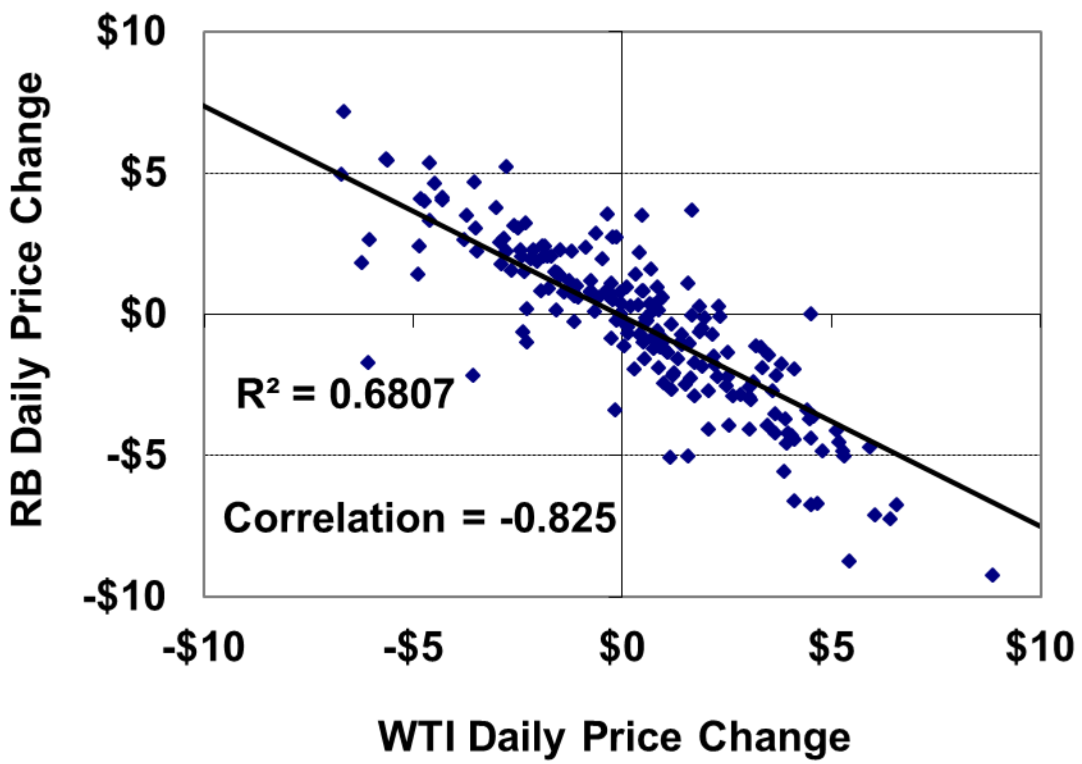


Example: Gasoline Crack

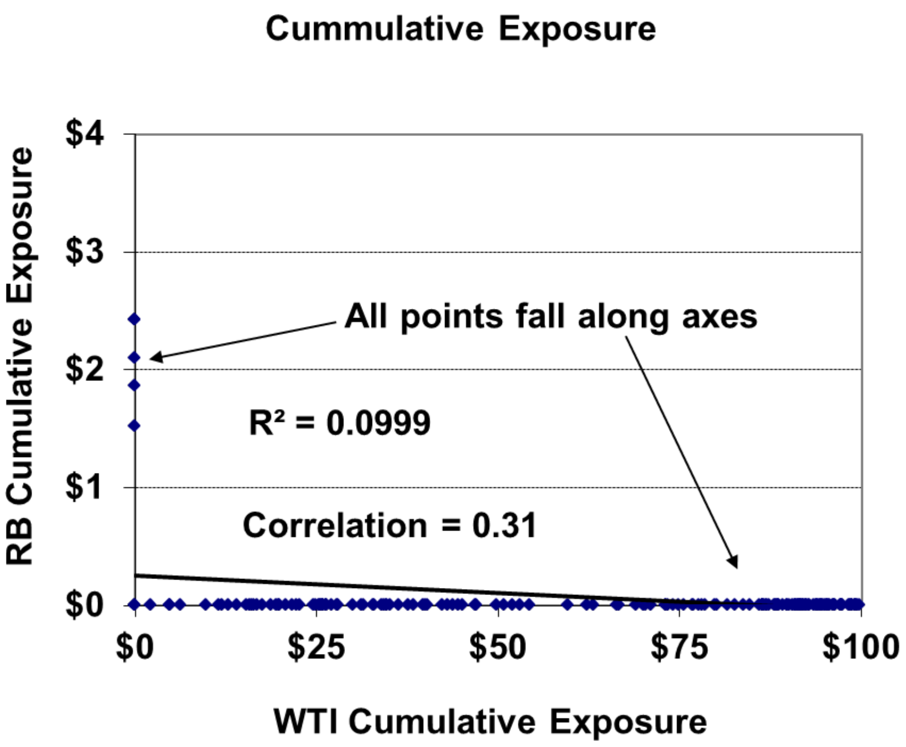


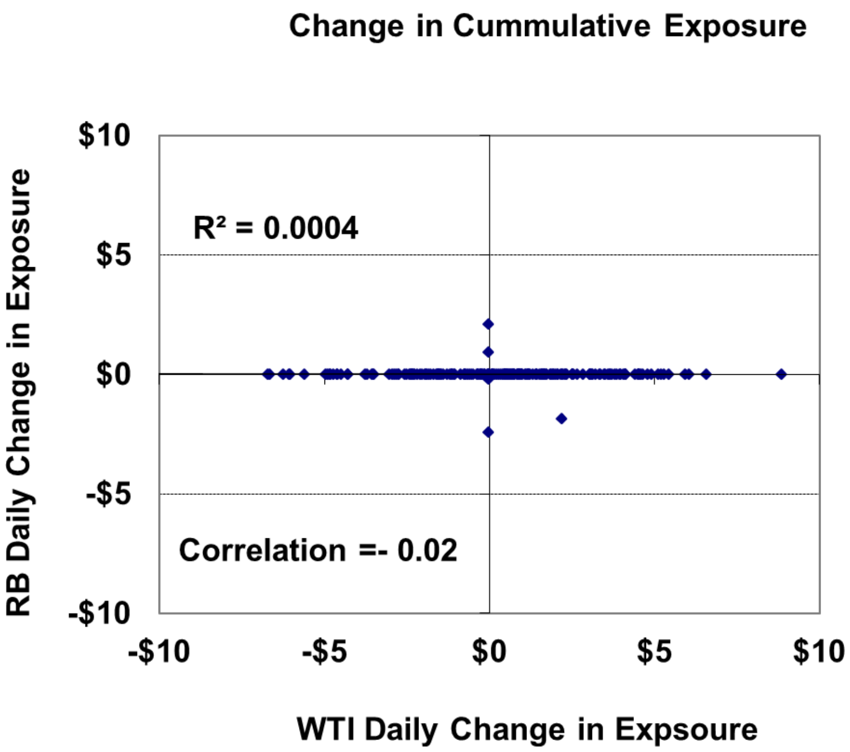


Example: Market Risk View



Example: Counterparty Exposure View





Key Points

- Long term price trend is more important than the daily price change
- Correlation of credit exposures must be handled with care
- Must think differently: counterparty credit risk requires a different paradigm

Monte Carlo

- The suite of exposure metrics is designed to measure different aspects of exposure, both now and in the future

- Exposure is max(MTM, 0)

- Almost all metrics are estimated using monte carlo

What is Monte Carlo?

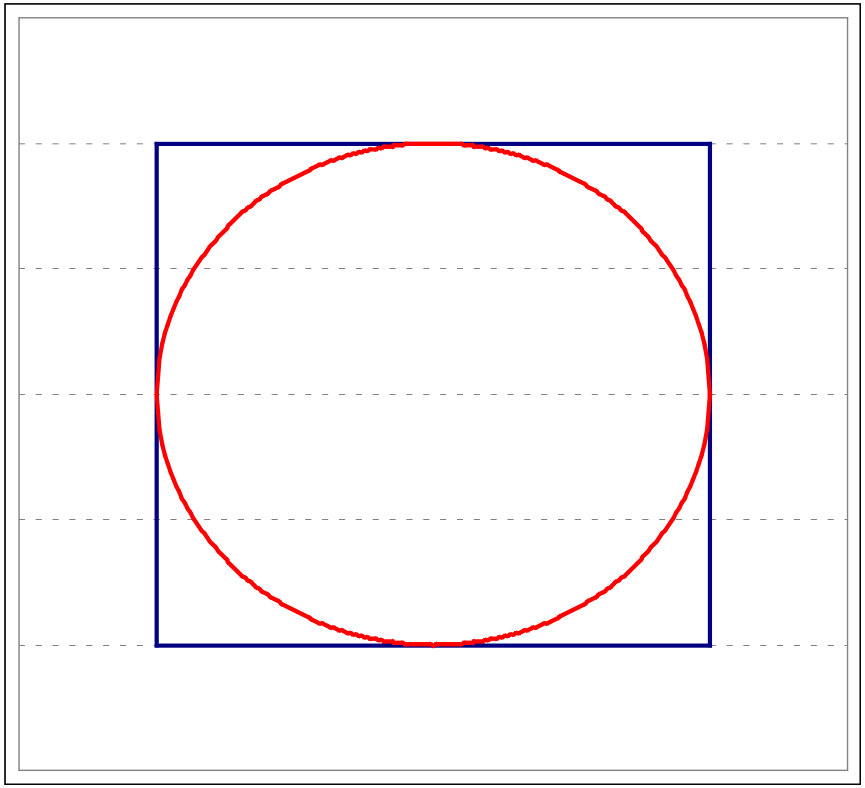
- Monte Carlo is a numerical process based upon repeated random sampling to obtain a numerical result
- The samples represent realizations of random variables, and are used to either solve mathematical problems or to simulate possible outcomes
  - Stock price returns, rainfall, traffic accidents, etc.
- For credit exposure metrics, think price scenarios

Examples

- Estimation of π
- Option pricing
- Value at Risk

Estimation of π

- Consider a circle that is inscribed in a square
  - Area of the circle: πr^2
  - Area of the square: length * width or (2*r)*(2*r) or $4r^2$
- Ratio of circle area to square area: $\pi/4$

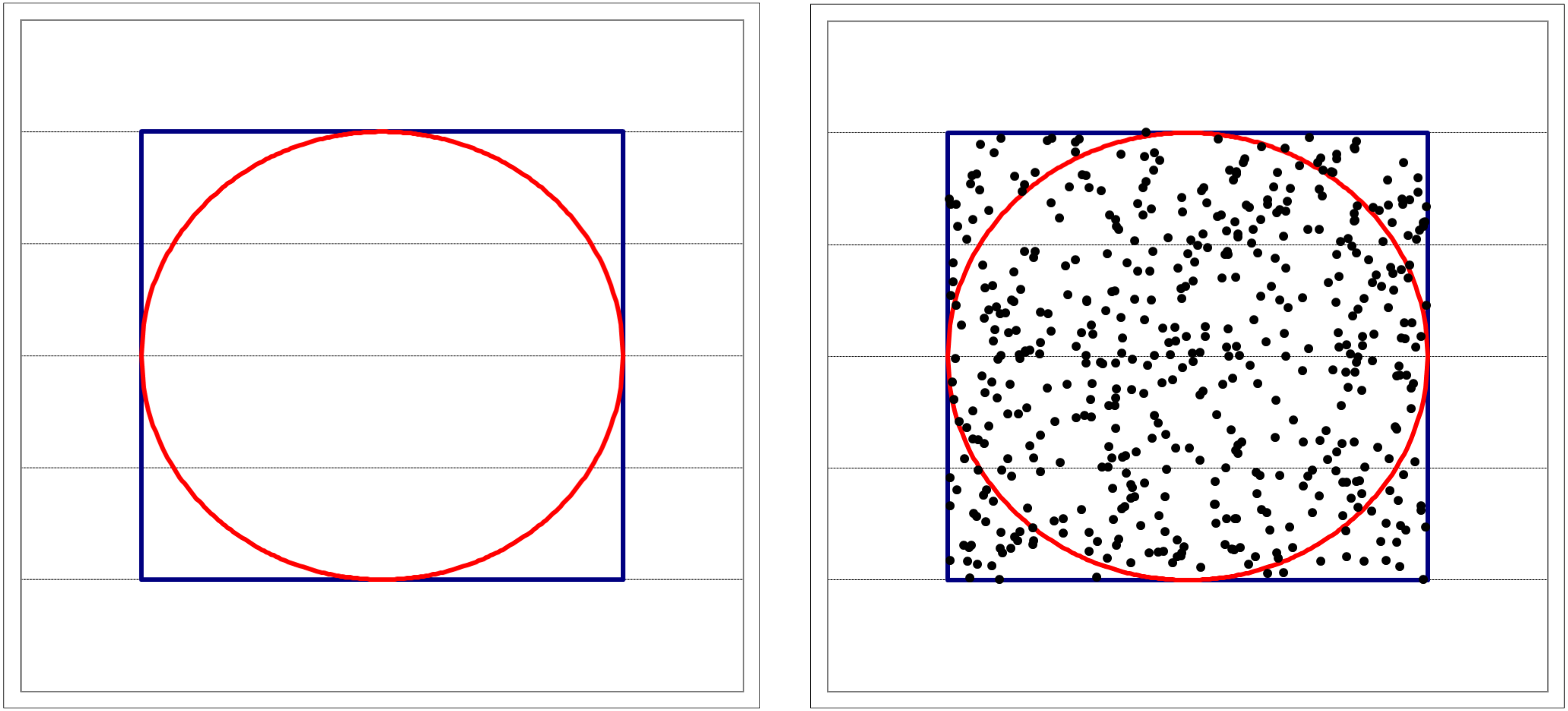


Estimation of π

- Idea: estimate the ratio by randomly choosing points on the chart (i. e., throw darts) and count the number of times that the point lies in the circle
  - "x" and "y" coordinate is unif[-1,1]
  - $\pi = 4 * \text{ratio}$

- Simple enough to do in an Excel spreadsheet

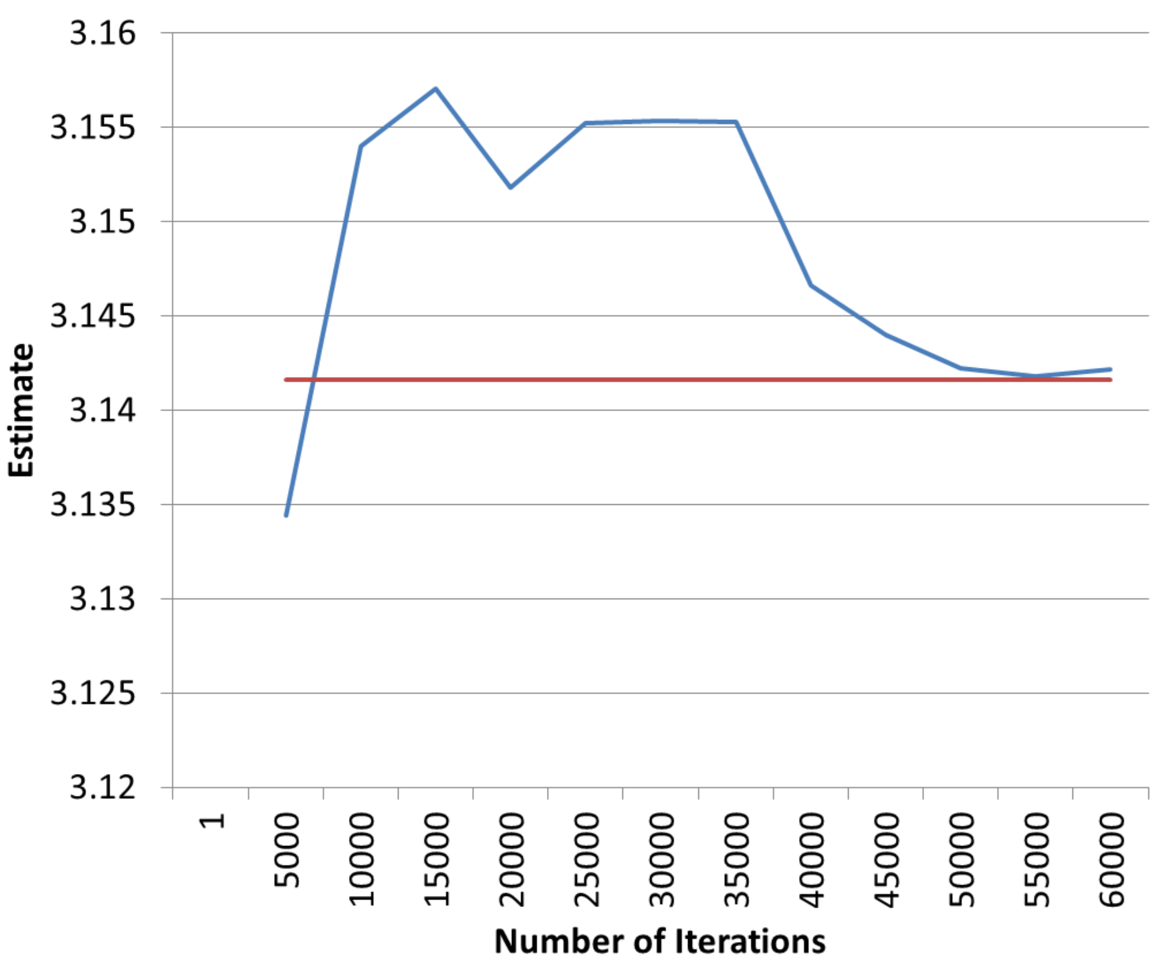
Estimation of π: 500 iterations



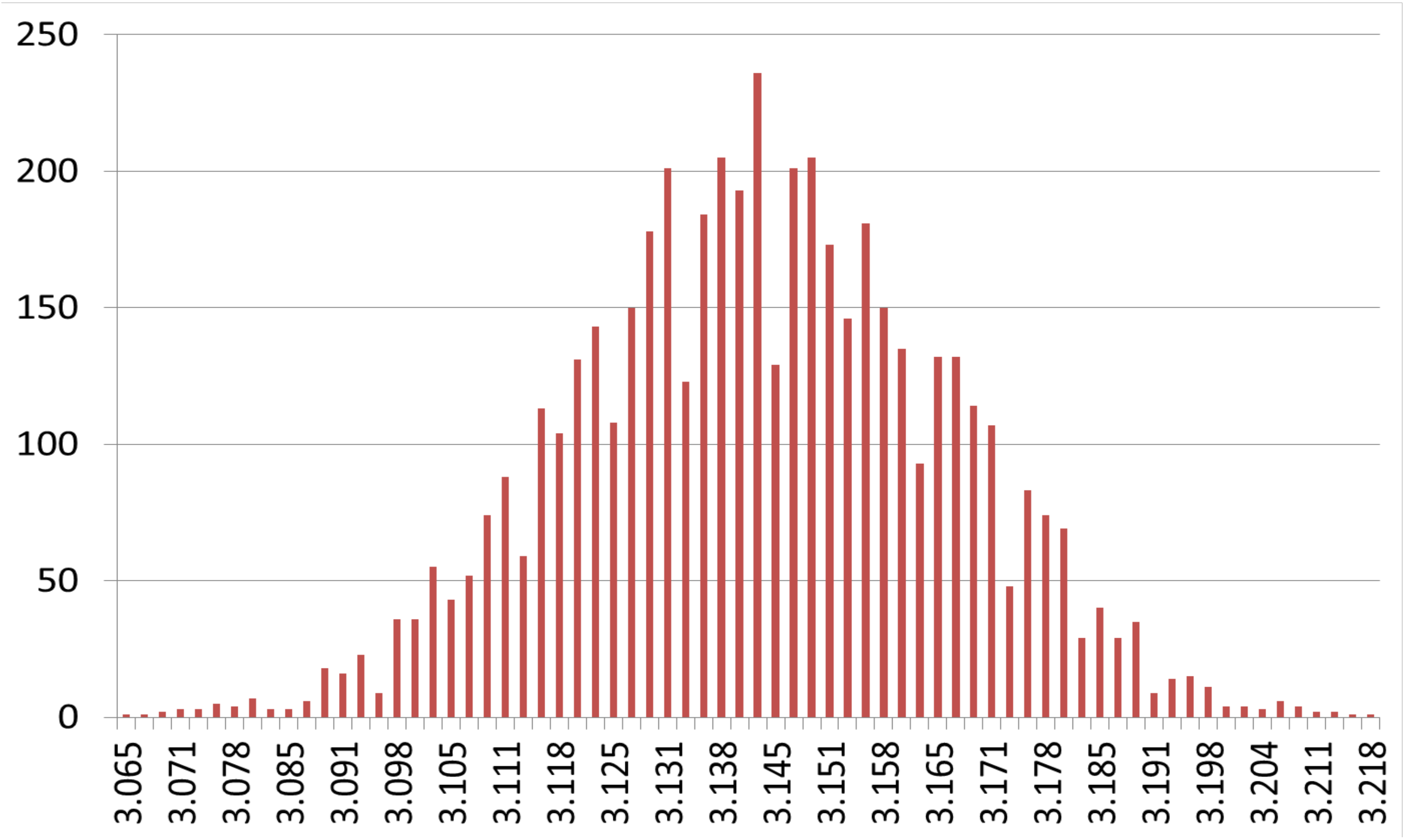
Estimation of π: Sampling Error

- At 500 iterations, the estimate is 3.10400 (not 3.14159). Why?
- Sampling error: variation is a natural consequence of monte carlo
  - Many times this can be reduced (variance reduction)
- Generally speaking, more iterations usually produce a more accurate estimate
  - Large technical literature on the topic

Estimation of π: Convergence



Estimation of π: Monte Carlo Batch

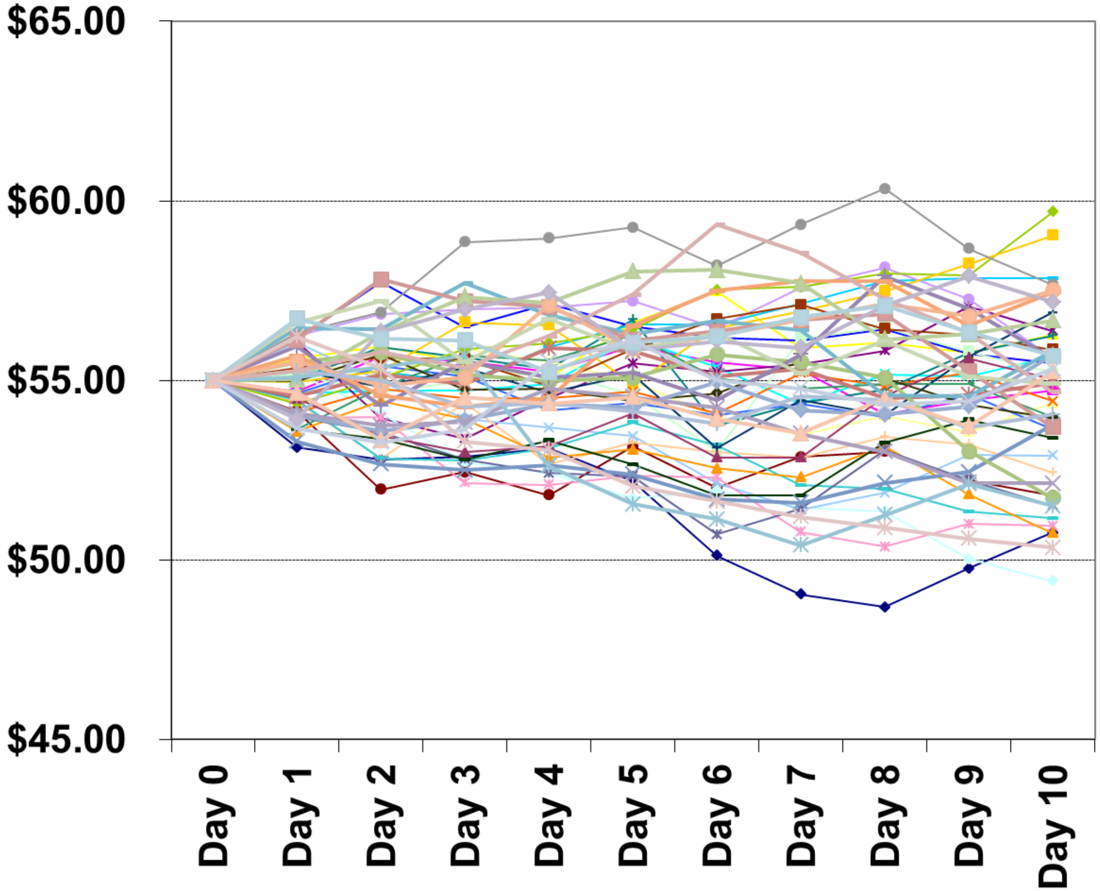


5000 iterations rerun 5000 times: average across batches is 3.14162

Generating Price Scenarios

- We can use a similar idea to generate price scenarios using a stochastic process
- In non-mathematical terms, a stochastic process can be thought of as an equation that generates price scenarios or returns
  - Most common is geometric brownian motion
- Price scenarios enable VaR, PFE, and the valuation of certain types of derivatives

Generating Price Scenarios



Option Pricing

- Monte Carlo provides a simple way to value European options

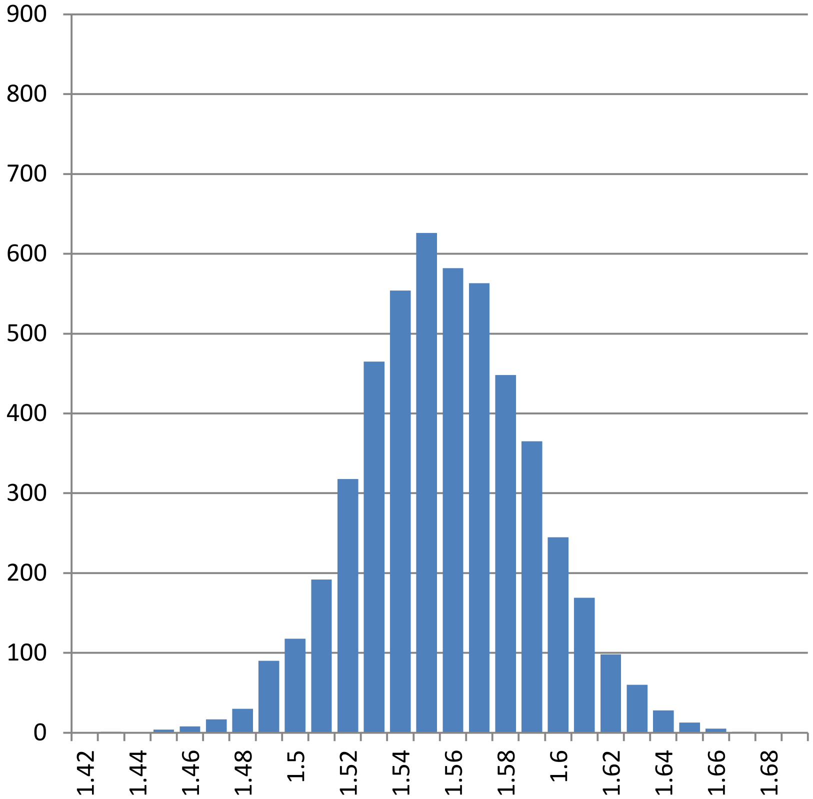
- Given the price scenarios…
  - Determine the option payoff for each scenario. For a call option, this is max(S-K,0)
  - Calculate the average of the option payoffs
  - Discount the average to the present

European Call Option

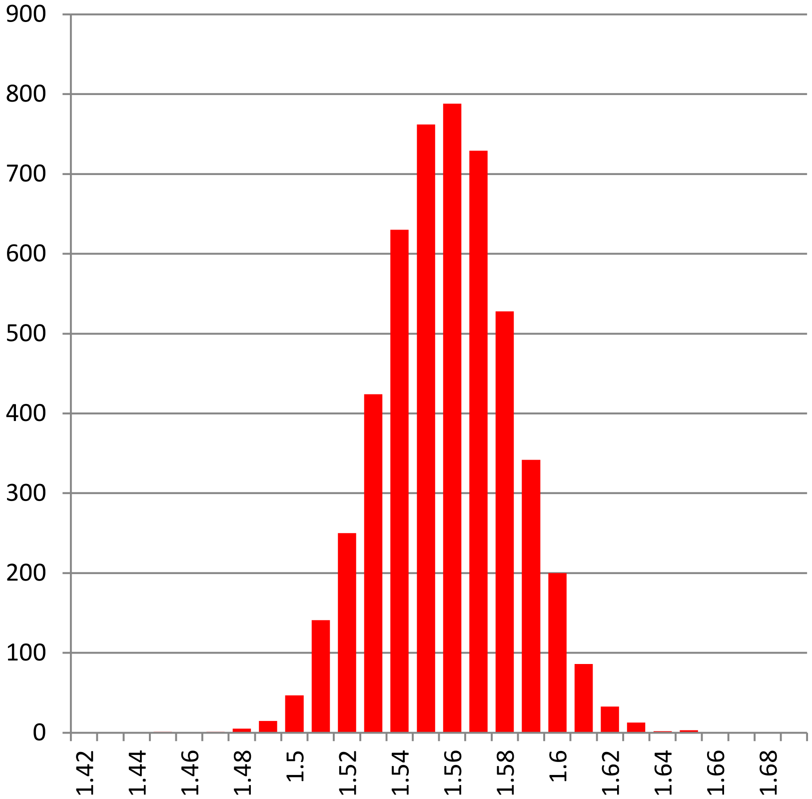
Starting Price		$50.00	
Strike		$50.00	
Risk free rate		1%	
Volatility		15%	
Time to Maturity (yrs)		0.25	
Iteration	dz	Simulated Price	Call Option Payoff
1	0.98672	$53.82	$3.82
2	-0.60236	$47.78	$0.00
3	1.49935	$55.93	$5.93
4	2.58489	$60.68	$10.68
5	-1.6808	$44.06	$0.00
6	1.36435	$55.37	$5.37
7	-2.35948	$41.88	$0.00
8	-0.11993	$49.54	$0.00
9	1.03071	$54.00	$4.00
10	0.12875	$50.47	$0.47

Distribution of the Estimate (5000/5000)

Standard Monte Carlo



MC with var. reduction



Estimate Summary

- Standard Monte Carlo: $1.557
- Monte Carlo with var. reduction: $1.558
- Black-Scholes formula: $1.557
- Coincidence?

Generating Price Scenarios: Standard Model

$$dS = \mu S dt + \sigma S dB(t)$$

$$\frac{\partial f}{\partial t} + rS\frac{\partial f}{\partial S} + \frac{1}{2}\sigma^2 S^2 \frac{\partial^2 f}{\partial S^2} = rf$$

Analytical

Trees

Numerical

Monte Carlo

$$S_{t+1} = S_o e^{\left(r - \frac{1}{2}\sigma^2\right)t + \sigma\sqrt{t}dz}$$

$$S_{t+1} = S_o e^{\sigma\sqrt{t}dz}$$

$$VaR = -1.65 * S_0 \sigma \sqrt{t} = -1.65\sigma_{std}$$

$$PCA$$

Many different stochastic processes available

Geometric Brownian Motion

Risk free interest rate

Time (forecast horizon)

Starting Price

$$S_{t+1} = S_o e^{\left(r - \frac{1}{2}\sigma^2\right)t + \sigma\sqrt{t}\,dz}$$

Volatility

Simulated price

Gaussian random variable

2.71828…

Value-at-Risk

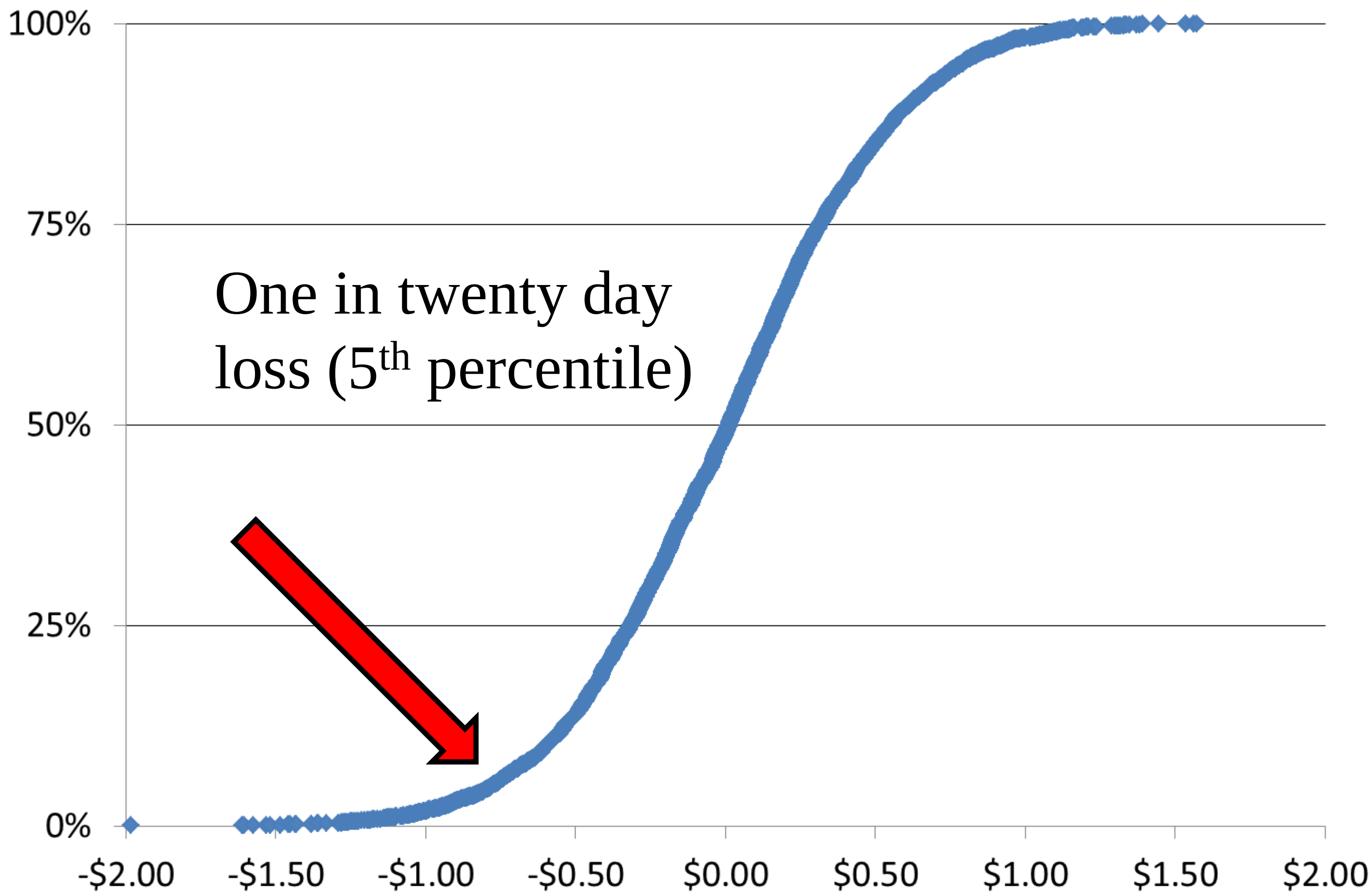
- What is VaR?
  - VaR is a statistical measure of market risk
  - “I am 95% certain that I will not lose more than $5MM over the next 24 hours.”
  - In practice, it is a percentile on a loss distribution

- VaR can be estimated using monte carlo
  - Simulate prices
  - Revalue the trade(s)
  - Calculate the change in mark to market
  - Sort from worst outcome to best outcome to estimate percentile of interest

Value-at-Risk

Starting Price		$50.00	
Risk free rate		1%	
Volatility		15%	
Forecast Horizon (one day)		0.003968254	
Iteration	dz	Simulated Price	Change in MTM
1	-1.99019	$49.07	-$0.93
2	0.47583	$50.23	$0.23
3	-0.07475	$49.96	-$0.04
4	1.41314	$50.67	$0.67
5	0.98087	$50.47	$0.47
6	0.50532	$50.24	$0.24
7	0.09591	$50.05	$0.05
8	-0.55897	$49.74	-$0.26
9	-0.73423	$49.65	-$0.35
10	0.6985	$50.33	$0.33

Value-at-Risk



Counterparty Credit Metrics

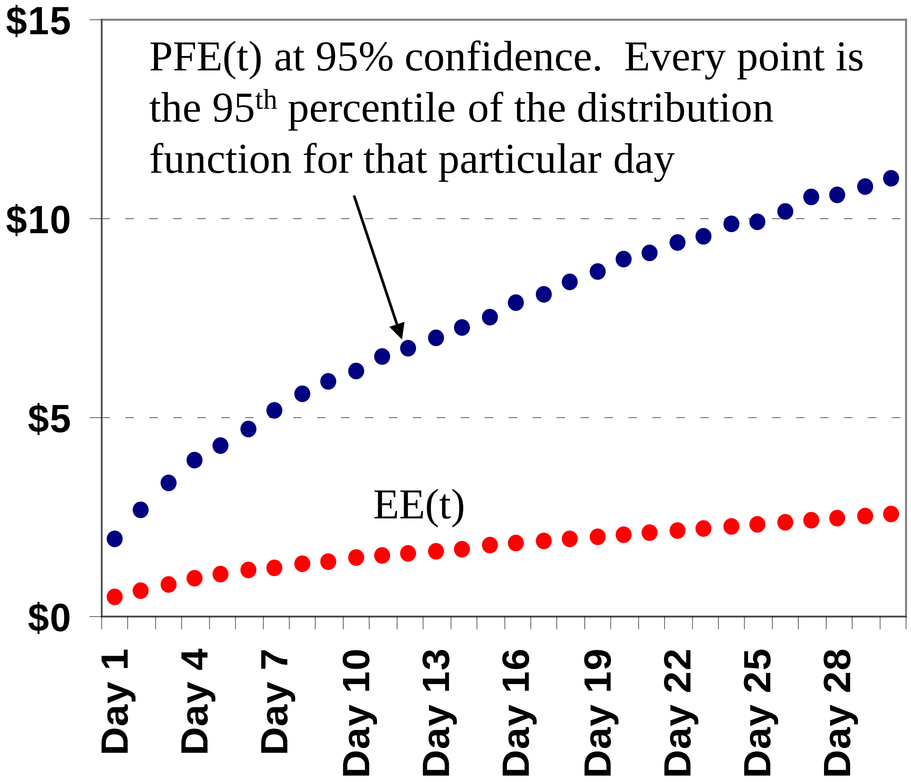
- Similar techniques are used to estimate counterparty credit metrics
  - Key idea: simulate prices and calculate the exposure as max(MTM,0)

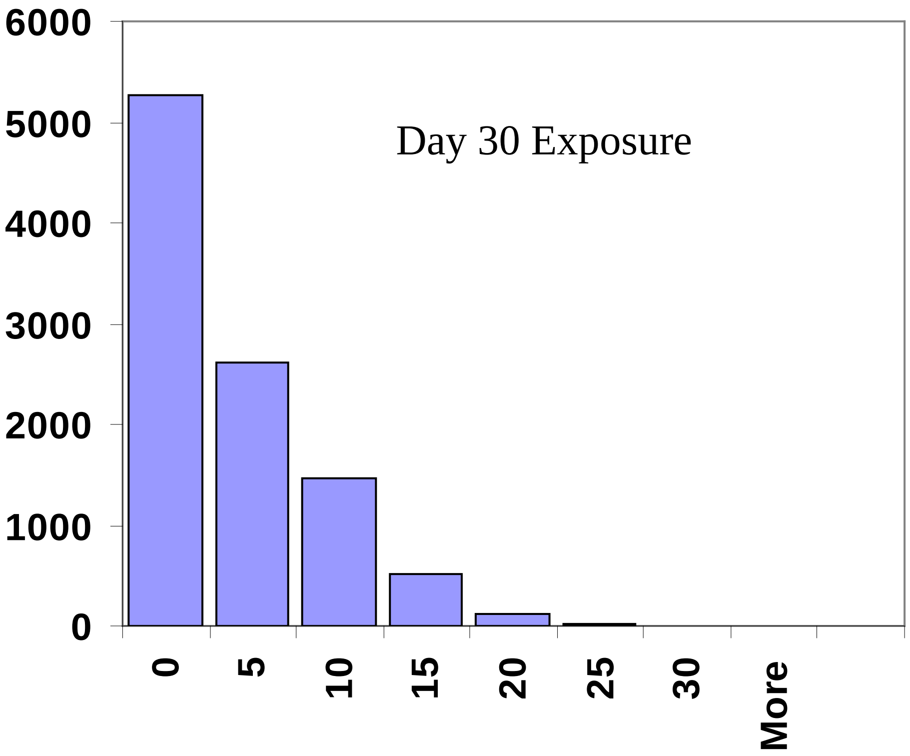
- Several different aspects to consider
  - Exposure
  - Loss events (due to default)
  - Credit Value Adjustment (CVA)
  - Collateral and margin requirements (FVA)

Exposure Metrics

- Large number of available metrics
  - Current Exposure (CE)
  - Potential Future Exposure (PFE)
  - Expected Exposure (EE)
  - Expected Positive Exposure (EPE)
  - Effective Expected Positive Exposure (Effective EPE)
  - Peak Exposure
- Formal definitions given in the glossary (page XX)
- Two examples at 10,000 iterations
  - Forward sale of one barrel of oil
  - 12 month strip sold forward

Example: Forward Sale

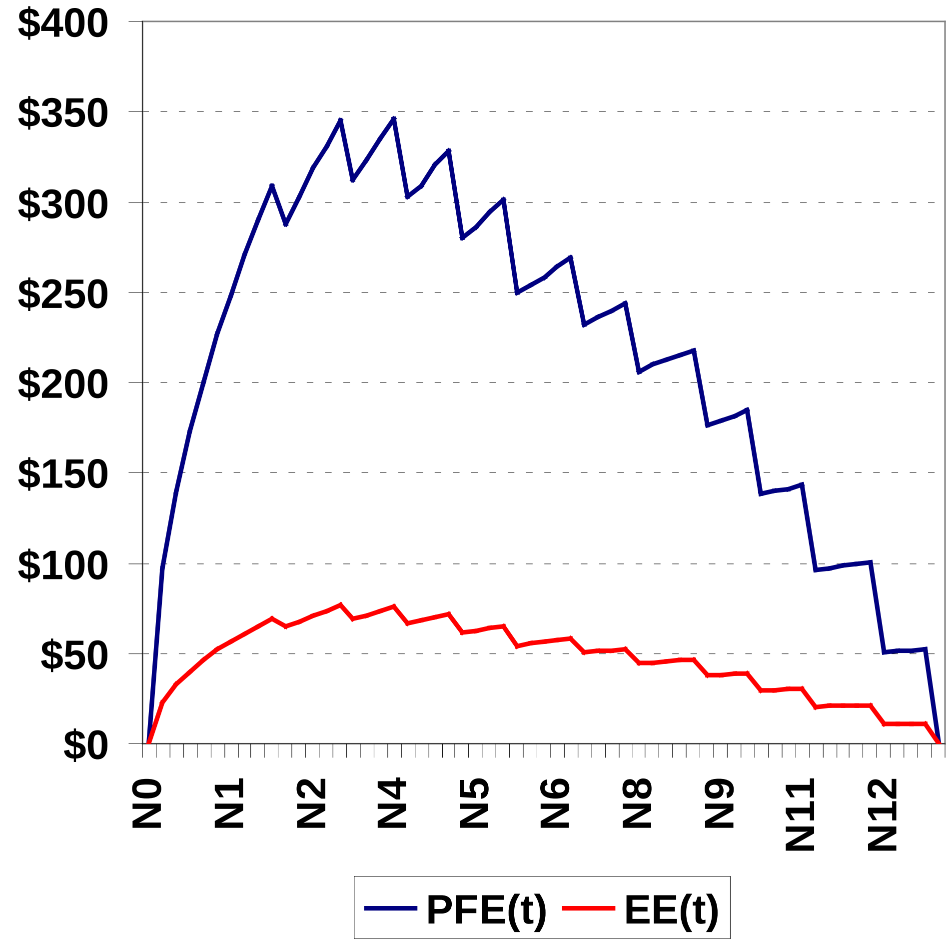




EPE (avg. of EE(t)) =$1.71

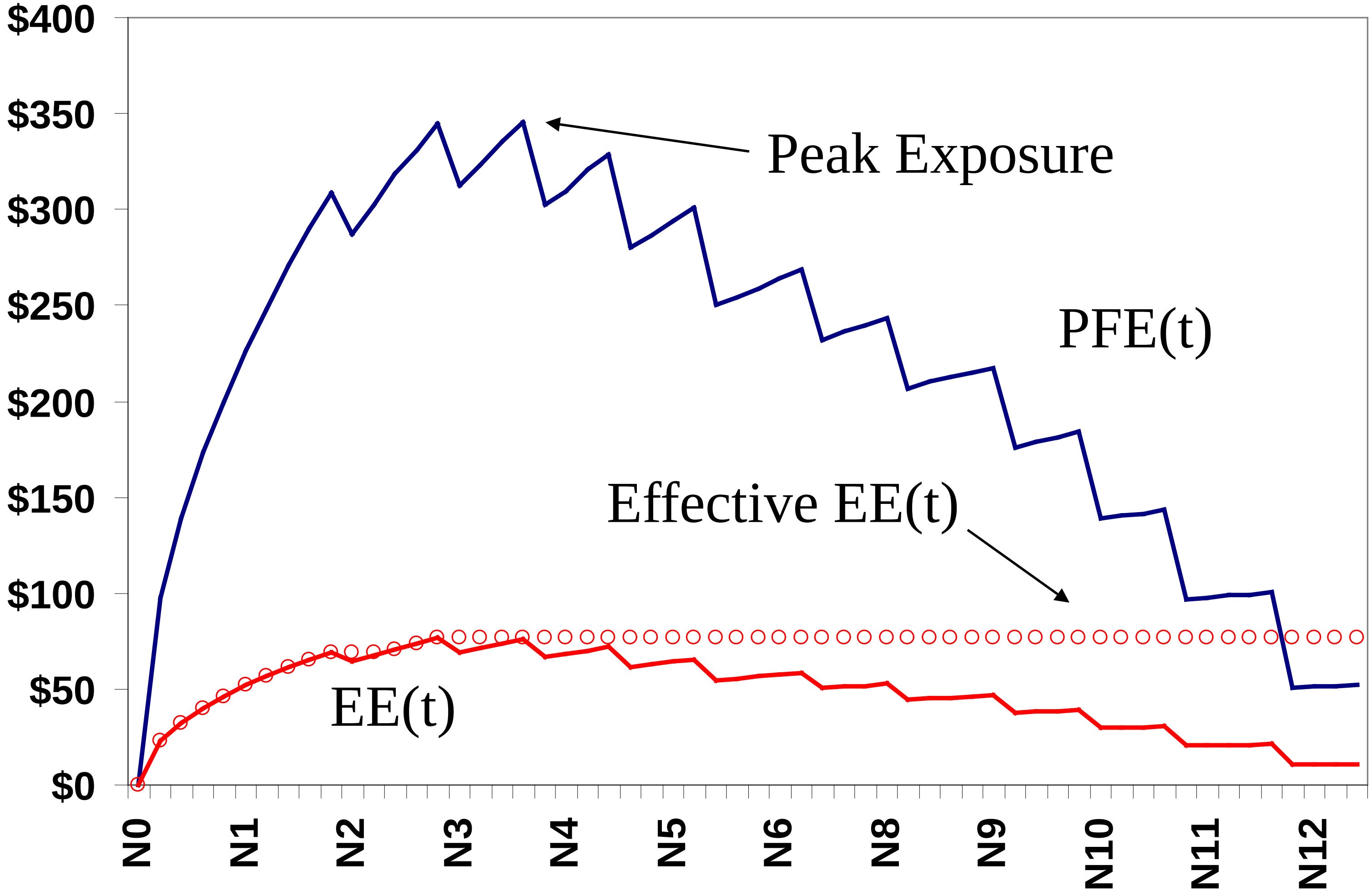
Example: 12 Month Strip

- Two competing effects
  - Price uncertainty increases over time
  - Volume amortizes as contracts roll off
- PFE(t) is max(MTM(t),0) at 95% confidence
- EE(t) is the average exposure at time t
- EPE is the average of EE(t) ~$47.56



Example: 12 Month Strip

Effective EPE is the average of Eff. EE(t)



Funding Liquidity

- Estimates for funding liquidity can be generated in a similar way, especially if collateral and margin requirements are formula based

- Details matter
  - Margin thresholds
  - Minimum transfer amounts
  - Time interval between collateral request and when the counterparty is considered in default (margin period of risk)

Estimating Credit Losses

- Estimating loss events requires both exposures and default probabilities

- Default probabilities are and will likely remain a hard problem
  - Scoring models
  - External credit ratings
  - Market observables (bonds, credit derivatives, etc.)
  - Expert judgment if no other information available

Estimating Credit Losses

- Default events can be included in the monte carlo process "with just a bit more work"…
  - …if a default event happens
  - …when the default happens
  - …the exposure at the time of default less any credit offsets
- The average loss is the credit value adjustment (CVA) in its simplest form

Practical Issues

- IT system
  - Netting and collateral requirements, credit offsets, ratings triggers, etc.
  - Legacy systems not designed to estimate metrics
  - Significant effort to run the model and report results
  - Potentially large computational requirements

- Possible regulatory interest: banks may be required to include default and funding risk when pricing derivatives (Basel III CVA capital charge)

Summary

- Even if not explicitly measured, counterparty credit risk is a risk you already have

- Much to consider
  - Exposure and funding/liquidity measures might be enough to address short term business needs
  - Decision to fully implement should not be taken lightly
  - Potential regulatory interest

Glossary

- Current Exposure (CE) is the larger of zero, or the market value of a transaction or portfolio of transactions within a netting set with a counterparty that would be lost upon the default of the counterparty, assuming no recovery on the value of those transactions in bankruptcy. Also called Replacement Cost.

- Potential Future Exposure (PFE) is a high percentile (typically 95 percent or 99 percent) of the distribution of exposures at any particular future date before the maturity date of the longest transaction in the netting set.

- Expected Exposure (EE) is the mean of the distribution of exposures at any particular future date before the longest maturity transaction in the netting set matures.

- Expected Positive Exposure (EPE) is the weighted average over time of expected exposures where the weights are the proportion that an individual expected exposure represents of the entire time interval.

- Effective Expected Positive Exposure (Effective EPE) is the weighted average over time of effective expected exposure over the first year, or over the time period of the longest maturity contract in the netting set where the weights are the proportion that an individual expected exposure represents of the entire time interval.

- Peak Exposure (PE) is a high percentile of the distribution of exposures at any particular future date before the maturity of the longest transaction in the netting set.

End Notes and References

1. The Application of Basel II to Trading Activities and the Treatment of Double Default Effects, April 2005, page 3.
2. David Lamb and Evan Picoult, Economic Capital: A Practicioner's Guide, pg 110
3. The Application of Basel II to Trading Activities and the Treatment of Double Default Effects, April 2005, page 21.

For more information on counterparty credit risk

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- David Lamb and Evan Picoult, "Economic Capital for Counterparty Credit Risk," in Economic Capital: A Practicioner's Guide, ed. Ahish Dev, Risk Books 2004
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