

Collateralized Debt Obligations and Their Connection to Sub-prime Mortgages

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Mealey's Subprime-Backed Securities Litigation Conference

LexisNexis Conferences

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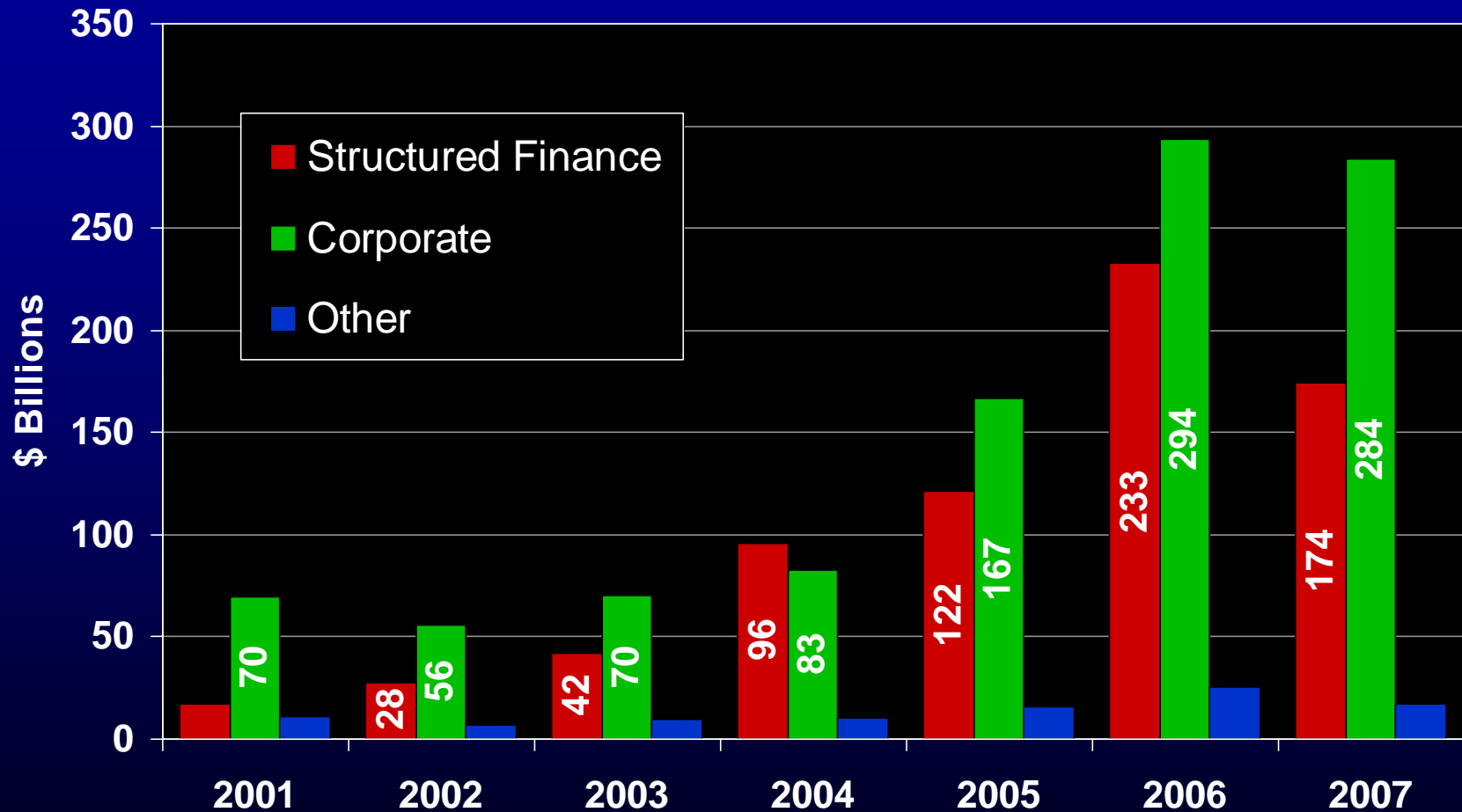
The CDO – Subprime Connection

- Moody's downgraded 1,390 tranches from 462 ABS CDOs (2007)
- S&P downgraded 1,509 tranches from 430 CDOs with subprime exposure (7/1/07 – 2/8/08)
- Moody's watchlisted 2,120 tranches from 580 ABS CDOs (2007)
- S&P watchlisted 2,441 tranches from 608 CDOs with subprime exposure (7/1/07 – 2/8/08)

The Current Situation

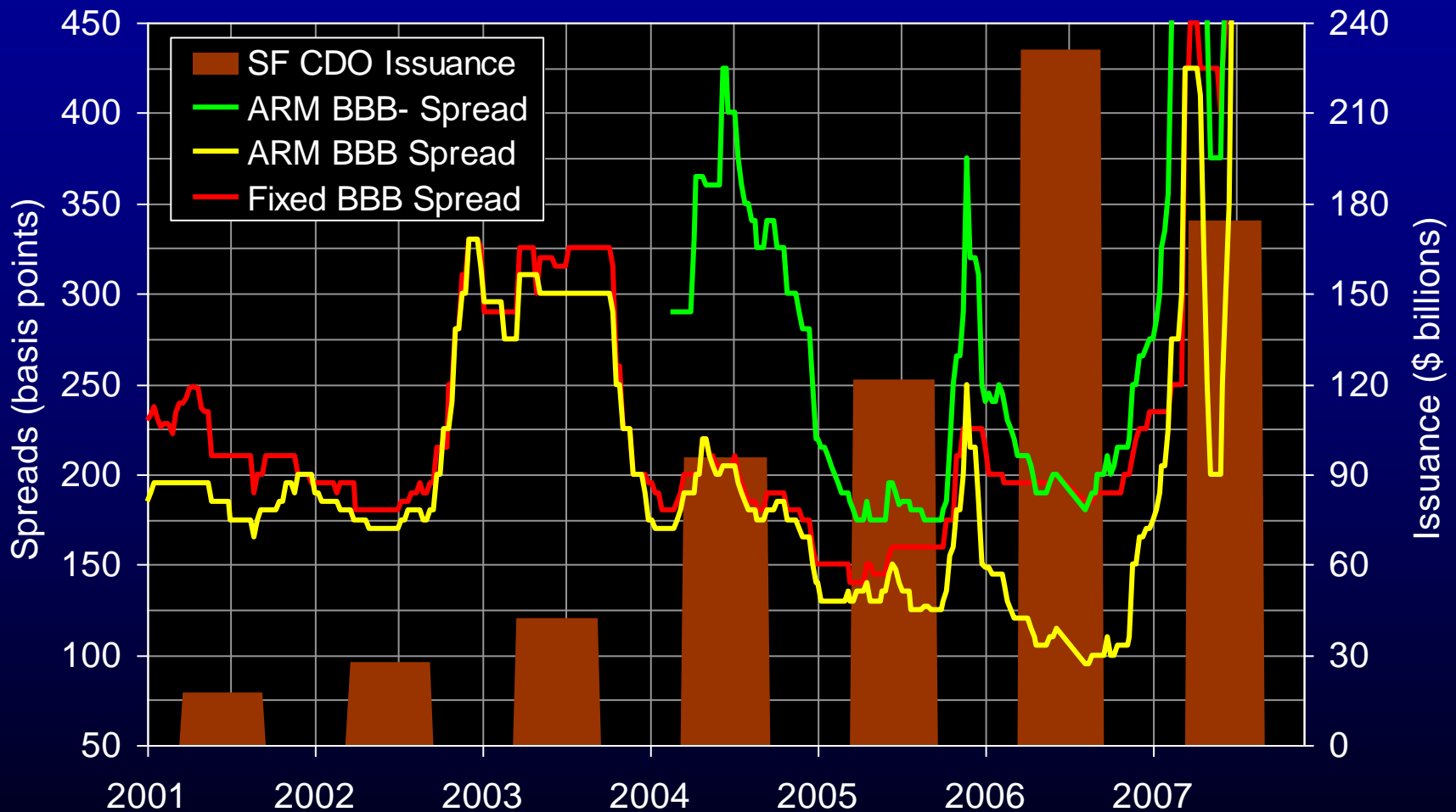
- Defaults are likely for **most** 2006-07 sub-prime mortgage ABS tranches initially rated triple-B
- Defaults are likely for **many** 2006-07 sub-prime mortgage ABS tranches initially rated single-A
- These defaults are not surprising in an environment of declining home prices
- ABS CDO tranches rated triple-A are likely to default because of concentrated exposure the triple-B and single-A layers of sub-prime mortgage deals
- CDO professionals did not expect so many securities rated at the triple-B and single-A levels to default at the same time because they had not observed it in the recent past

Global CDO Funded Issuance Volume



Source: JPMorgan

Home Equity ABS Yield Spreads over Swaps/LIBOR and Annual Structured Finance CDO Funded Issuance Volume

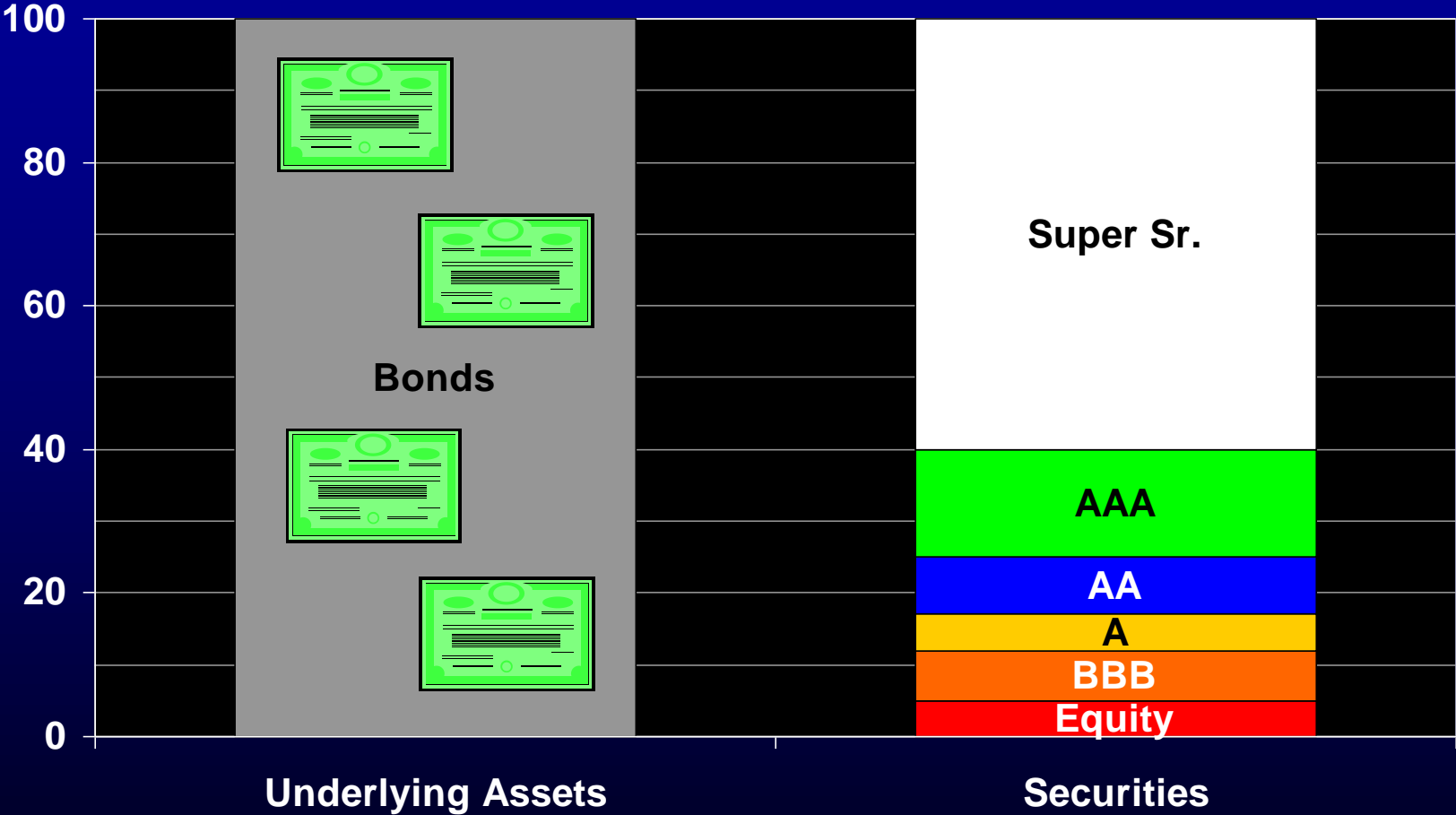


Source: JPMorgan

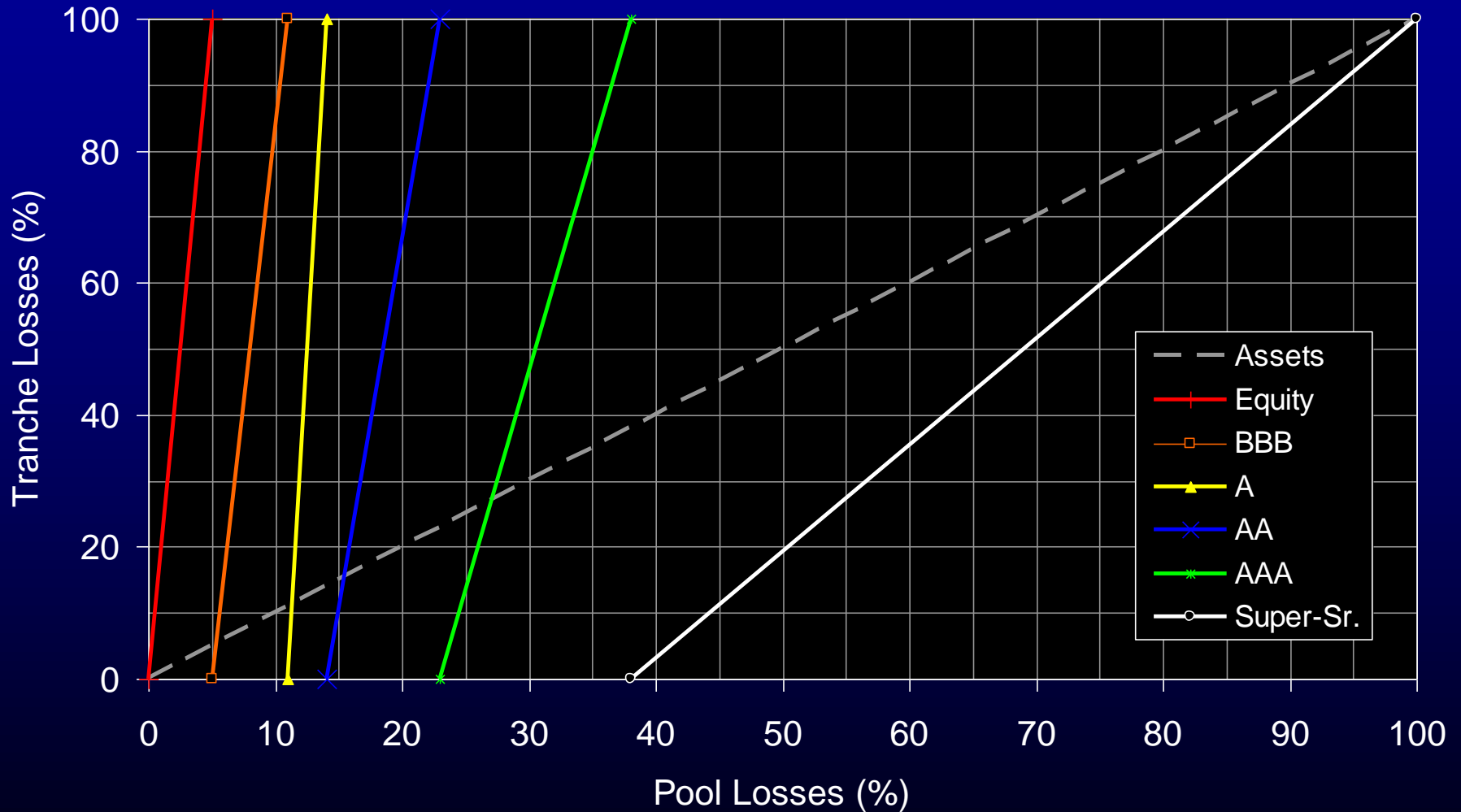
CDO Highlights

- CDO is like a mutual fund that sells debt and equity
- Early CDOs were backed by portfolios of junk bonds
- Later CDOs emphasized corporate loans or ABS
- Diversification of the underlying portfolio is the key to understanding the risk in a CDO
- Portfolios are actively managed, subject to rules
- CDOs have multi-layered capital structure with several debt "tranches"

Basic CBO Structure – Tranching



CDO Tranching Works Like ABS Tranching



Gearing/Leverage in Everyday Life

(GM 4L65-E)



1st: 3.06:1

2nd: 1.63:1

3rd: 1.00:1

4th: 0.70:1

Structure – Additional Features

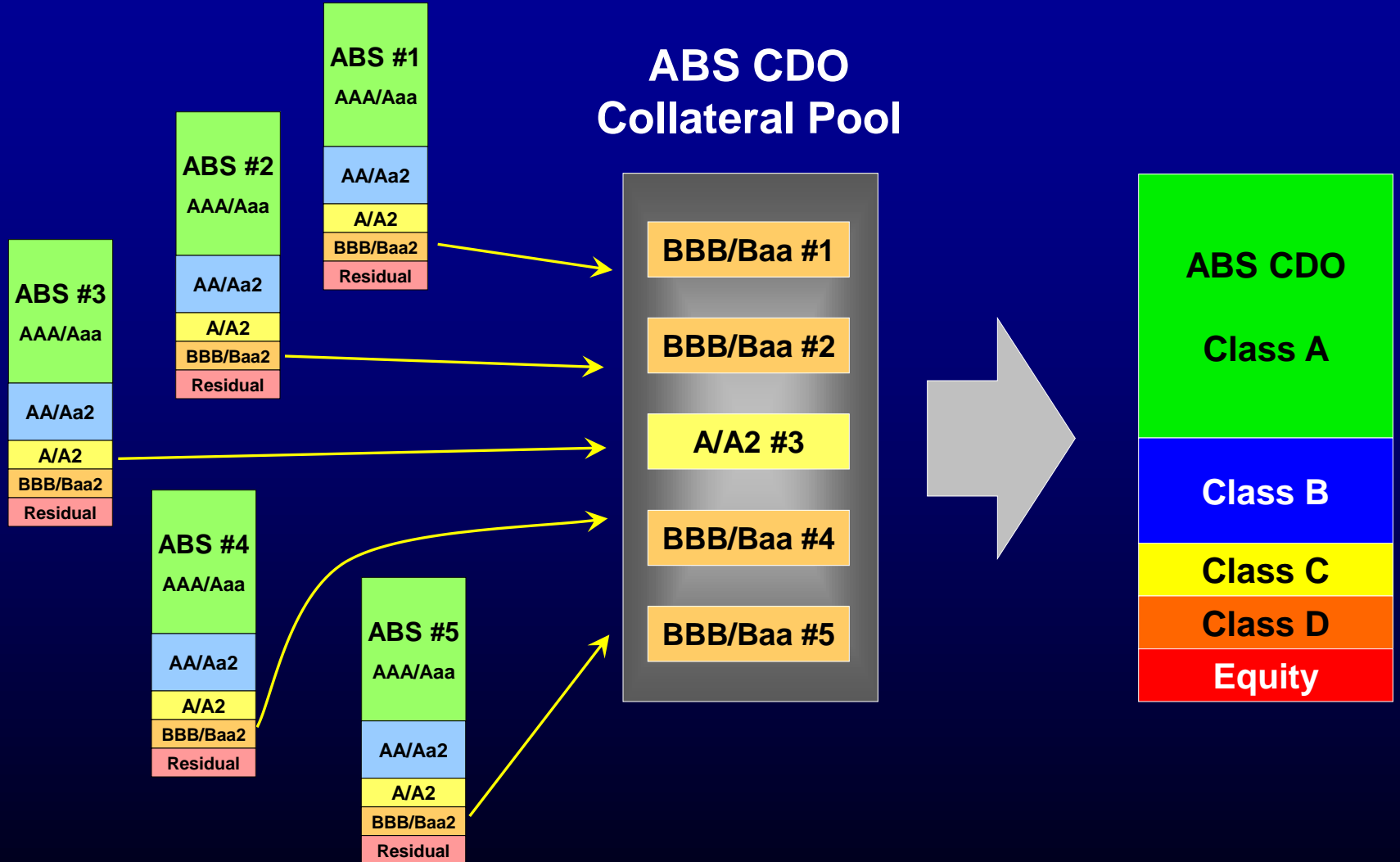
- CDO lifecycle
 - Ramp-up phase
 - Revolving phase
 - Amortization phase
- Waterfall
 - Pre-2005: mostly sequential
 - Post-2005: mostly pro rata (sometimes with toggle)
- Collateral quality tests (eligibility)
- Performance tests
 - Overcollateralization (OC) – par haircuts
 - Interest coverage (IC)
- Events of Default

Vocabulary for CDOs of ABS

■ Synonyms

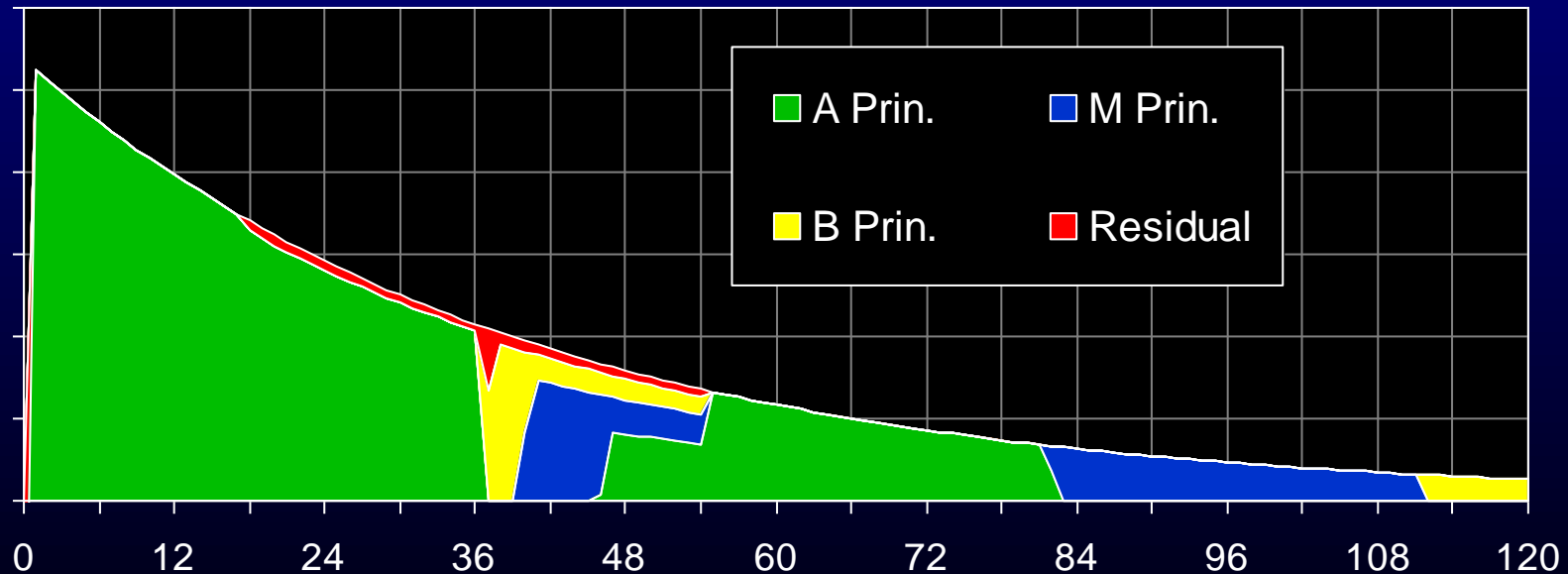
- CDO of ABS
- ABS CDO
- structured finance CDO
- SF CDO
- Multi-sector CDO

ABS CDO – Pool of Subordinate ABS

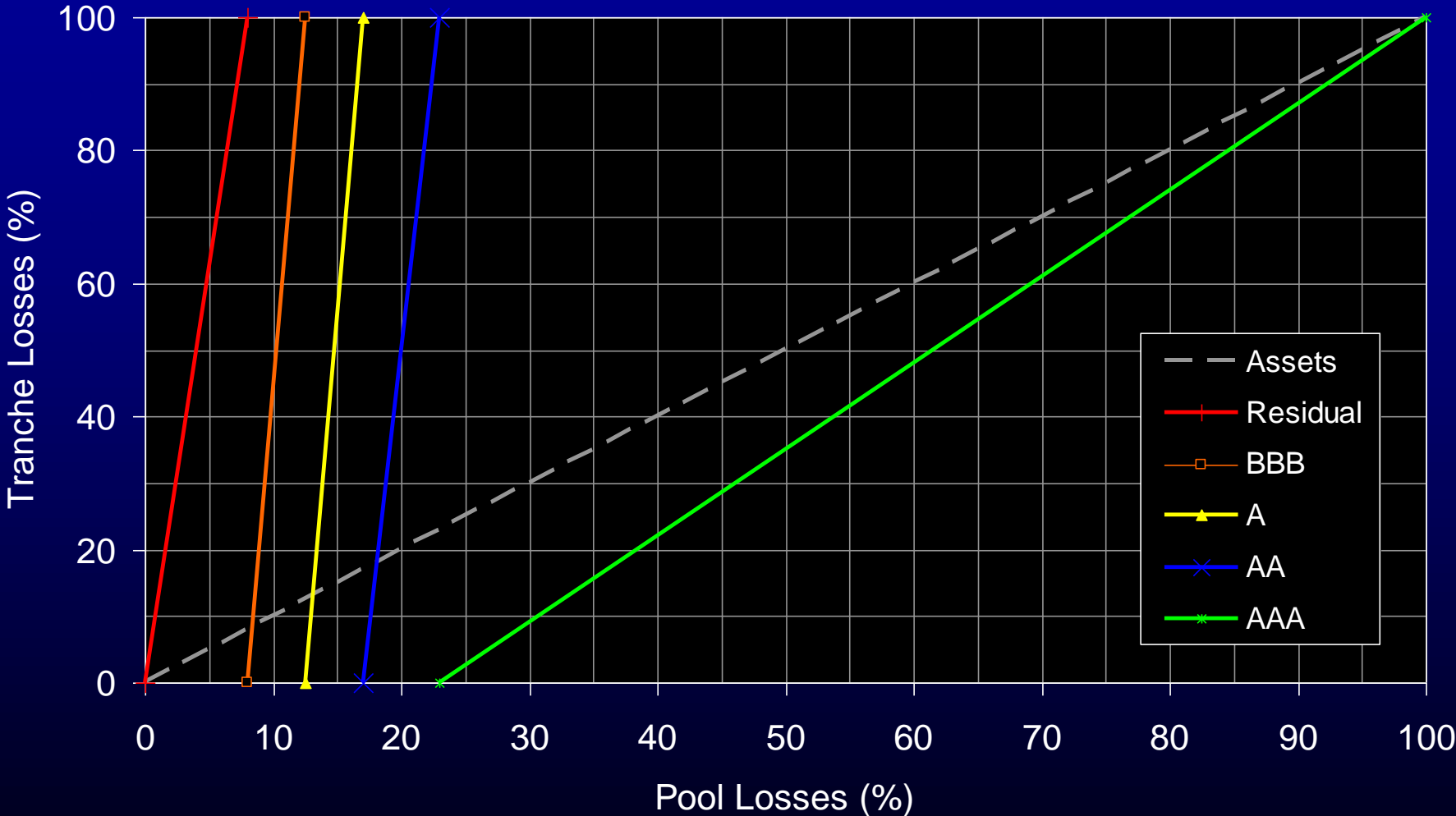


HEL ABS Deal Structure – Cash Flow

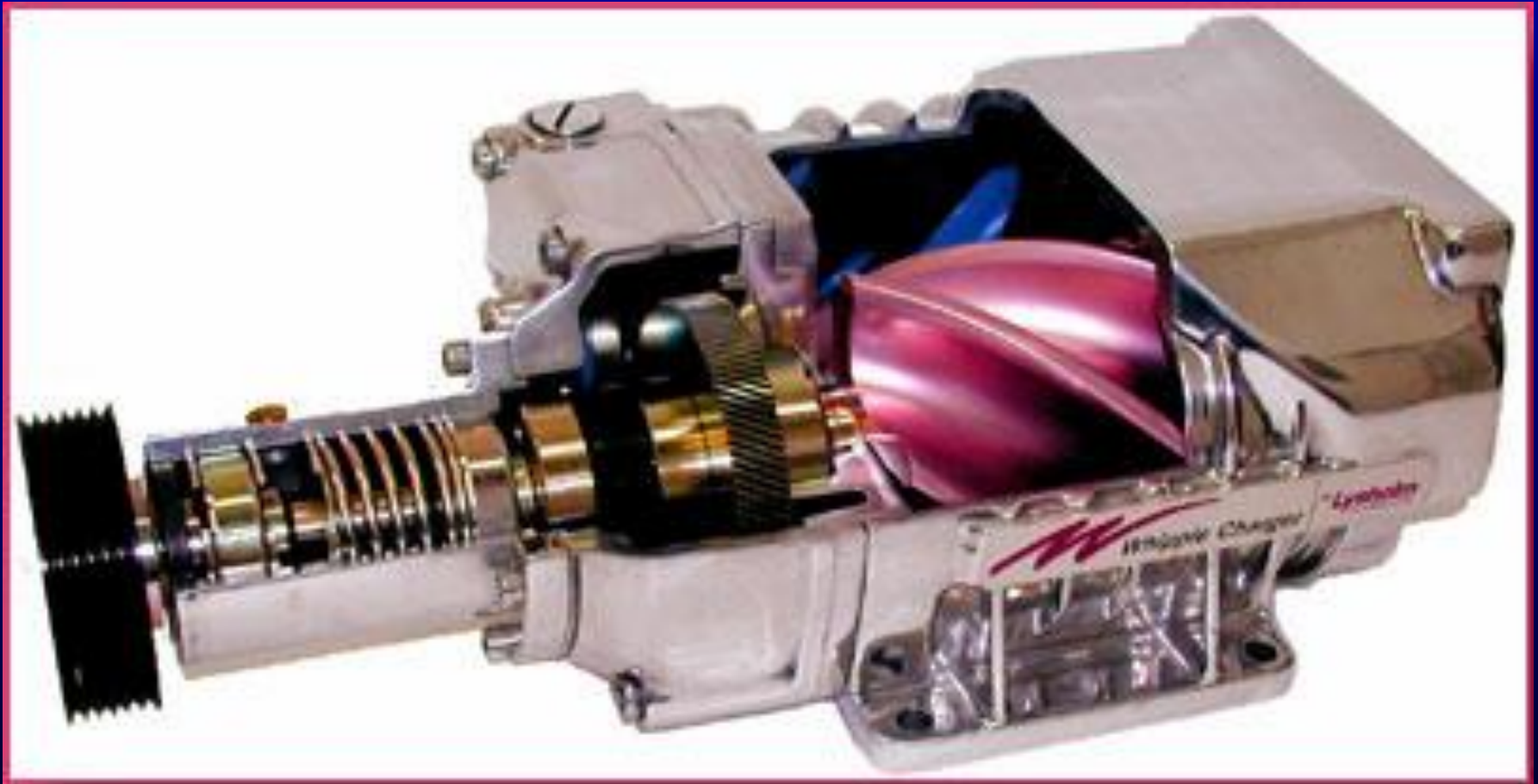
- Senior-sub, O/C (not like prime MBS six pack)
- Sequential / pro-rata / reverse sequential, with triggers
- Spreadsheet examples



HEL ABS Deal Structure – Tranching

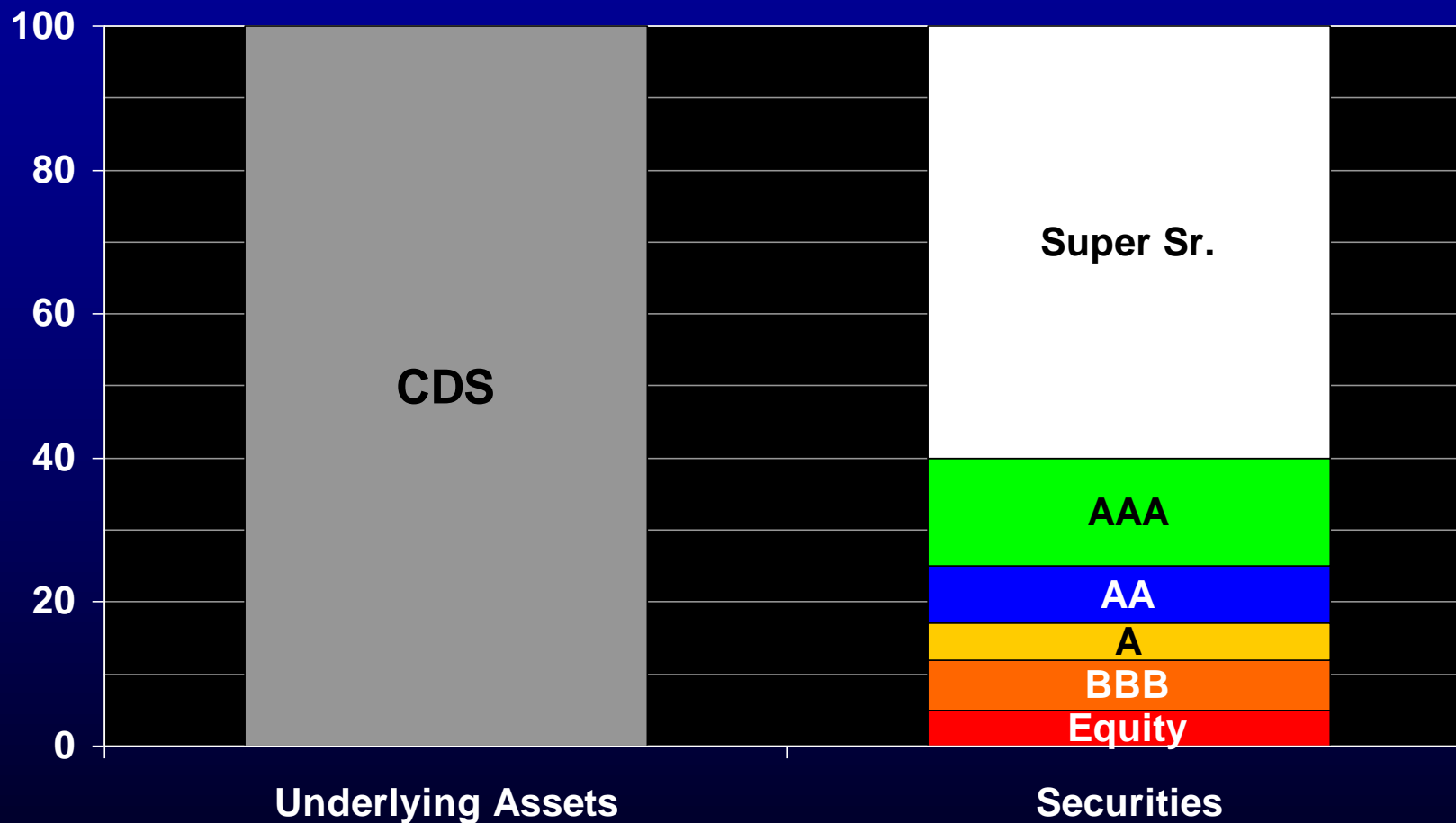


Tranching Twice Boosts Leverage

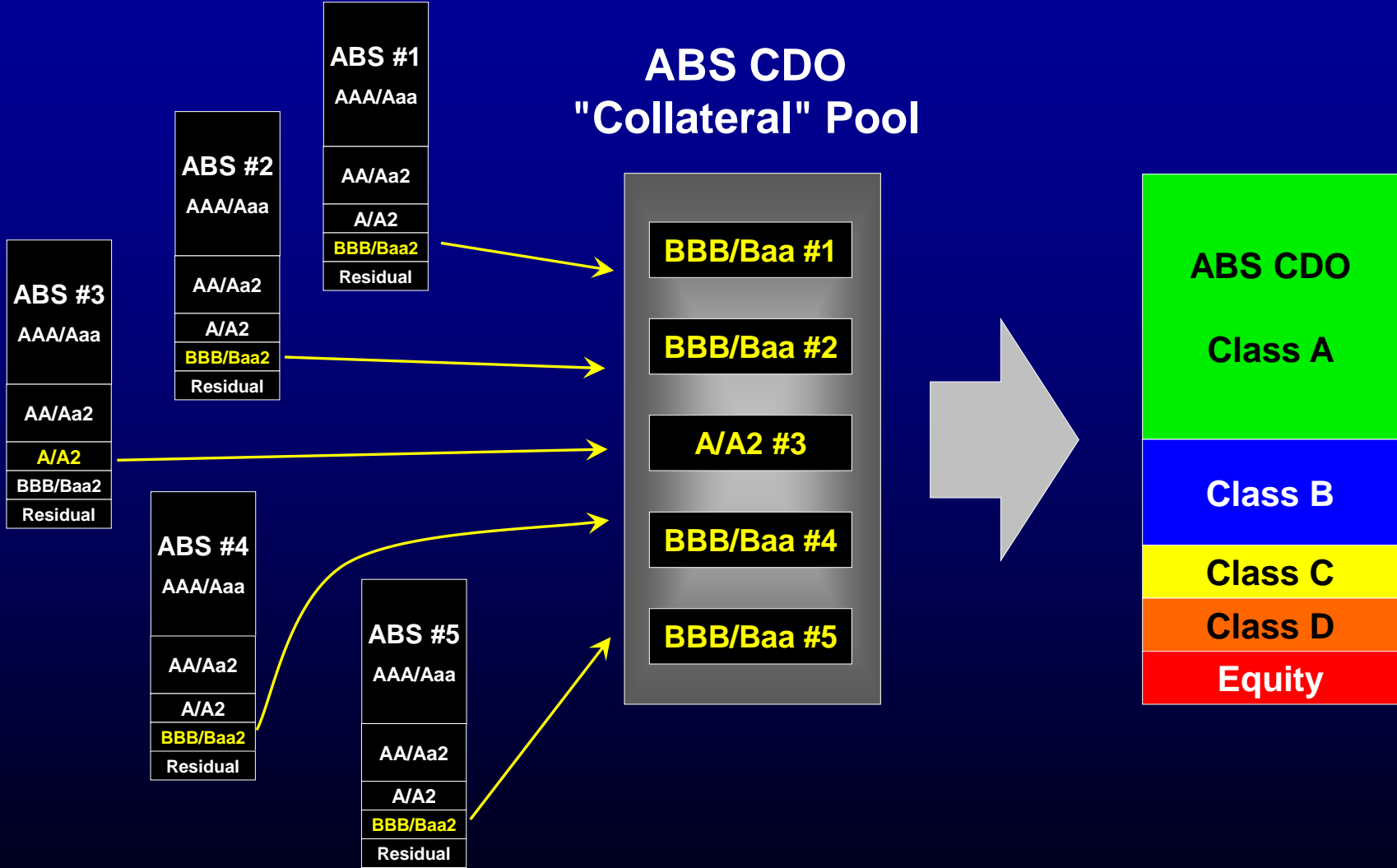


Whipple Twin Screw Supercharger

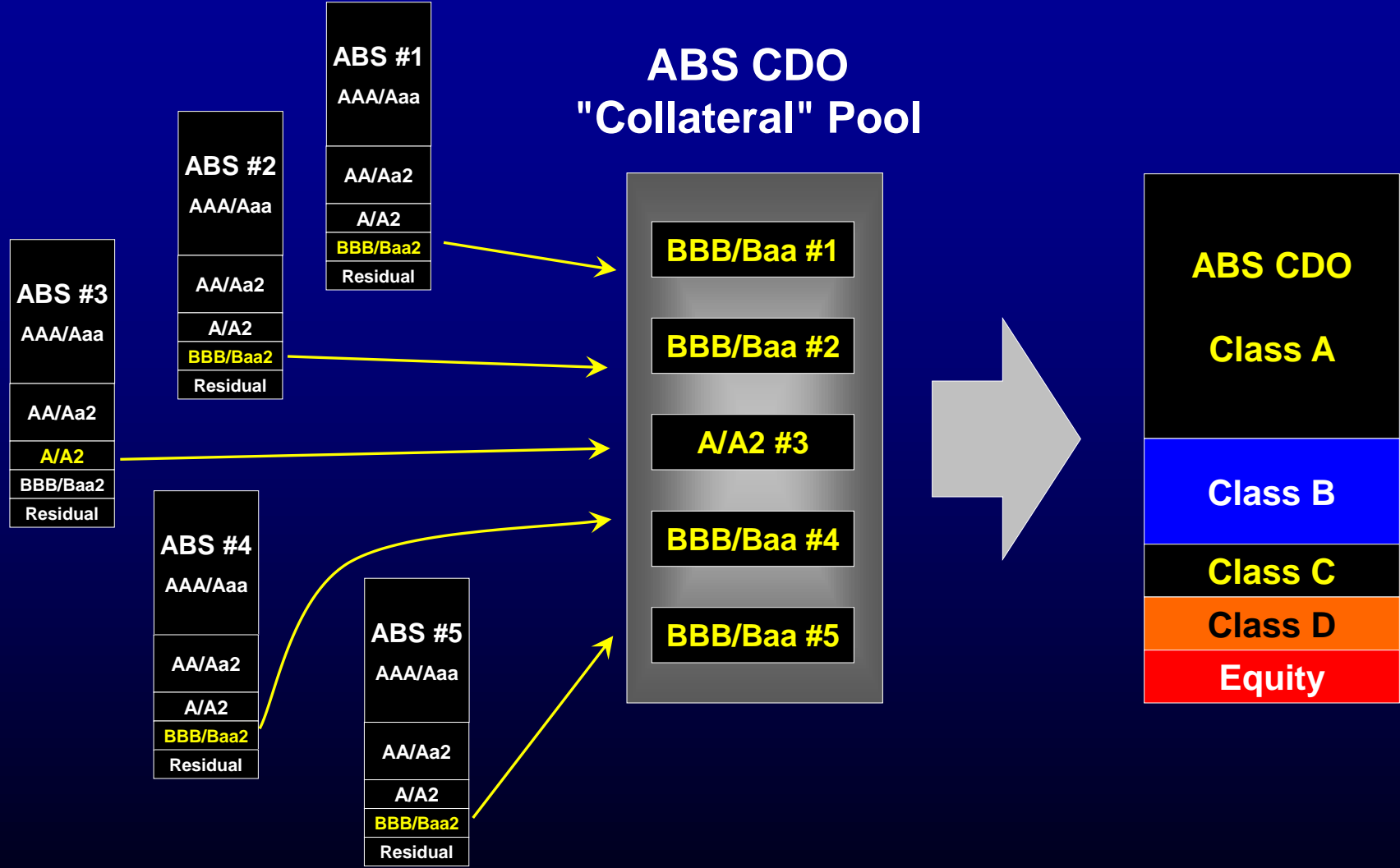
Synthetic CDO Structure – CDS Replace Bonds



ABS CDO – Synthetic Underlying



ABS CDO – Synthetic/Synthetic



Close-up on Events of Default

- OC test failures from collateral downgrades
- Who gets to decide?
- What are the choices?
- References:
 - Jordan P., et al., *S&P Offers Guidance on Treatment of CDOs with O/C Events of Default; Two Ratings on Watch Neg*, S&P (10/31/07)
 - Kharnak, L., et al., *Impact of Subprime Downgrades on OC-Linked Events of Default in CDOs*, Moody's (11/1/07)
 - Liocce, S., *Understanding the Consequences of ABS CDO Events of Default Triggered by Loss of Overcollateralization*, Moody's (1/7/08)

Valuation – Monte Carlo Simulation Modeling

■ Key Variables

- Probability of default
- Recovery rate
- Correlation
- Price

- Given a market price for a tranche and a specified correlation model, we can calculate the "implied" correlation of default risk among the reference assets
- Give an assumed level of correlation and a specified correlation model, we can calculate the theoretical price of a tranche

Pricing Challenges

- Estimating probabilities of default
 - generally estimated from individual CDS spreads...
 - ...but the market is not always “right”
 - dealers seek widest spreads in each rating category
- Oversimplifying correlation
 - time-varying
 - many interdependencies
- Estimating recoveries

Pure Theory: Model the Universe with Just Six Numbers

- $N = 10^{36}$ – the ratio of the strength of the electrical force to the gravitational force
- $\epsilon = 0.007$ – the proportion of mass converted to energy when hydrogen fuses to form helium; how firmly atomic nuclei bind together
- $\Omega \approx 0.3$ – the ratio of the total mass of the universe to the mass that would be required to cause eventual gravitational collapse (i.e., density)
- $\lambda \approx 0.7$ – vacuum energy; "anti-gravity" force that drives expansion of the universe
- $Q = 10^{-5}$ – ratio of energy required to break-up large scale structures to the rest mass energy of those structures; describes the degree of homogeneity of the universe
- $D = 3$ – number of spatial dimensions; allows for crucial inverse square relationships of force over distance

Source: Rees, M., [Just Six Numbers](#), Basic Books, 2001.

Rating Agency Views

- Monte Carlo simulation-based approaches
- Assumptions
 - default frequencies
 - recovery rates
 - correlations
- Factor-based correlation models
 - Systems for assigning pair-wise correlations
- Software tools:
 - S&P: CDO Evaluator™ 3.3
 - Moody's: CDOROM™
 - Fitch: VECTOR 3.0

S&P Methodology Evolution (1)

- Grossman, R., et al., "High Yield Cash Flow Criteria," S&P CreditWeek, p. 19 (16 May 1988)
 - Initial move into rating CBOs of junk bonds
 - Rules developed from analysis of hypothetical historical pool
- Global CBO/CLO Criteria (1999)
 - No explicit treatment of correlation; instead, focus on "diversification" and "risk concentration"
 - Baseline industry concentration of 8%
 - Excess concentrations addressed by higher default rate assumption

S&P Methodology Evolution (2)

- Bergman, S., "CDO Evaluator Applies Correlation and Monte Carlo Simulation to the Art of Determining Credit Quality" (12 Nov 2001)
 - Introduction of Monte Carlo simulation approach through CDO Evaluator™
 - Corporate correlation: 30% intra-industry, 0% inter-industry
 - 0% inter-industry assumption sharply criticized (e.g., Cifuentes A., and N. Chen, "The Young and the Restless: Correlation Drama at the Big Three Rating Agencies," Wachovia Securities (22 Feb 2005))
 - ABS correlation: 30% intra-sector, 10% inter-sector
 - Produced lower stressed default rates for ABS than the earlier Risk Tabulator model
- "Global Cash Flow and Synthetic CDO Criteria" (21 Mar 2002)
 - Notable emphasis on synthetic collateral
 - No change re default probabilities or treatment of correlations

S&P Methodology Evolution (3)

- "Criteria For Rating Synthetic CDO Transactions" (Sep 2003)
 - 65 pages
 - Heavy focus on documentation for synthetics
 - Specific treatment of synthetic CDOs of ABS (pp. 57-58)
 - credit events
 - settlement mechanisms (i.e., physical and cash)
 - recoveries

S&P Methodology Evolution (4)

- Parisi, F., "Loss Correlations Among U.S. Consumer Assets" (Feb 2004)

Results: Loss Correlations by SF Asset Type Combinations (with 95% confidence intervals)				
Asset	Mfd. Hsg	Bank Cards	Auto Loans	RMBS
Mfd. Hsg.	0.55 (0.518, 0.568)			
Bank Cards	0.22 (0.208, 0.233)	0.17 (0.162, 0.179)		
Auto Loans	0.37 (0.356, 0.390)	0.21 (0.201, 0.219)	0.48 (0.464, 0.492)	
RMBS	0.13 (0.124, 0.133)	0.07 (0.069, 0.076)	0.18 (0.172, 0.185)	0.06 (0.061, 0.064)

S&P Methodology Evolution (5)

- Bradley, E., et al., "CDO Spotlight: Synthetic CDO of ABS Documents Evolving Towards a Standard But Nuances Remain" (26 Apr 2005)
 - Published a few months before the release of the first ISDA forms for CDS of ABS
 - Survey of documentation features
 - Identified varying practices in credit events and valuation concepts for settlements
 - No mention of PAUG structures

S&P Methodology Evolution (6)

- Gilkes, K., N. Jobst, and B. Watson, "CDO Evaluator Version 3.0: Technical Document" (19 Dec 2005)
 - Replaces the assumption of 0% inter-industry correlation for corporate bonds
 - Produced watchlisting of 35 tranches from 18 synthetic CDO deals
 - 14 of the 18 deals carried ratings only from S&P
 - rating shopping issue
 - Reduced assumed intra-industry corporate correlation to 15%
 - Adopts different default rate assumptions for different types of instruments

S&P Methodology Evolution (7)

Default Probabilities Used in S&P CDO Evaluator 3.2 (percent)										
	AAA	AA+	AA	AA-	A+	A	A-	BBB+	BBB	BBB-
Three-Year										
ABS	0.008	0.014	0.042	0.053	0.061	0.088	0.118	0.340	0.488	0.881
Corporate	0.016	0.027	0.085	0.102	0.138	0.172	0.262	0.701	1.162	2.899
CDO	0.030	0.050	0.135	0.166	0.212	0.263	0.396	0.850	1.405	3.415
Five-Year										
ABS	0.043	0.066	0.144	0.185	0.216	0.269	0.389	0.745	1.255	1.890
Corporate	0.061	0.098	0.219	0.276	0.371	0.459	0.686	1.391	2.323	5.179
CDO	0.118	0.182	0.356	0.452	0.578	0.709	1.020	1.704	2.812	6.046
Seven-Year										
ABS	0.116	0.168	0.315	0.407	0.468	0.576	0.798	1.357	2.203	3.000
Corporate	0.144	0.224	0.420	0.543	0.719	0.887	1.287	2.261	3.672	7.434
CDO	0.285	0.420	0.701	0.897	1.128	1.368	1.883	2.792	4.443	8.635
Within each time horizon, cells with similar values are shaded in the same color.										

Moody's Methodology Evolution (1)

- Lucas, D., N. Kirnon, and L. Moses, "Rating Cash Flow Transactions Backed by Corporate Debt" (Mar 1991)
 - Original methodology
 - Based on "WARF" and "Diversity Score"
 - Credit enhancement from tables
 - 32-industry classifications
- Backman, A. and G. O'Connor, "Rating Cash Flow Transactions Backed by Corporate Debt, 1995 Update" (7 Apr 1995)
 - Essentially the same methodology
 - Addressed additional situations (estimated and implied ratings)

Moody's Methodology Evolution (2)

Moody's Rating Factors			
Rating	Factor	Rating	Factor
Aaa	1	Baa3	610
Aa1	10	Ba1	940
Aa2	20	Ba2	1,350
Aa3	40	Ba3	1,780
A1	70	B1	2,220
A2	120	B2	2,720
A3	180	B3	3,490
Baa1	260	Caa	6,500
Baa2	360	Ca	10,000

Moody's Diversity Scoring	
Firms in Same Industry	Diversity Score
1	1.00
2	1.50
3	2.00
4	2.33
5	2.67
6	3.00
7	3.25
8	3.50
9	3.75
10	4.00
>10	Case-by-case

Source: Backman, A. and G. O'Connor, "Rating Cash Flow Transactions Backed by Corporate Debt, 1995 Update" (7 Apr 1995)

Moody's Methodology Evolution (3)

- Cifuentes A. and G. O'Connor, "The Binomial Expansion Method Applied to CBO/CLO Analysis" (13 Dec 1996)
 - Introduced "binomial expansion technique"
 - assumptions: default probability, diversity score, recovery rate
 - Formula for calculation of expected loss

$$P_j = \frac{D!}{j!(D-j)!} p^j (1-p)^{D-j}$$

p = average probability of default

D = diversity score

j = no. of defaults in j^{th} scenario

P_j = probability of scenario j

E_j = expected loss in scenario j

$$\text{Expected Loss} = \sum_{j=1}^D P_j E_j$$

Moody's Methodology Evolution (4)

- Cifuentes, A. and C. Wilcox, "The Double Binomial Method and Its Application to a Special Case of CBO Structures" (20 Mar 1998)
 - Adaptation of BET to special cases
 - DBM offers better view of certain pools such as 80% emerging market debt combined with 20% U.S. high yield bank loans
 - Difference between BET and DBM is important only for low diversity pools ($D < 10$) composed of two distinct asset groups (barbelled assets)
 - Example: two uncorrelated groups of assets with markedly different average properties

Moody's Methodology Evolution (5)

- Gluck, J. and H. Remeza, "Moody's Approach to Rating Multisector CDOs" (15 Sep 2000)
 - Introduced "alternative diversity score methodology" for assets with correlated default risk

$$D = \frac{\left(\sum_{i=1}^n p_i F_i \right) \left(\sum_{i=1}^n q_i F_i \right)}{\sum \sum \rho_{ij} \sqrt{p_i q_i p_j q_j F_i F_j}} \quad \text{and} = \frac{n}{1 + (n-1)\rho} \quad \text{if } \rho_{ij} = \rho$$

- Correlation parameters disseminated confidentially
- Covered structured finance assets in addition to corporates
- Addressed geographic, servicer, and vintage concentrations

Moody's Methodology Evolution (6)

- Tolk, J., "Understanding the Risks in Credit Default Swaps" (16 Mar 2001)
 - Initial focus on ISDA credit events for corporates
 - Comparison to Moody's default definition
 - issue of "soft" (non-default) credit events
 - Valuation and settlement
 - Brief mention of non-corporate reference credits
- Yoshizawa, Y., "Moody's Approach to Rating Synthetic CDOs" (29 July 2003)
 - Focus on multiple binomial method
 - Par per diversity test
 - Soft credit event update (stress default probabilities 5% to 12.5%)

Moody's Methodology Evolution (7)

- Witt, G., "Moody's Correlated Binomial Default Distribution" (10 Aug 2004)
 - Alternative to diversity score for capturing correlation
 - Assumes single default correlation between all asset pairs
 - Also assumes default prob., recovery rate, & no. of assets
 - Closed form solution but computationally hard
- Fu, Y., et al., "Moody's Revisits Its Assumptions Regarding Corporate Default (and Asset) Correlations for CDOs (30 Nov 2004)"
 - Inter-industry asset correlation 3%
 - Intra-industry asset correlation 15%
 - telecom and utilities 20%
 - chemicals, electronics, retail, textiles 10%



Moody's Methodology Evolution (8)

- Toutain, O., et al., "Moody's Revisits Its Assumptions Regarding Structured Finance Default (and Asset) Correlations for CDOs (27 July 2005)
 - "Tree" approach to sector risk: global, meta, broad, narrow
 - Add-ons for regional, vintage, and "key agent" effects
 - Complicated...
- Xie, M. and G. Witt, "Moody's Modeling Approach to Rating Structured Finance Cash Flow CDO Transactions" (26 Sep 2005)
 - Use CBM with single correlation parameter from CDOROM™
 - Assumed pair-wise correlations generate the single correlation parameter within CDOROM™
 - simulates losses
 - applies moment matching scheme to match skew of CBM loss distribution to that of CDOROM™ simulated loss distribution

Moody's Methodology Evolution (9)

- Kim, T., "Moody's Initial Views on the Dealer Form of Confirmation for Pay-As-You-Go Derivative Transactions" (21 Jun 2006)
- Bharwani, P., "Moody's Approach to Rating Collateralized Debt Obligations with Pay-As-You-Go Credit Default Swaps" (13 Nov 2006)
 - Objects to appraisal reduction as writedown
 - Strongly objects to implied writedowns but allows as floating payment event if certain conditions satisfied
 - Rating downgrade to Caa OK w/ physical settlement only
 - Ca cash settle OK after six monts
 - C cash settle OK immediately
 - Counterparty risks
 - Amendments

Rating Agency Views – Reprise

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- Assumptions
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Non-Rating Agency Approaches

- Dealers: trying to fit ABS CDOs into the simulation-based models used for corporate CDOs
 - Try to derive "implied" correlations from market prices
 - Some believed that TABX trading would provide implied correlations for sub-prime mortgage ABS
- Investors: 3 main approaches
 - Rely on ratings
 - Macro view, manager trades
 - Scenario analysis, Intex-based

My View: A Blended Approach

- Static pools and resecuritizations: main tool should be scenario analysis
- Managed deals: combine Monte Carlo simulation with scenario analysis
 - Examine full distribution of outcomes from simulations and think in terms of the "**margin of error**" or confidence interval
 - Apply scenario analysis or "**stress testing**" to compare performance under "benchmark" cases and to identify key stress levels

Model Risk

- Is our model working?
- When will it stop working?
- How can we tell when it stops working?

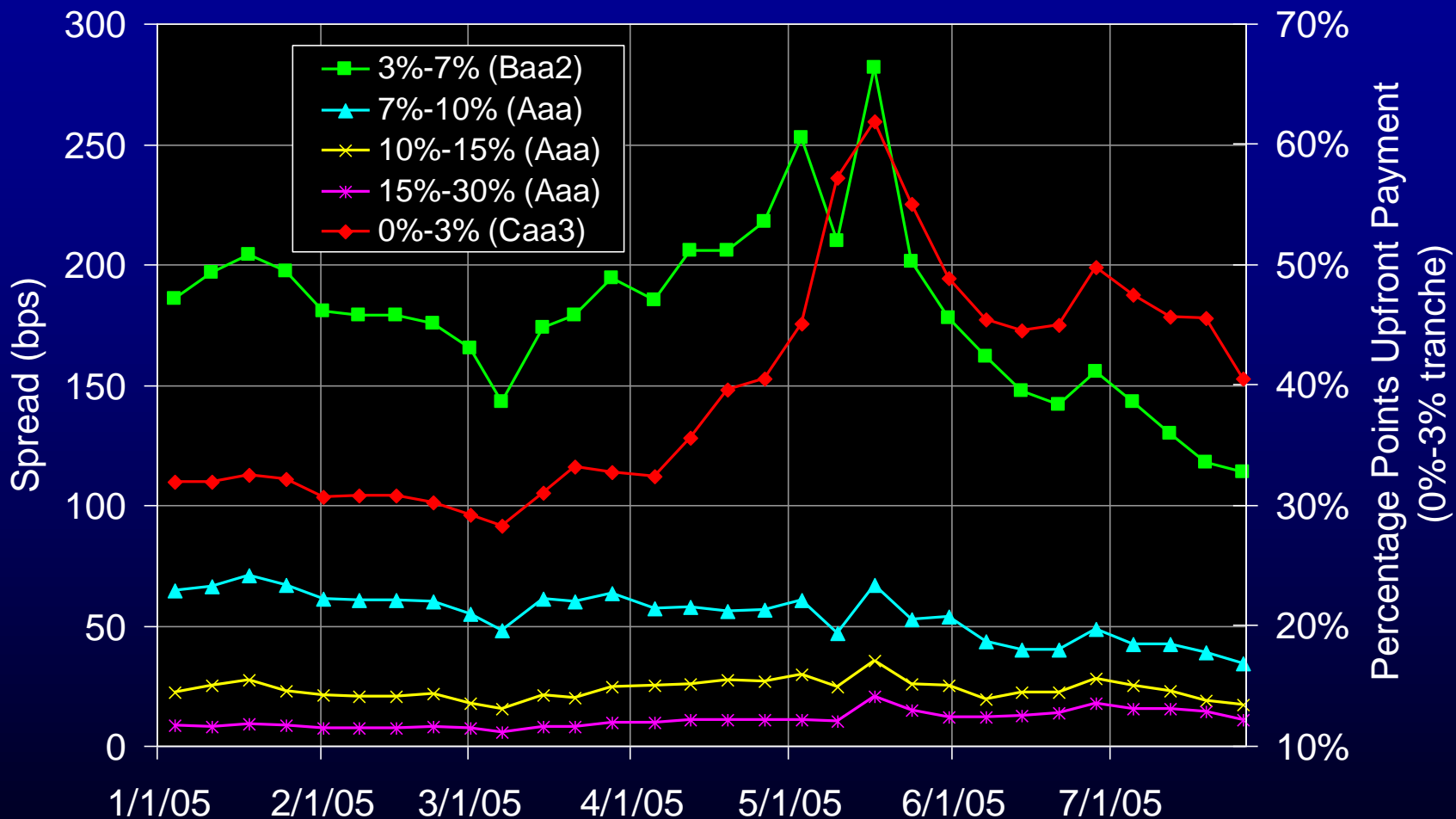
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- These defaults are not surprising in an environment of declining home prices
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Example: U.S. Automakers and Implied Correlations

- Investors buy equity tranches of CDS indices (DJ.CDX.NA.IG or iTraxx) and delta hedge the spread risk of the positions by shorting mezzanine tranches
- S&P downgrades GM and Ford on 5 May 2005
- Investors try to unwind positions selling equity tranches and purchasing mezzanine tranches
- Implied correlations of equity and mezzanine tranches moved in opposite directions
- Model-based hedges didn't work

CDS Tranches Spreads – DJ.CDX.NA.IG

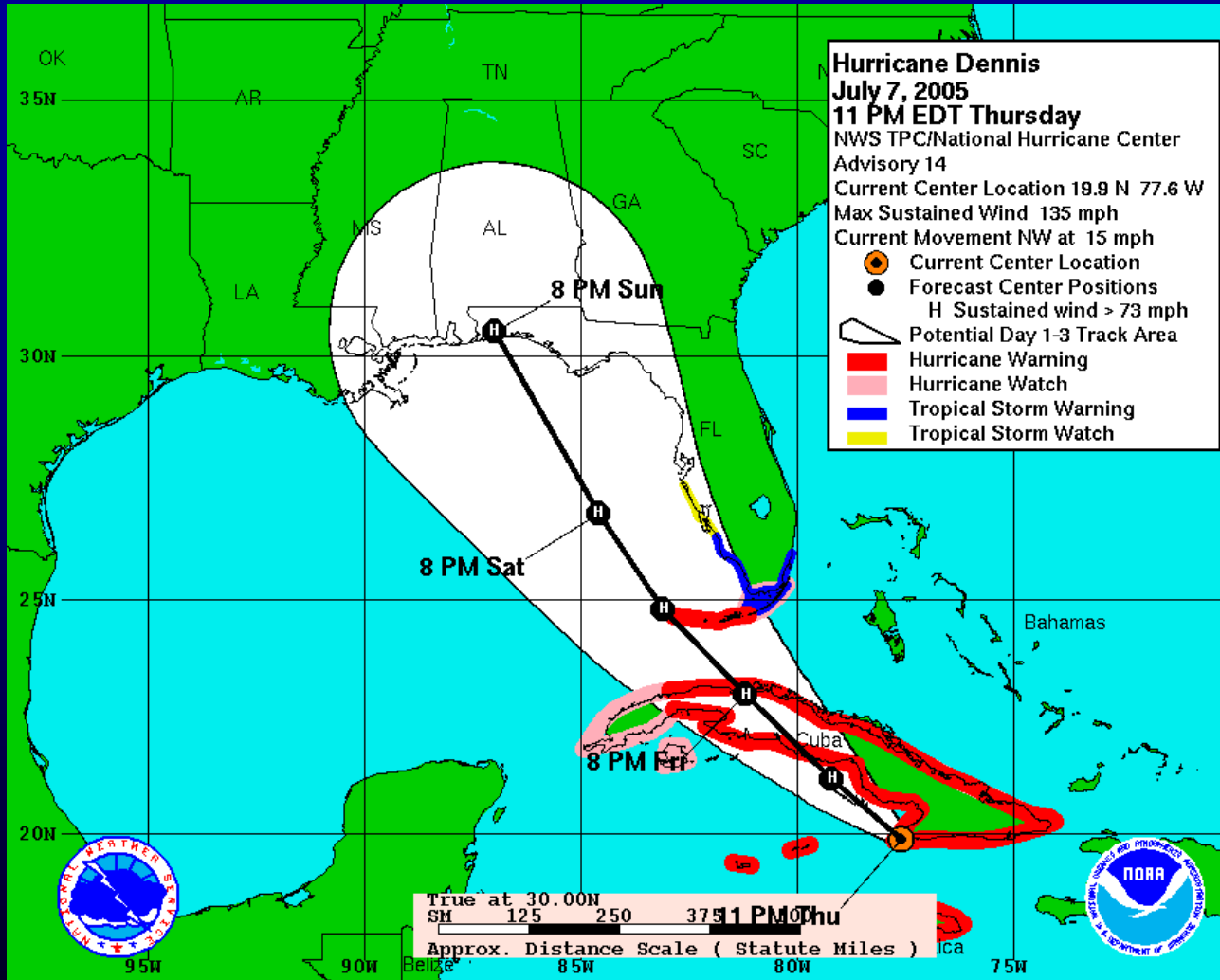


Source: Creditflux

Other Famous Examples

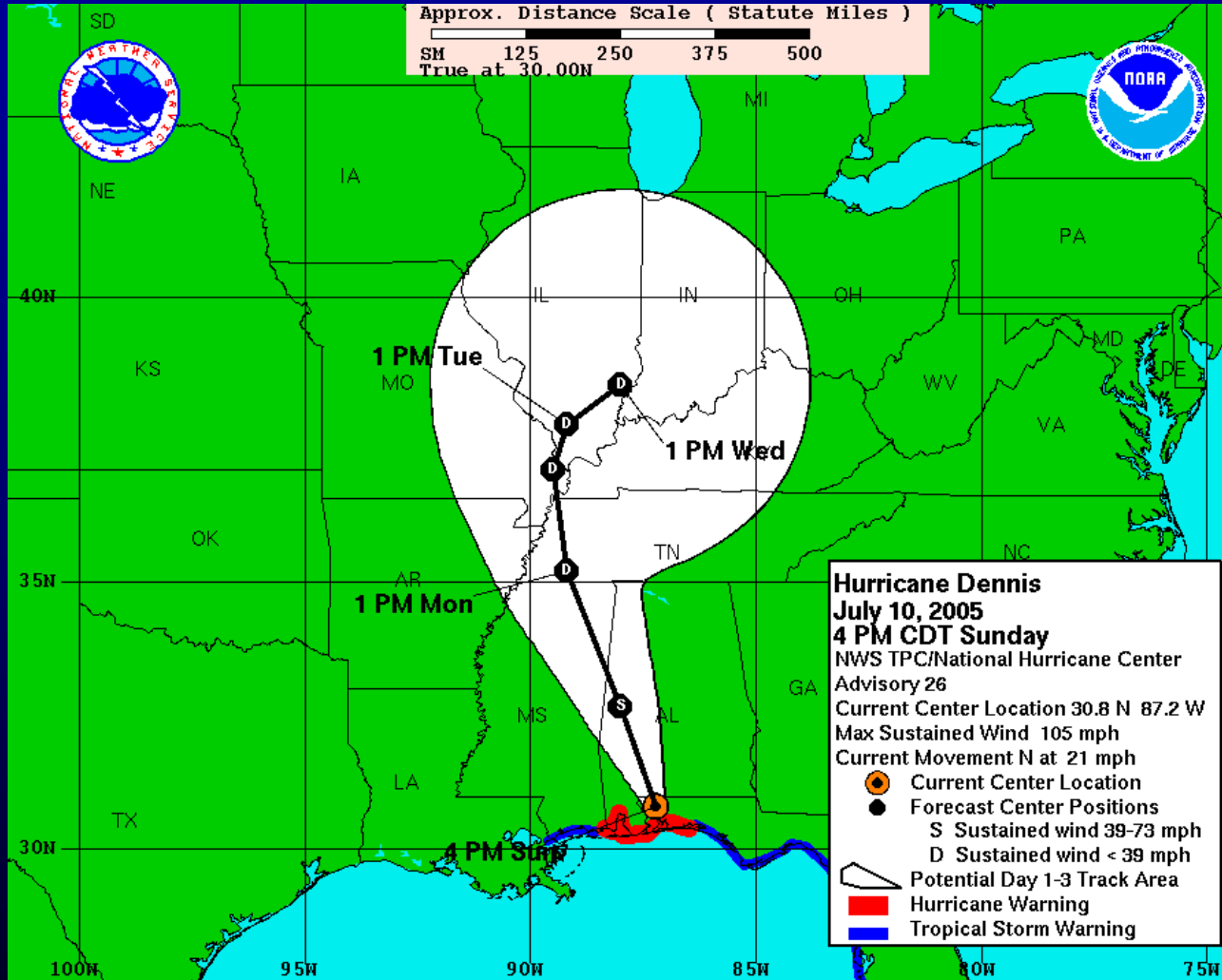
- Hunt Brothers silver squeeze, 1974-1979
 - falling prices, margin calls
- Metallgesellschaft AG, oil futures, \$1.5 billion loss, 1983
 - contango causes losses on rolling hedges
- 1987 U.S. stock market crash
 - program trading strategies crumble against limited liquidity
- Long Term Capital Management, 1998
 - hedging strategy based on Black-Scholes theory

Margins of Error – Weather



Source: NOAA

Margins of Error – Weather



Source: NOAA

Stress Testing: Space Shuttle Main Engine LOX Turbopump



This photo shows the exhaust from the pre-burner that is used to generate the hot gases to drive the space shuttle engine LOX (Liquid Oxygen) turbopump during the test. For a typical turbopump test, the low pressure tank is pressurized to simulate the NPSH (Net Positive Suction Head) of the space shuttle turbo pump inlet. The high pressure LOX and hydrogen tanks are pressurized to approximately 1500 psi in order to control the starting flows into the pre-burner. The valve resolution problems experienced when controlling a wide range of flows are solved by controlling three fast acting electro-hydraulic valves in parallel in each propellant line. The acceleration of the turbopump is less than 4 seconds to simulate main engine operation which requires the high pressure propellant tanks to be ramped in pressure to 9000 psi. The liquid hydrogen is conditioned by a liquid/gas mixer to simulate shuttle main engine inlet temperatures. The high response control system controls the tank pressurization, propellant flow, temperature and turbopump speed. The abort system monitors over 200 parameters and calculations and initiates shutdown or test termination if an anomaly is detected.

Source: EDF, Inc., <http://www.edfinc.com/pages/shuttlepump.htm>

Key Scenario: Does It Work When You Push the Button?

Site: Elugelab Island, Enwetak atoll, Marshall Islands

Detonation: Surface Type: Fission/Fusion

The device called Sausage, detonated in the Mike test was the first true thermonuclear bomb ever tested. However, the Sausage was not a deliverable weapon. It was an enormous, complex device, 80 inches wide and 244 inches long. The entire assembly weighted 82 metric tons. Sausage was built using Teller-Ulam principles of staged radiation implosion. Interestingly Teller himself didn't participate in development. Los Alamos Panda Committee, directed by J. Carson Mark did the job. TX-5 fission bomb was used as a fuse (primary stage). Super cooled, liquid hydrogen was used as a thermonuclear fuel. *The Cab*, the building which housed the device, was located on the zero island. A plywood tube was assembled from the Cab to the furthest island, where the detection station was, some 2 miles away. The tube was filled with Helium, to allow radiation rays travel faster before it was consumed by the fireball.

The explosion yielded 10.4 Mgt. Mike's fireball measured 3 miles. The cloud formed by Mike shot was immense. Stabilized, it reached 135 000 ft high, and stretched 60 miles in diameter, which eventually spread over 1000 miles.

Mike destroyed the entire Elugelab island. The crater formed as a result of the explosion measured 6240ft (1.5Km) across and 164ft (53m) deep. Following the test, high levels of radiation covered most of the Enwetak atoll.

This was 4th largest test ever conducted by US, (the largest at that time). For comparison, this is more then all allied bombs dropped during WW II together.

Test: Mike

Operation: Ivy

Date: 31 October 1952

Yield: 10.4 Megatons



source: <http://zvis.com/nuclear/dimg.php3?ivymike5,ivymike>

Financial Engineering vs. Financial Theory

- Real world testing vs. simulation alone
- Simulation implicitly relies on the notion that underlying phenomena are governed by (or at least behave as though governed by) the laws of probability
- Historical experience provides a form of real world test
 - Corporate bond default studies
 - ABS credit migration studies

Conclusion – Implications for Litigation

■ Events of default

- Ambiguous documents

■ Disclosure

- Private placements
- Pitch books highlighted that falling home prices had never been seen on a national level
- Irish Financial Services Regulatory Authority
- http://www.ifsra.ie/industry/in_mark_prosp.asp

■ Collateral damage

- Bond insurers
- Sub-prime mortgage ABS market