Enterprise Risk Management Symposium
Credit Risk Modeling and Management

Concurrent Session 7

July 30, 2003

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AIG

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Introduction and Disclaimer

- All comments made at this conference are the opinion of the presenter and do not reflect the opinion of American International Group, Inc.
- Recent events have reminded the industry of the importance of credit issues
- Throughout this turmoil we have all been confronted with key credit challenges
- In addressing these challenges the actuarial community can assist us credit professionals
- Our panel will address some of those issues and hopefully prompt questions for further study

Key Credit Challenges for Effective Credit Risk Management

- Measure
- Analyze
- Cost
- Model
- Manage
- Collect

Measuring Credit Risk

- Current exposure
- Expected exposure
- Potential exposure

Measuring Credit Risk

- Current exposure
  - Book value, market value, historical cost on bonds
  - Mark to market value on derivative instruments
  - Loss reserves, IBNR, and recoverables on insurance
- Expected exposure
- Potential exposure

Measuring Credit Risk

- Current exposure
- Expected exposure
  - Mean of the distribution of possible outcomes
  - Bond values plus accrued interest
  - Mark to market value on derivatives plus add-on at 50% confidence
  - Loss pick or expected mean value for insurance
- Potential exposure

Measuring Credit Risk

- Current exposure
- Expected exposure
- Potential exposure
  - Possible exposure given a chosen degree of confidence
  - Exposure within an agreed time horizon
  - Exposure at default

Analyzing Credit Risk

- Issuer/obligor/counterparty analysis
- Probabilities of default
- Loss given default

Analyzing Credit Risk

- Issuer/obligor/counterparty analysis
  - External rating agencies
  - Broker/dealer investment research
  - Internal research and risk rating methodologies
- Probabilities of default
- Loss given default

Analyzing Credit Risk

- Issuer/obligor/counterparty analysis
- Probabilities of default
  - Historical data studies
  - "Mertonesque" approaches to default frequency using option theory
  - Implied probabilities from marketplace
- Loss given default

Analyzing Credit Risk

- Issuer/obligor/counterparty analysis
- Probabilities of default
- Loss given default
  - Internal data
  - Industry data
    - Historical recovery statistics
    - Estimates based on secondary market prices
    - Implied values from marketplace

Costing Credit Risk

- Expected loss
  - Credit exposure X probability of default X loss given default
- Unexpected loss or capital at risk is the variance off the mean of the expected loss equation, as a result of
  - Probability of default
  - Loss given default
  - Correlation or clustering of risk

Credit Risk Instruments

How can the actuarial community help?

- Investments
- Financial services
- Insurance and reinsurance

Credit Risk Instruments

- Fixed income investments
  - Bonds
    - Corporates
    - Institutional
    - Sovereigns
  - Private placements and loans
  - Structured product
    - Asset backed
    - CDOs

Credit Risk Instruments

- Financial services
  - Counterparty risk from commodity and derivatives trading
  - Consumer finance
  - Other

Credit Risk Instruments

- Insurance and reinsurance
  - General insurance
    - Reinsurance and captives
    - Casualty deductible programs
    - Paid loss retrospectively rated programs
    - Deductible funding programs
  - Life insurance
    - Structured settlements
    - Reinsurance
  - Credit lines
    - Surety
    - Financial Guarantees
    - Trade credit
    - Political risk

Modeling Credit Risk

- Actuarial approaches
- Market pricing approaches
  - Using stock market prices together with balance sheet information
  - Using credit spread prices embedded in credit default swap prices

Credit Risk Modeling and Management

"Actuarial Approach"

Using Stochastic Simulation Techniques to Measure Credit Risk

Scott A. Christensen, FSA, MAAA
Investment Actuary
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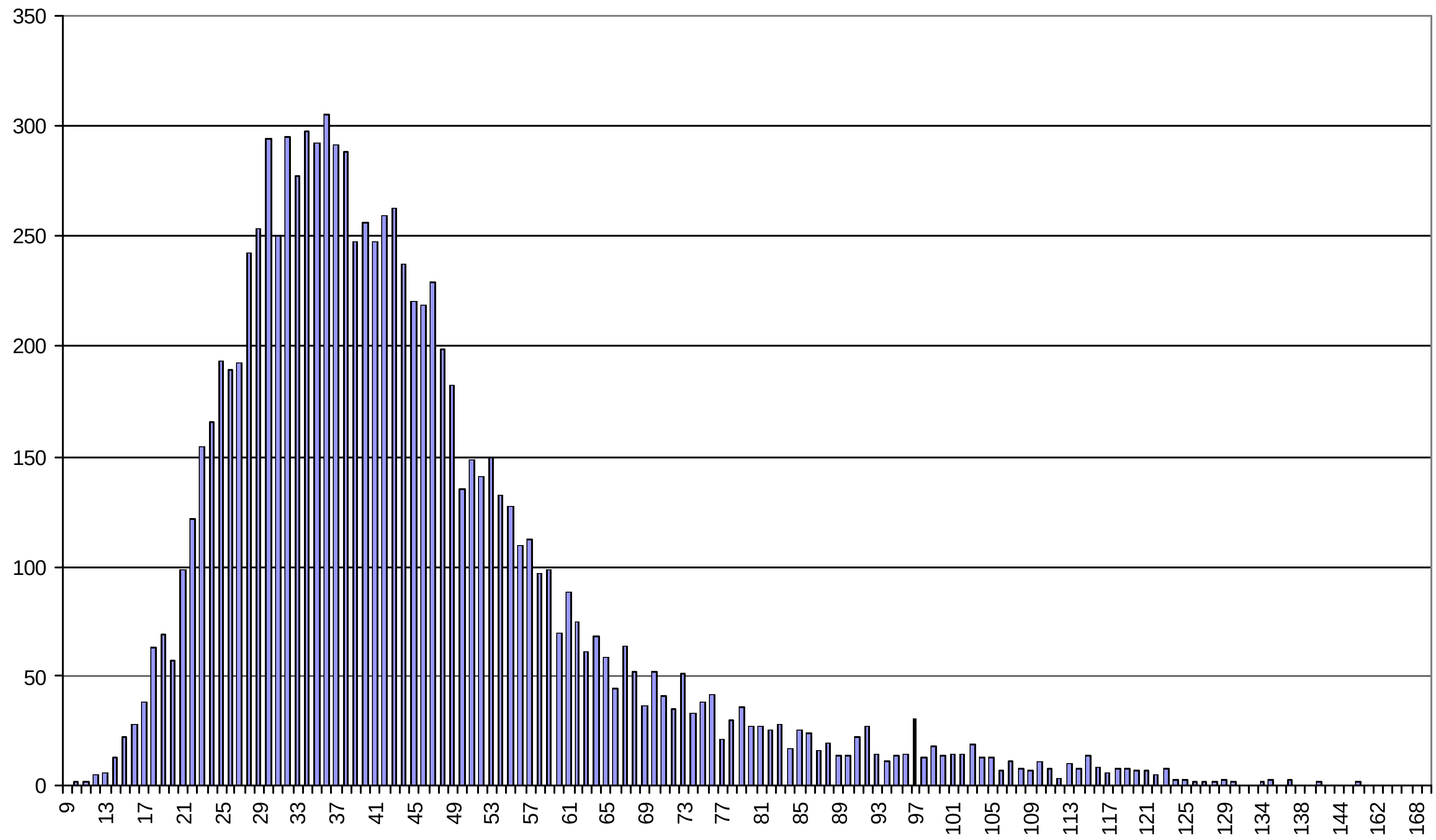
Introduction

- Traditionally, actuaries have focused on measuring expected credit losses to reflect in liability pricing
- Reliance on a blend of internal experience studies and default/recovery data from rating agencies
- Primary focus has been on the mean and less focus on the distribution of credit losses

Distribution of Credit Losses

- Distribution is skewed and has a fat tail
- Lose a little…lose a little….lose a little….LOSE A LOT!!!!…. lose a little…..lose a little, etc.
- Easy to be lulled to sleep and underestimate credit risk during good economic times
- On average, I expect to lose X basis points, but what is the probability that my losses will be greater than Y basis points?

Illustration of Credit Loss Deduct needed for 10 Year, BBB- Bond



Difficulties in measuring the distribution

- Lack of data points
- Credit Losses are low frequency events
- Rating agency data may be limited to 10-20 years
- Problems with collecting good, consistent, internal data
- Future experience expected to be different than historical experience

Stochastic Simulation Model

- One tool to help measure distribution of credit losses
- Model life cycle of a portfolio of bonds from “cradle to grave”
- Probability distributions for default, recovery, and transition need to be defined
- Base distributions on historical data from rating agencies. Modify as appropriate to reflect internal experience or to reflect view on future experience
- Build model in Excel using VB code or in APL

Step #1a – Define Default Distribution

- Defaults by credit rating are not independent. Best way to reflect this is to simultaneously define default rate for each credit rating based on point in economic cycle.

- Good starting point is default rate data from rating agencies and modify as appropriate to reflect internal experience and/or views on future experience.

Moody's Issuer-Weighted Annual Default Rates

	etc.	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Aaa		0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aa1		0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aa2		0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aa3		1.4	0	0	0	0	0	0	0	0	0	0	0	0	0
A1		0	0	0	0	0	0	0	0	0	0	0	0	0	0
A2		0	0	0	0	0	0	0	0	0	0	0	0	0.42	0
A3		0	0	0	0	0	0	0	0	0	0	0	0	0	0.43
Baa1		0	0	0.75	0	0	0	0	0	0	0	0	0.28	0.27	1.26
Baa2		0.79	0	0	0	0	0	0	0	0	0.31	0	0	0.27	0.72
Baa3		1.06	0	0	0	0	0	0	0	0	0	0.34	0.97	0	1.78
Ba1		0.79	2.67	1.08	0	0.83	0	0	0	0	0	0.47	0.94	0.51	1.58
Ba2		1.82	2.82	0	0	0	0	0	0	0	0.62	0	0.63	1.38	1.41
Ba3		4.71	3.93	10.08	0.73	0.76	0.59	1.76	0	0.47	1.12	2	1.04	2.93	1.58
B1		5.76	8.5	5.86	1	3.24	1.88	4.35	1.17	0	2.11	3.28	3.24	3.19	2
B2		9.79	22.64	12.9	1.59	5.04	3.75	6.42	0	1.54	7.55	6.91	4.1	11.07	6.81
B3		18.05	29.11	28.42	24.84	11.29	7.95	4.06	3.28	7.22	5.52	9.63	10.88	16.38	6.86
CCC		25	58.82	36.84	26.67	28.57	5.13	11.57	13.99	14.67	15.09	20.44	19.65	34.45	29.45

1. Randomly select a year. Define probability transition matrix between years to attempt to model economic cycle.
2. Default rate for each credit rating assumed to be equal to year that is randomly selected

Step #1b – Define Recovery Distribution

- Again, good starting point is data from rating agencies that can then be further modified to reflect internal experience and/or views on future experience
- Should define different distributions depending on public vs. private, secured vs. non-secured, etc.
- Recovery distributions are non-normal. A Beta distribution works well for recoveries.
- Can define how recoveries are to be correlated with default rates.

Step #1c – Define Rating Transition Matrix

- Define probability of moving from one rating category to the next

	Rating to														
Rating from	Aaa	Aa1	Aa2	Aa3	A1	A2	A3	Baa1	Baa2	Baa3	Ba1	Ba2	Ba3	B1	B2
Aaa	89.06%	6.16%	3.04%	0.49%	0.74%	0.29%	0.17%	0.00%	0.00%	0.00%	0.04%	0.00%	0.00%	0.00%	0.00%
Aa1	2.65%	79.22%	8.20%	6.86%	2.41%	0.33%	0.05%	0.19%	0.00%	0.00%	0.09%	0.00%	0.00%	0.00%	0.00%
Aa2	0.74%	3.05%	80.93%	8.82%	4.13%	1.42%	0.61%	0.17%	0.00%	0.00%	0.00%	0.00%	0.05%	0.08%	0.00%
Aa3	0.08%	0.64%	3.52%	81.51%	9.30%	3.29%	0.89%	0.25%	0.22%	0.17%	0.00%	0.04%	0.09%	0.00%	0.00%
A1	0.03%	0.11%	0.63%	5.76%	80.92%	7.50%	3.00%	0.81%	0.28%	0.14%	0.38%	0.26%	0.05%	0.13%	0.01%
A2	0.05%	0.06%	0.30%	0.80%	5.57%	80.83%	7.49%	2.99%	0.83%	0.41%	0.29%	0.10%	0.11%	0.03%	0.07%
A3	0.05%	0.11%	0.05%	0.24%	1.56%	8.69%	75.48%	7.04%	3.84%	1.50%	0.57%	0.20%	0.23%	0.35%	0.05%
Baa1	0.08%	0.02%	0.14%	0.19%	0.21%	2.85%	8.06%	74.78%	7.74%	3.30%	1.09%	0.48%	0.37%	0.58%	0.09%
Baa2	0.07%	0.11%	0.13%	0.18%	0.18%	0.92%	3.88%	7.29%	75.56%	7.42%	1.78%	0.55%	0.69%	0.51%	0.48%
Baa3	0.03%	0.00%	0.03%	0.07%	0.19%	0.61%	0.70%	3.45%	9.99%	71.74%	6.83%	2.77%	2.03%	0.86%	0.33%
Ba1	0.09%	0.00%	0.00%	0.03%	0.24%	0.13%	0.74%	0.82%	3.23%	8.44%	73.07%	5.06%	4.27%	1.23%	1.40%
Ba2	0.00%	0.00%	0.00%	0.03%	0.04%	0.17%	0.15%	0.39%	0.78%	2.57%	9.33%	71.50%	6.93%	1.87%	4.14%
Ba3	0.00%	0.02%	0.00%	0.00%	0.04%	0.18%	0.19%	0.19%	0.29%	0.78%	3.05%	5.66%	74.92%	5.43%	5.80%
B1	0.02%	0.00%	0.00%	0.00%	0.07%	0.10%	0.17%	0.08%	0.27%	0.34%	0.48%	2.86%	6.47%	75.98%	5.93%
B2	0.00%	0.00%	0.07%	0.01%	0.13%	0.00%	0.08%	0.20%	0.14%	0.21%	0.35%	1.94%	3.52%	6.86%	73.00%
B3	0.00%	0.00%	0.08%	0.00%	0.03%	0.05%	0.08%	0.14%	0.15%	0.25%	0.23%	0.45%	1.49%	5.12%	4.28%
CCC	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.76%	0.76%	1.01%	0.00%	2.15%	2.93%	1.95%

Step #2 – Define Beginning Cohort

- Can be an actual bond portfolio or a theoretical bond portfolio. Usually will model hundreds or thousands of bonds.

Scenario	Bond	Par	Original Rating	Current Rating	Secured/ Unsecured	Status	Year Defaulted	Loss given Default
1	1	1000	Aaa	Aaa	Secured	Active		
1	2	1000	Aa1	Aa1	Unsecured	Active		
1	3	4000	Aa3	Aa3	Secured	Active		
1	4	1000	A1	A1	Unsecured	Active		
1	5	1000	A2	A2	Unsecured	Active		
1	6	3000	A2	A2	Unsecured	Active		
1	7	10000	A2	A2	Unsecured	Active		
1	8	1000	A3	A3	Unsecured	Active		
1	9	1000	A3	A3	Secured	Active		
1	10	6000	Baa1	Baa1	Unsecured	Active		
1	11	1000	Baa2	Baa2	Unsecured	Active		
1	12	1000	Baa2	Baa2	Unsecured	Active		
1	13	2000	Baa2	Baa2	Unsecured	Active		
1	14	1000	Ba3	Ba3	Secured	Active		
1	15	1000	CCC	CCC	Unsecured	Active		

Step #3 – Model life cycle of portfolio

- Model portfolio for X number of years. For each year, do the following:

1. Randomly select a year of default experience. (ex. 1991).
2. Apply default rates to bond portfolio based on current rating to model bond defaults
3. For bonds assumed to default, sample an observation from recovery distributions defined
4. Change status of bonds assumed to default
5. Apply transition matrix to "survivors"

Example: Modeled Portfolio at time 1

Scenario	Bond	Par	Original Rating	Current Rating	Secured/ Unsecured	Status	Year Defaulted	Loss given Default
1	1	1000	Aaa	Aaa	Secured	Active		
1	2	1000	Aa1	Aa1	Unsecured	Active		
1	3	4000	Aa3	Aa3	Secured	Active		
1	4	1000	A1	A1	Unsecured	Defaulted	1	500
1	5	1000	A2	A3	Unsecured	Active		
1	6	3000	A2	A2	Unsecured	Active		
1	7	10000	A2	Baa2	Unsecured	Active		
1	8	1000	A3	A3	Unsecured	Active		
1	9	1000	A3	A3	Secured	Active		
1	10	6000	Baa1	Baa1	Unsecured	Active		
1	11	1000	Baa2	A3	Unsecured	Active		
1	12	1000	Baa2	Baa2	Unsecured	Defaulted	1	800
1	13	2000	Baa2	Baa2	Unsecured	Active		
1	14	1000	Ba3	Ba3	Secured	Active		
1	15	1000	CCC	Ba2	Unsecured	Active		

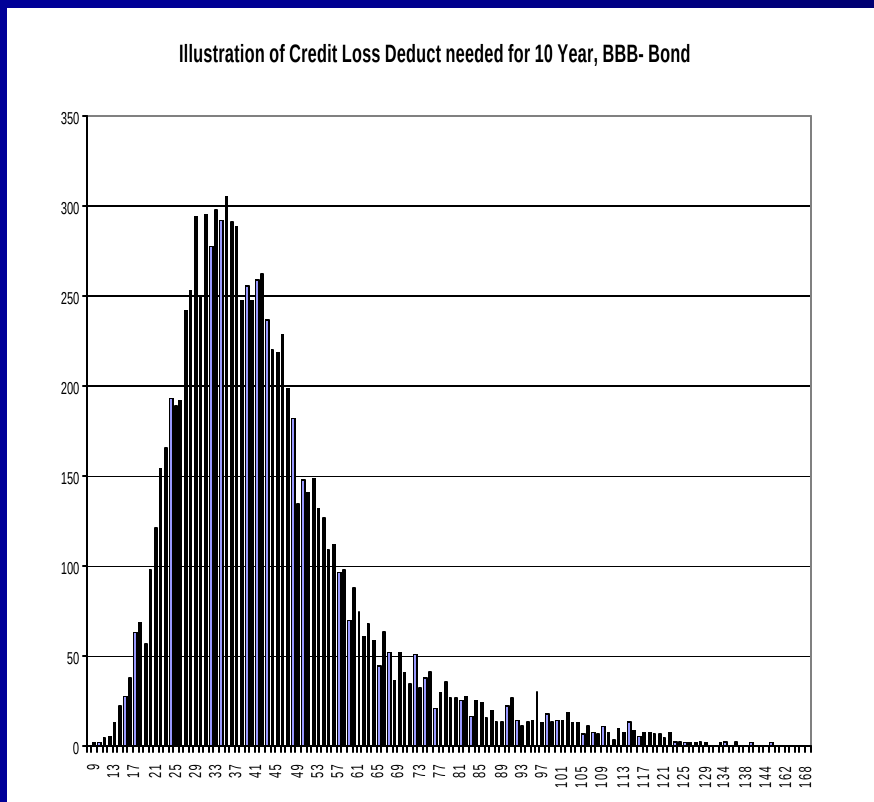
Example: Modeled Portfolio at time 2

Scenario	Bond	Par	Original Rating	Current Rating	Secured/ Unsecured	Status	Year Defaulted	Loss given Default
1	1	1000	Aaa	Aaa	Secured	Active		
1	2	1000	Aa1	Aa3	Unsecured	Active		
1	3	4000	Aa3	Aa3	Secured	Defaulted	2	1000
1	4	1000	A1	A1	Unsecured	Defaulted	1	500
1	5	1000	A2	A3	Unsecured	Active		
1	6	3000	A2	A2	Unsecured	Active		
1	7	10000	A2	Baa2	Unsecured	Defaulted	2	9000
1	8	1000	A3	A3	Unsecured	Active		
1	9	1000	A3	Ba2	Secured	Active		
1	10	6000	Baa1	Baa1	Unsecured	Active		
1	11	1000	Baa2	A1	Unsecured	Active		
1	12	1000	Baa2	Baa2	Unsecured	Defaulted	1	800
1	13	2000	Baa2	CCC	Unsecured	Active		
1	14	1000	Ba3	CCC	Secured	Active		
1	15	1000	CCC	Ba2	Unsecured	Active		

Step #4 – Store results for multiple scenarios

- Run model for thousands and thousands of scenarios
- Given default is a low frequency event, especially for investment grade bonds, want to run enough scenarios to try to capture the distribution
- After each scenario, store results in a relational database that can be easily queried

Step #5 – Summarize and Analyze results



Mean	49
50th percentile	45
60th percentile	48
70th percentile	52
80th percentile	58
90th percentile	68
95th percentile	80

Usefulness of Stochastic Simulation Technique

- Help set credit limits to a particular risk rating
- Help decide on level of diversification necessary in portfolio
- Help determine optimal level of capital to hold for credit risk
- Test sensitivity of assumptions on final results

Shortcomings of Stochastic Simulation Technique

- Reliance on historical data
- Sensitivity to assumptions
- Correlations between individual securities other than by rating are difficult to capture

Conclusion

- Results should not be accepted blindly
- Provides a good starting point for measuring credit loss distribution however

Credit Risk Modeling and Management
A Market-Based Approach

Concurrent Session 7

July 30, 2003

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- One of the quantitative credit risk management tools used at Prudential is provided by Moody's/KMV.
- Moody's/KMV has approved the use of their slides which appear in this presentation.
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Market-based Models

- Alternative to accounting-based default prediction models, attributed to the works of Black & Scholes on option pricing as extended by Merton.

- Fundamental insight: a firm's equity can be viewed as a call option on the underlying value of the firm. The probability that this option is out of the money is theoretically related to the probability that the firm will default.

Market Based Approach

- An assessment of the company's future has already been made by all market participants and is reflected in the firm's current market value.

- Both current and prospective investors are constantly performing this analysis, and their actions set the price.

Single Issuer Analysis

EDF™ Credit Measure

- EDF stands for “Expected Default Frequency™”

- EDF is the probability that the firm will default within a given time horizon – failing to make an interest or principal payment

Causal Model of Default

- A firm defaults when the value of its business falls below what it owes

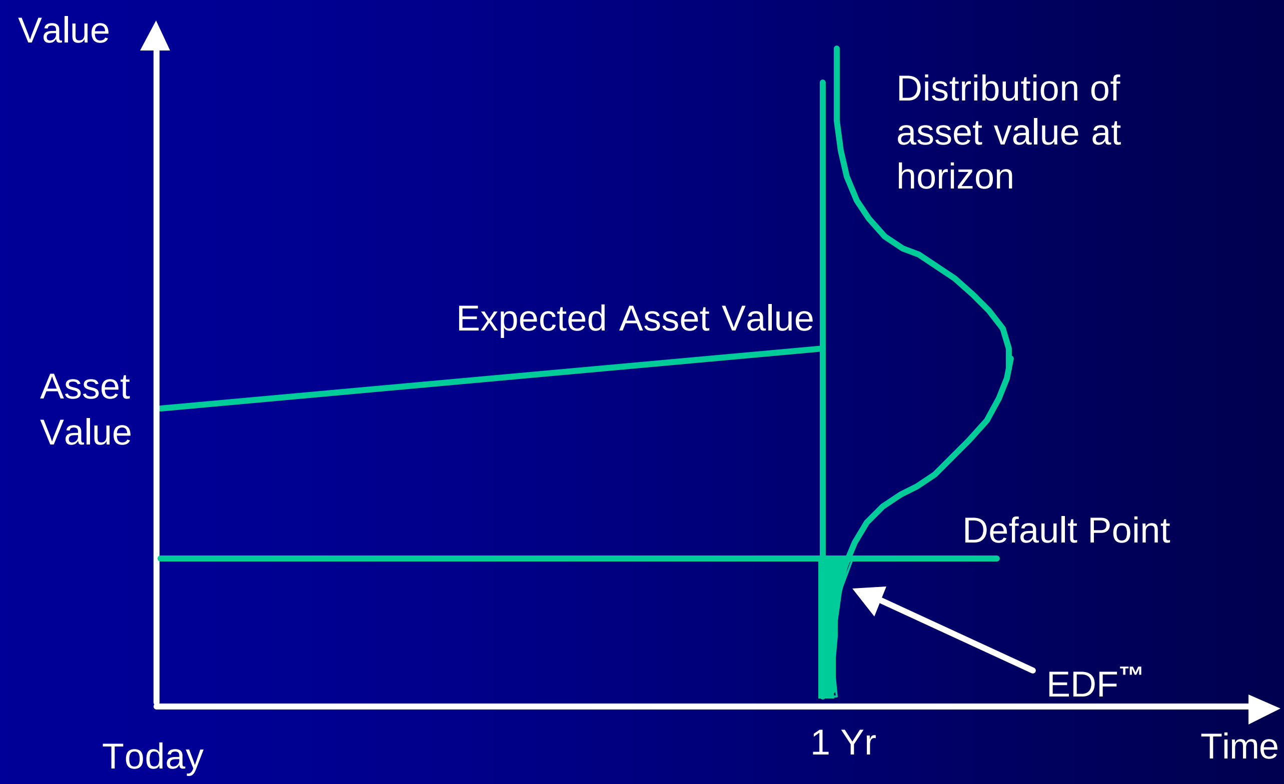
- If the value of the business is greater than the obligations due, the equity holders have the ability and incentive to pay the debt obligations

- Market values reflect distress (or improvement) well before accounting figures

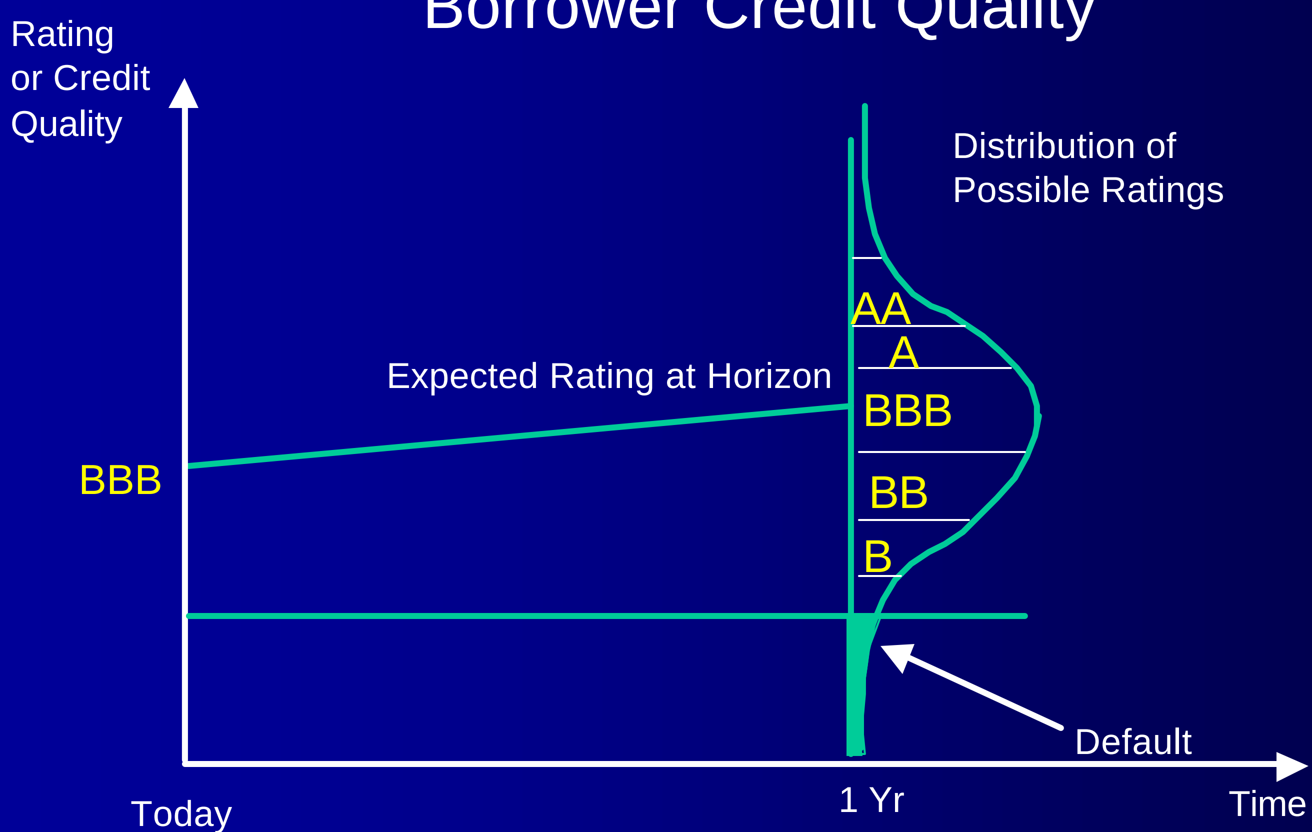
EDF Drivers

1. *Market Value of Assets (or Business Value)*
   Market Investors' assessment of the future cash flows of the business
2. *Asset Volatility (or Business Risk)*
   The variability of the market value of assets
3. *Default Point (or Liabilities Due)*
   The liabilities due in the event of distress

Borrower Asset Value



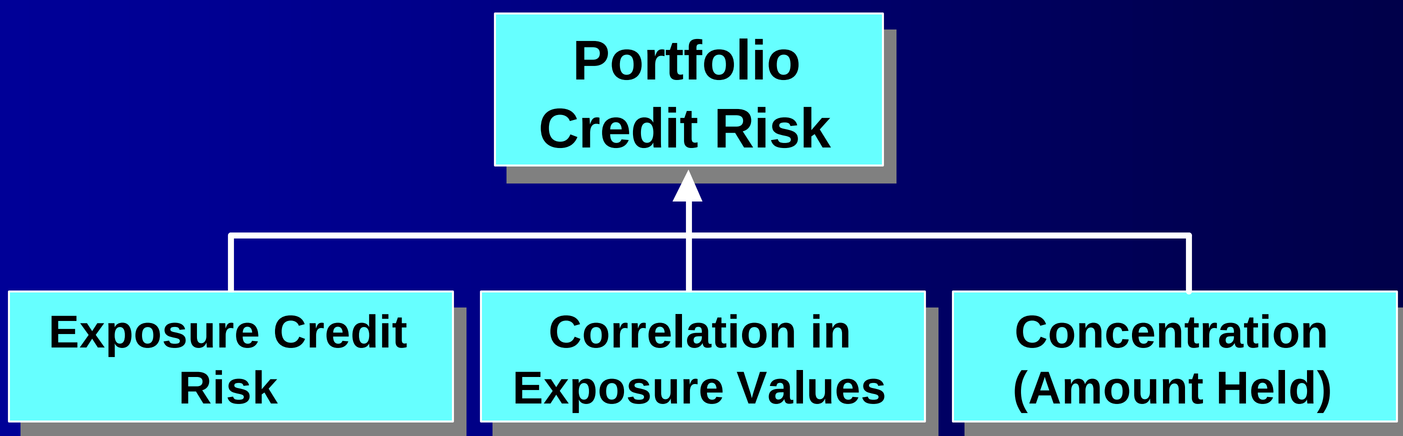
Borrower Credit Quality



Portfolio Analysis

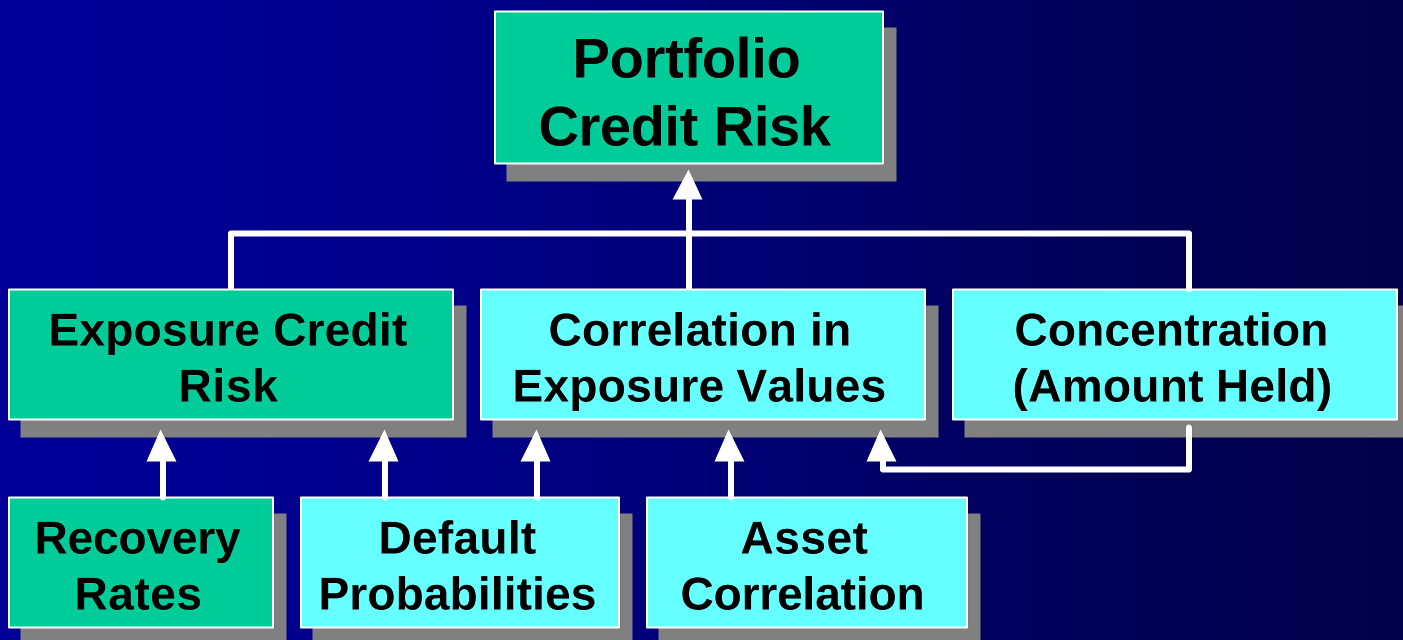
Elements of Portfolio Credit Risk

- Portfolio Credit Risk is the risk of changes in the market value of the portfolio over a time horizon as a result of changes in credit quality



Elements of Portfolio Credit Risk

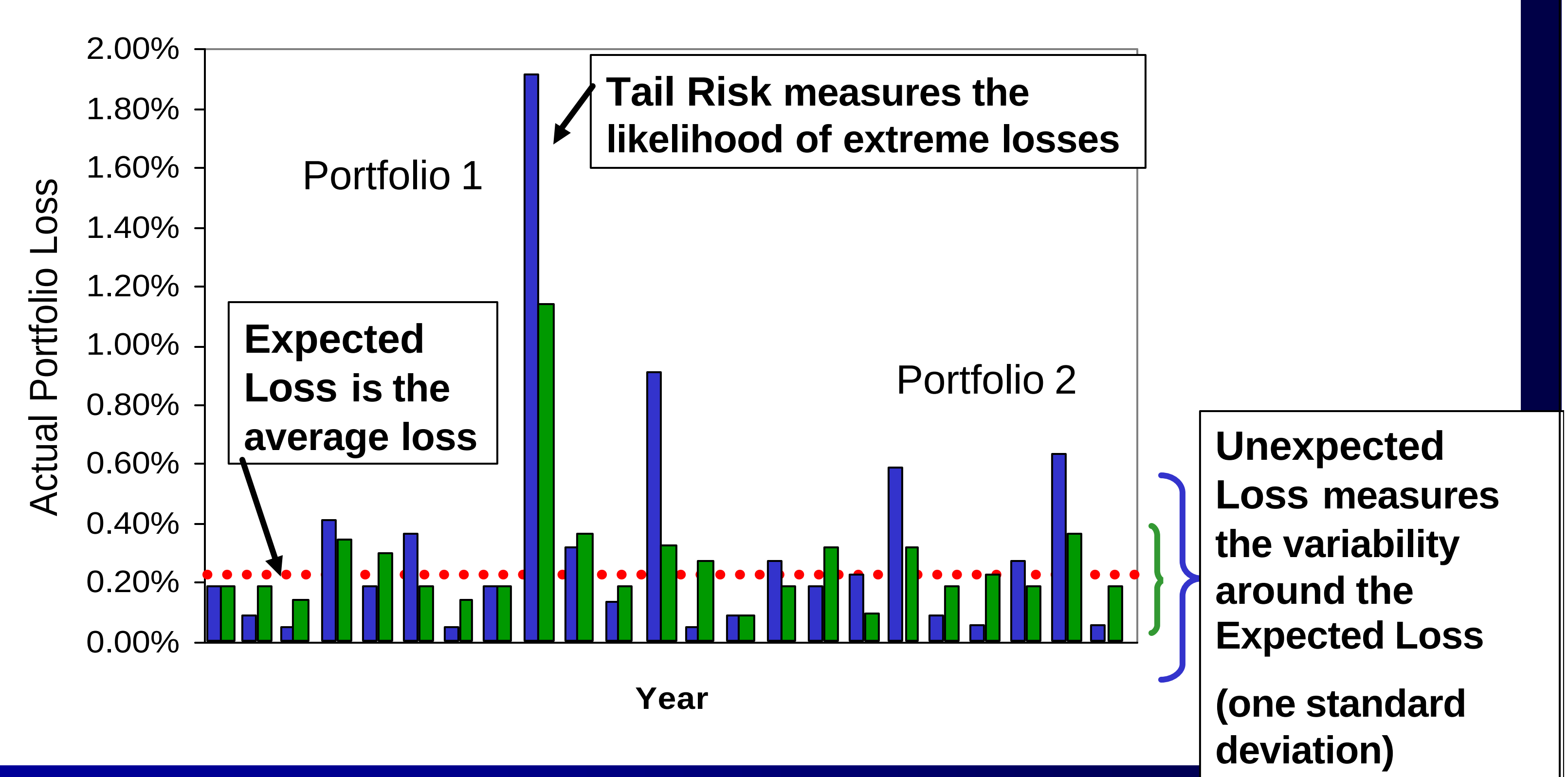
- Exposure Credit Risk is a function of recovery rates and default probabilities.
- Correlation in exposure values is a function of the default probabilities, the correlation in asset values of the obligors, and the exposure concentration



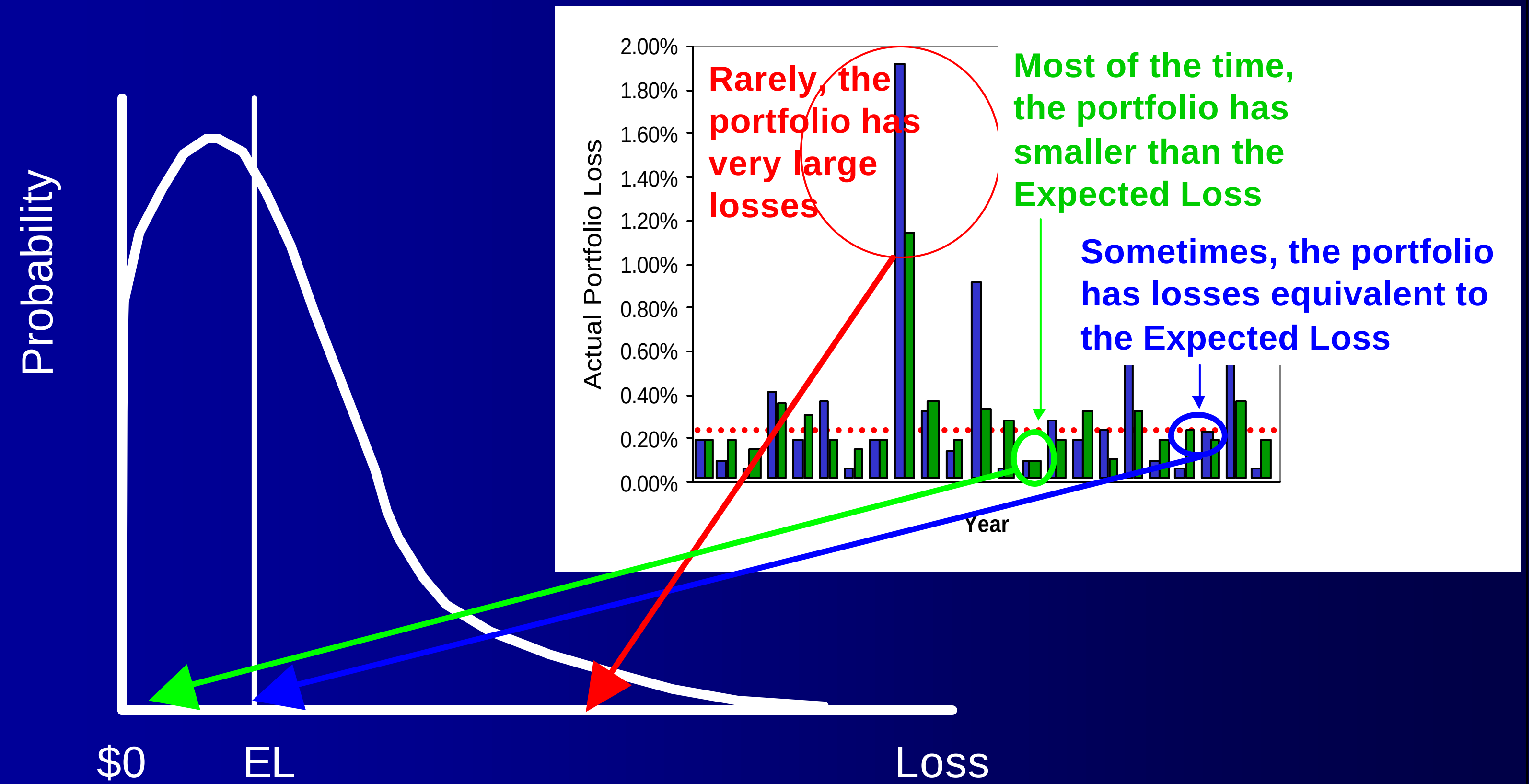
Measures of Portfolio Risk

- Portfolio risk is measured by the distribution of losses
- Three common loss measures:
  - Expected Loss (Average Loss)
  - Unexpected Loss (Volatility)
  - Tail Risk (Risk of extreme losses from the Loss Distribution)

Expected & Unexpected Loss & Tail Risk

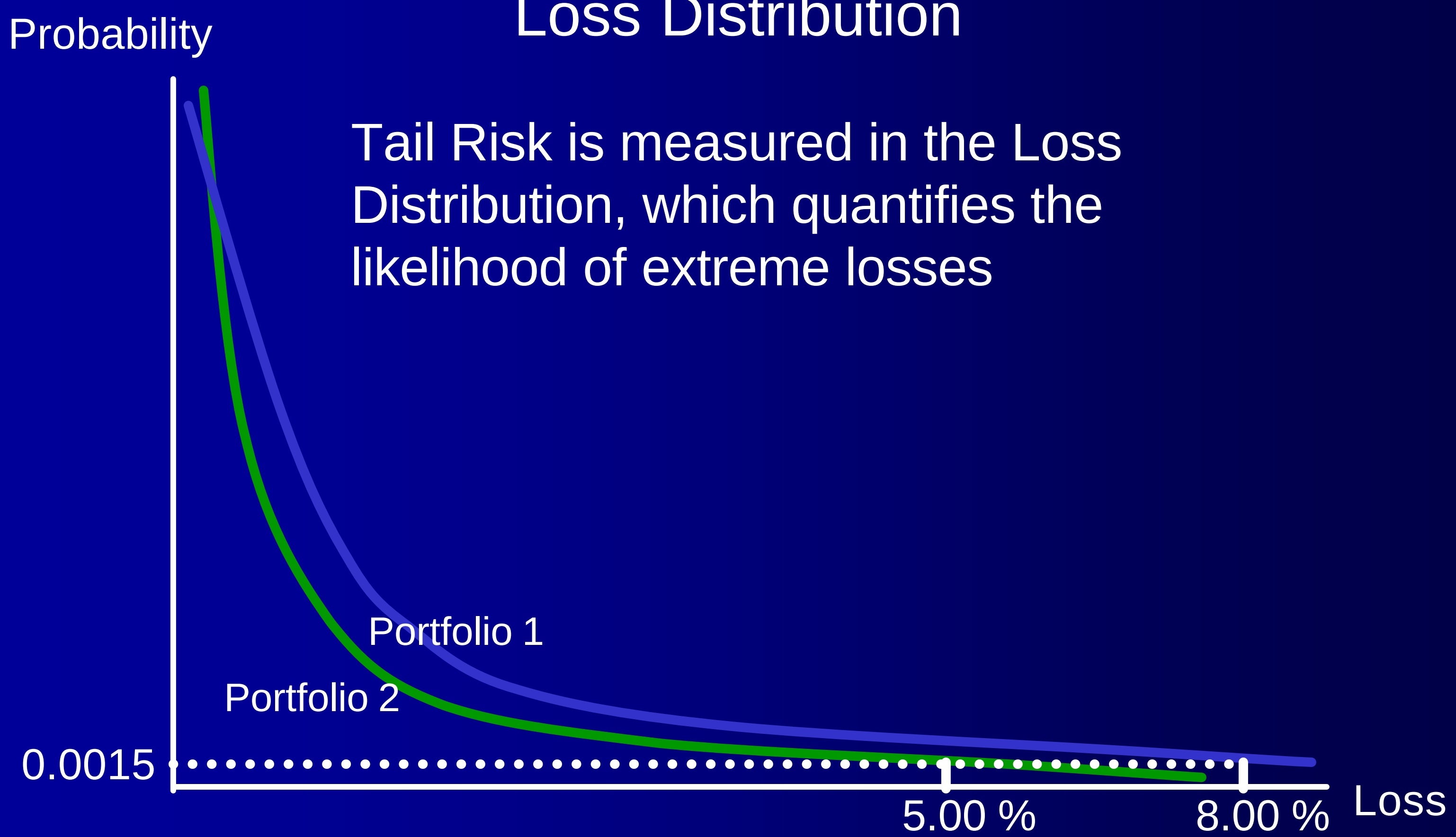


Portfolio Loss Distribution



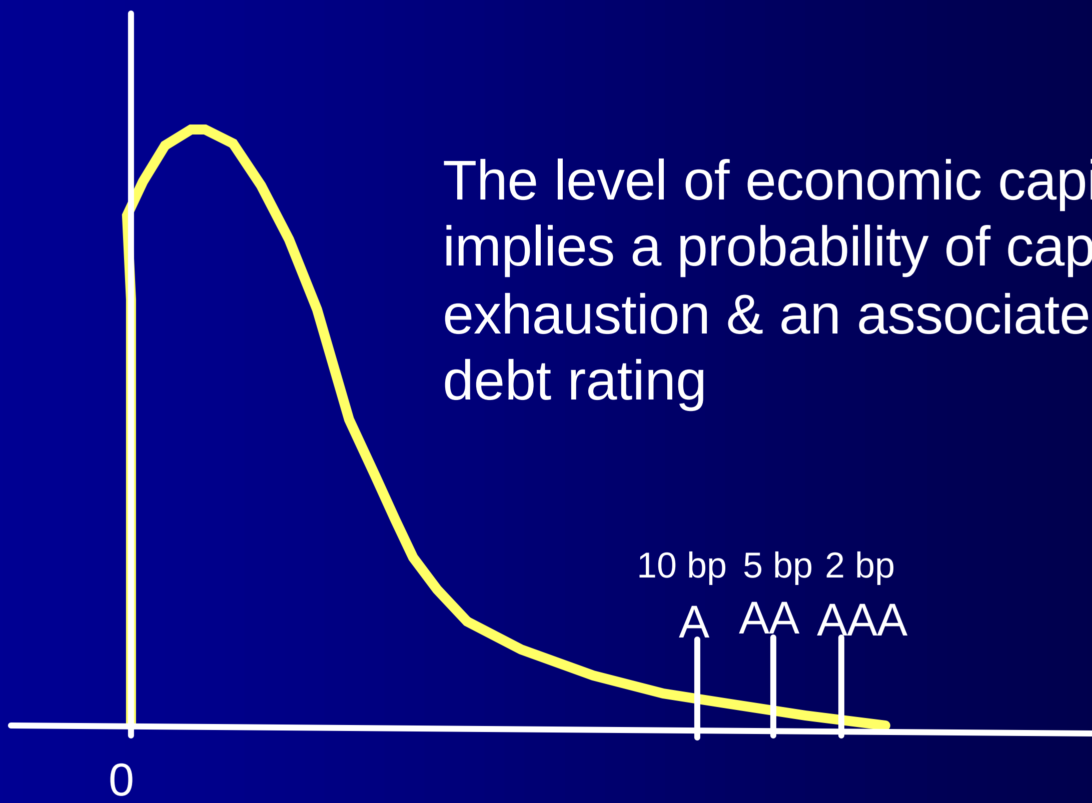
Loss Distribution

Tail Risk is measured in the Loss Distribution, which quantifies the likelihood of extreme losses

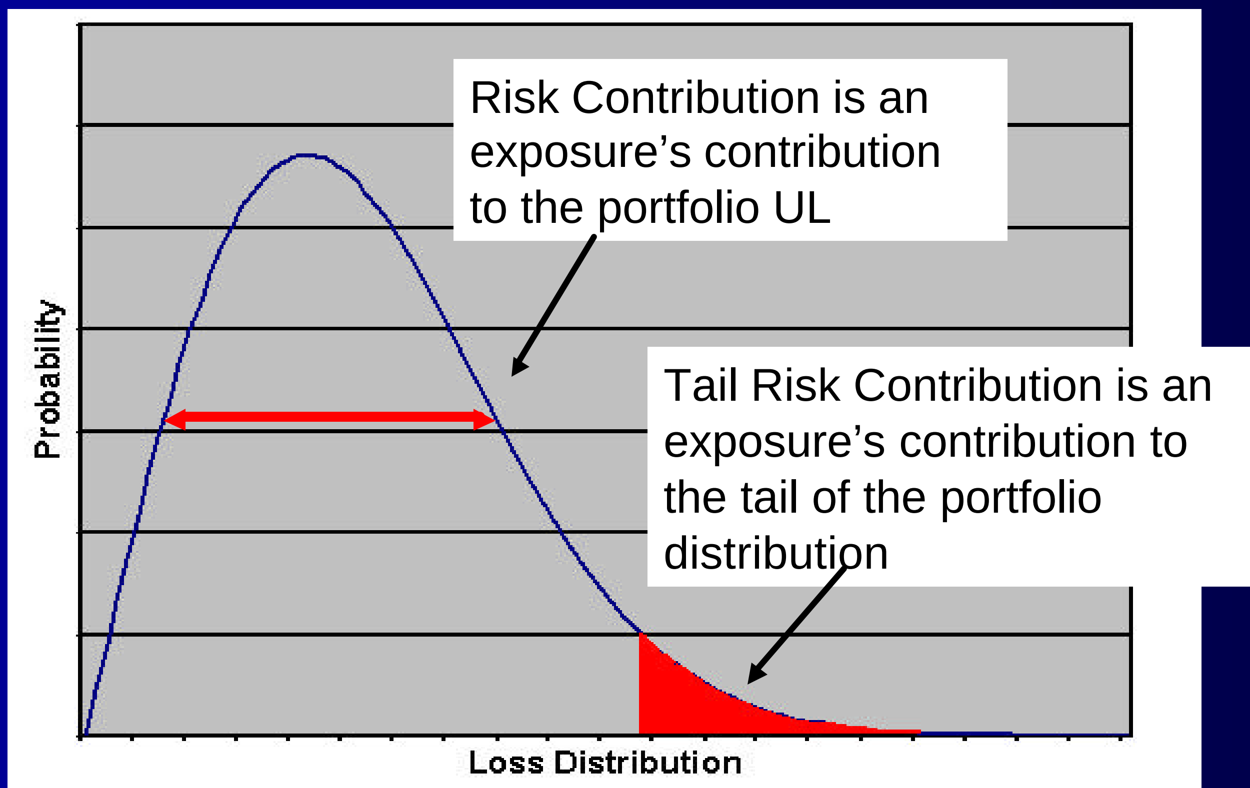


Portfolio Capital

The level of economic capital implies a probability of capital exhaustion & an associated debt rating



Risk Contribution and Tail Risk Contribution



Credit Risk Modeling and Management

A Market-Based Approach

Using Current Market Prices Observed in the Credit Derivative Market to Model Credit Risk

Robert E. Lewis
Senior Vice President & Chief Credit Officer
American International Group, Inc.

Modeling Credit Risk
A Market Pricing Approach

- Description of credit default swaps
- Credit protection buyers and sellers
- The price of these swaps reflects the market's estimate of future credit loss
- Prices also include illiquidity premium and return required to assume unexpected loss risks

Critical Model Inputs

Inputs	Actuarial Based	Market Based	
		"Mertonesque"	Credit Spread
Default Probability	Long-term historical default experience	Calculated using stock prices and accounting info	Implied from credit default swap prices
Default Correlation	None	Derived from equity correlations	Derived from equity or asset return correlations
Loss Given Default	User input – usually historical averages	User input – usually historical averages	User input – usually historical averages

Comparison with Other Modeling Approaches

- **Actuarial** – use of long term averages smooths results, producing steady and low valuations of risk
- **“Mertonesque” Approaches** – more conservative and volatile than actuarial, but dependent on indirect forecasting ability of Merton theory
- **Credit Derivative Pricing** – most volatile over time, can be extremely conservative, if supply/demand imbalance in market, and limited coverage and liquidity

An Example of Modeling Differences

Valuation Differences Modeling the Same AAA Tranche of a Recent Synthetic CDO

	Actuarial	"Mertonesque"	Credit Swaps
Bond Price	103.89	101.85	95.91