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### Credit Analysis of Securitizations: RMBS & CDOs

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#### **Credit Ratings and Fixed-Income Credit Analysis**

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### **Risk is Our Business**

- SF permits choosing among different kinds of risk
  - prepayment risk
  - asset credit risk
  - model risk
  - company risk (minimize)
- SF permits manipulation of risk
  - tranching risk
  - derivatives



# Residential Mortgage-Backed Securities (RMBS): Actuarial Approach

### **U.S. Residential Mortgage Volume**



Source: Inside Mortgage Finance (1990-2011); Mortgage Bankers Association (2012, 2013, and projections).

## **U.S. RMBS Issuance**



Source: 2007 Mortgage Market Statistical Annual, Inside MBS & ABS (22 Feb 2008), SIFMA

## **Mortgage Loan Basics**

- Traditional loan is 30-year, fixed rate, fully amortizing, payable monthly, and prepayable at any time
- Variations
  - 15-year, 20-year
  - adjustable interest rate (ARMs)
    - index
    - caps
  - hybrid (fixed/adjustable)
- Affordability features: interest only, negative am., 40-year
- Specialty mortgage products: alt-A, sub-prime

# **Refinancing: A Valuable Option**

- Fixed rate loans
  - When interest rates fall, a borrower can refinance his loan at a lower interest rate
  - When interest rates rise, a borrower has the benefit of having locked-in a lower rate in the past
- Floating rate loans
  - When hybrid loan resets borrower can refinance to new hybrid or to fixed
  - When interest rates fall, a borrower has the ability to "permanently" lock-in the benefit of the low rates by refinancing into a fixed rate loan

# Mortgage Loan = A Bond minus an Option

- Bond portion: obligation to pay principal and interest in monthly installments
- Option portion: opportunity to "call" (purchase) the bond at a price of par, at any time
- Lender is long the bond and short the option
- Borrower is short the bond and long the option
- Jargon: Mortgage loan contains an embedded short option
- Value of a mortgage loan is the value of the bond minus the value of the option
- Valuing the option is hard to do

### **MBS Basic Features (GSE MBS)**

- Pass-through security
  - Monthly collections of interest and principal, <u>including</u> <u>prepayments</u>, "passed through" to investors
  - Servicer collects payments from borrowers (for a fee)
  - GSE guarantee protects investors from credit risk on loans
- Pass-through rate is like an interest rate on the MBS
  - Lower than the interest rates on the loans
  - Difference is the servicing fee plus the guarantee fee
- Loans backing an MBS are generally similar
  - Interest rates
  - Loan maturities

### **Basic MBS Cash Flow**

Homeowners make monthly payments of principal and interest at the mortgage rate.

The servicer retains a portion of the interest component of each monthly payment as the "servicing fee."

The pass-through rate is the mortgage rate net of the servicing fee rate.



# **Ginnie Mae**

- Guarantees securities issued by banks and mortgage banks that participate in Ginnie Mae programs
- Part of HUD
- Loans have federal insurance or guarantees (e.g. FHA or VA; usually low- or moderate income borrowers)
- Full faith and credit guarantee
- Used to compete with sub-prime for loans

### Fannie Mae & Freddie Mac

- Private corporations, federally chartered & regulated
- Directly issue MBS
- Accept conventional mortgage loans  $\leq$  \$625K/\$417K
- Cash and swap programs for lenders
- Regular and special servicing
  - with and without recourse; most sellers choose without
- Guarantees its own MBS against credit losses on the underlying loans
- Guarantee is backed by the federal gov't since 2008
- Loan Interest rates usually in 1.75% band

# **Structure: Prepayments (1)**

Basic Cash Flows, 30 Year, 7% Mortgage Loan



# **Structure: Prepayments (2)**

Principal Cash Flows, 30 Year, 7% Mortgage Loan



# **Structure: Prepayments (3)**

Principal Cash Flows, 30 Year, 7% Mortgage Loan

Money→



Time→

# **Structure: Prepayments (4)**

Principal Cash Flows, 30 Year, 7% Mortgage Loan

Money→



Time→

# **Structure: Prepayments (5)**

Principal Cash Flows, 30 Year, 7% Mortgage Loan

Money→



Time→

### **Private-Label MBS**

- Issued by private companies
- No GSE guarantee
- Rated securities w/ credit support
  - Subordinate tranches absorb losses before senior tranches
  - Mortgage loan credit quality is a key factor
- Jumbo: loans above conforming limit
- Alt-A: loans that contain non-standard features but which have borrowers of "A" creditworthiness
- Subprime: borrower has a tarnished credit record

### **Securitization Diagram**



#### **Private-Label MBS Subordination Structure**



**Underlying Assets** 

**Securities** 

#### **Private-Label MBS Subordination (Subprime)**



### More on Credit Enhancement (1)

- Subordination
- Overcollateralization
- Excess spread
- Triggers/alternate waterfall
  - Pro rata
  - Sequential
- Third-party guarantee/insurance

# More on Credit Enhancement (2)

- Six pack structure (jumbo and "true" alt-A)
  - Prepayment lockout: seven years or 2× subordination, phase-out, triggers
- Excess spread/overcollateralization structure (sub-prime and weak alt-A)
  - Use excess spread to cover current losses and build OC (turbo)
  - Surplus excess to residual class
  - Principal lockout w/ triggers (3 years or  $2\times$ )

### **Subprime MBS Cash-flow Example**

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



# Credit Analysis of Mortgage Loans

Three C's of Mortgage Credit (new loans)

- Credit reputation
- Capacity
- Collateral



## Freddie Mac Guidelines: Three C's

#### **37.1: Underwriting a Mortgage for sale to Freddie Mac (01/01/13)**

Freddie Mac purchases Mortgages that meet the standards included in this Single-Family Seller/Servicer Guide (Guide). The conclusion that a Mortgage is acceptable must be based on a determination that the Borrower is creditworthy (acceptable credit reputation and capacity) and the Mortgaged Premises (collateral) is adequate for the transaction. Credit reputation, capacity and collateral are often called the "three Cs" of underwriting. If one of these components is not acceptable or if there is excessive layering of risk across components, the Mortgage is not acceptable for sale to Freddie Mac.

Source: Freddie Mac, Single-Family Seller/Servicer Guide, Vol 1, Ch. 37.1 (1 Jan 2013).



### **Other Factors**

- Occupancy owner occupied, investment, vacation home
- Loan purpose purchase, refi, cash-out
- Loan amortization type 30, 15, interestonly, negative-amortization
- Property type and number of units single family, condo, PUD, mobile home
- Product type (if applicable) FRM, ARM, hybrid

# **Underwriting a Mortgage Loan**

- Analysis of credit quality
  - analysis considers trade-offs between various risk factors
    - Three C's
    - other factors
  - risk layering
- Screens for fraud (reasonableness and logical consistency)
- Verify accuracy of information

# **Freddie Mac Guidelines: Layering**

The Seller must determine that each component (credit reputation, capacity and collateral) is acceptable and that the overall layering of risk is acceptable. A conclusion that the Mortgage is acceptable cannot be reached by looking only at a single underwriting component or by placing the most weight on a single component, but may result from balancing the weakness of one component against the strength of the other two components. For example, a Borrower with weak capacity may be found to be acceptable because of strong collateral and credit reputation, but a Borrower with weak capacity and weak credit reputation is not acceptable because only collateral is strong.

Even when each of the three components is acceptable, layered risk may make a Mortgage unacceptable. Characteristics specific to the Mortgage request, such as the type of Mortgage product, the purpose of the Mortgage and the property type securing the Mortgage, add layers of risk that must be considered.

Source: Freddie Mac, Single-Family Seller/Servicer Guide, Vol 1, Ch. 37.1(c) (1 Jan 2013).



# **Fannie Mae Underwriting Matrix**

Standard Eligibility Requirements - Manual Underwriting Excludes: Refi Plus, High-Balance, HomeStyle Renovation, and MyCommunityMortgage						
		Maximum DTI ≤ 36%		Maximum DTI ≤ 45%		
Transaction Type	Number of Units	Maximum LTV, CLTV, HCLTV	Credit Score/LTV	Minimum Reserves	Credit Score/LTV	Minimum Reserves
Principal Residence						
Purchase Limited Cash- Out Refinance	1 Unit	FRM: 95% ARM: 90%	FRM: 680 if > 75% FRM: 620 if ≤ 75% ARM: 680 if > 75% ARM: 640 if ≤ 75%	0	700 if > 75% 640 if ≤ 75%	0
			660 if > 75%	6	FRM: 680 if > 75% FRM: 620 if ≤ 75% ARM: 680 if > 75%	2
	2 Units	FRM: 85% ARM: 75%	680 if > 75% 640 if ≤ 75%	6	700 if > 75% 660 if ≤ 75%	6
					680 if > 75% 640 if ≤ 75%	12
	3-4 Units	FRM: 75% ARM: 65%	660	6	680	6
					660	12
Cash-Out Refinance	1 Unit	FRM: 80% ARM: 75%	680 if > 75% 660 if ≤ 75%	0	700 if > 75% 680 if ≤ 75%	0
			660 if > 75% 640 if ≤ 75%	6	680 if > 75% 660 if ≤ 75%	2
	2-4 Units	FRM: 75% ARM: 65%	680	6	700 680	6 12

Source: Fannie Mae, *Eligibility Matrix*, p. 4 (10 Nov 2014)



# **Measuring the Three C's**

- Credit reputation
  - FICO<sup>®</sup> score
  - Credit history



- Stability factors (time in home/job)
- Capacity
  - Debt-to-income ratio (DTI)
  - Financial reserves (no. of months)
- Collateral
  - Loan-to-value ratio (LTV)

### **Components of a FICO<sup>®</sup> Score**



# **Automation: Fannie Mae's DU**

- Credit history
- Delinquent accounts
- Mortgage accounts
- Revolving credit
  utilization
- Public records, foreclosures, and collection accounts
- Inquiries



- Borrower's equity and LTV
- Total expense ratio
- Liquid reserves
- Loan purpose
- Loan term
- Loan amortization type
- Occupancy type
- Property type
- Co-borrowers

# **Things Not Considered**

- Illegal factors: age, race, sex
- Type of job
- Type of neighborhood
- Type of lending in homes in the neighborhood



# Credit Analysis of RMBS
# **Designing the Analysis**

- Define archetypical loan and pool
- Calibrate "triple-A" enhancement for archetypical loan
- Define sensitivities for varying loan attributes
   Some are non-linear
- Define inter-relationships
  - Multiplicative or additive
- Define pool-level adjustments
  - Geographic concentration
  - Small number of loans

## **Archetypical Loan & Pool**

- Archetypical loan
  - 75% LTV
  - 725 FICO<sup>®</sup> score
  - 36% DTI (back end)
  - FRM30, purchase-money
  - Single-family detached home
  - Full documentation & appraisal
- Archetypical pool
  - At least 250 loans
  - Geographically diversified

### **Triple-A Calibration for Archetypical Pool**

- Extreme stress scenario
- Similar to the Great Depression
- 30% (vs. 24.9%) unemployment
- Half of those suffering unemployment default
  - Implies 15% default frequency
- 50% loss severity on each default
  Implies 7.5% total losses

#### Sensitivities, Inter-relationships & Adjustments

- LTV: risk rises geometrically with rising LTV
- FICO<sup>®</sup>: risk rises geometrically w/ falling score
- DTI: risk rises geometrically with rising DTI
- Other attributes: mostly multipliers
- Inter-relationships: mostly multiplicative
- Pool-level adjustments: rare

# **Seasoned (Old) Loans**

- Performance delinquencies and losses
- Macroeconomic drivers
  - Home price appreciation
  - -Unemployment rate

### **RMBS Analytic Challenges**

## **Description of Delinquencies**

Which history suggests more risk?:

Jan	Feb	Mar	Apr	May	Jun
\$1,000	<b>\$0</b>	\$1,000	\$1,000	\$1,000	\$1,000

Jan	Feb	Mar	Apr	May	Jun
\$1,000	\$0	\$2,000	\$1,000	\$1,000	\$1,000

# **Description of Delinquencies**

Borrower's payment history:

Jan	Feb	Mar	Apr	May	Jun
\$1,000	<b>\$0</b>	\$1,000	\$1,000	\$1,000	\$1,000

- As of June 1, the borrower is:
  - 120 days delinquent one time (1x120)
  - 30 days delinquent four times in a row (4x30)
  - 30 days delinquent once on a "rolling" basis (1x30)

# **Time Since Bankruptcy**

- Time since filing
  - Borrower is in financial trouble at time of filing
- Time since discharge
  - Borrower may be getting back on his feet by the time he gets out of bankruptcy



## **Debt-to-Income Ratio**

- Income
  - Regular job
  - Investment income
  - Second job
  - Home business
  - Gifts

- Debt
  - Fully indexed rate
  - Teaser rate
  - Included debts



### **Appraisals**

#### **Regular Appraiser**



#### **Automated Appraiser**



#### Quarterly Average S&P AAA Credit Enhancement Levels for Jumbo FRM30 Deals



# Collateralized Debt Obligations (CDOs): Monte Carlo Simulation Approach

## The CDO Monte Carlo Paradigm

- Each credit exposure can be represented by mathematical parameters based on:
  - Par amount
  - Rating
  - Industry
- Mathematical parameters are:
  - Default probability
  - Loss severity (recovery rate) upon default
  - Correlation to other exposures
- Copula technique

# **Copula Technique (1)**

Mapping Survival Probability to Default Time



# **Copula Technique (2)**

- Generate a normally distributed random variable for each credit, ε<sub>1</sub> to ε<sub>n</sub>, plus one extra one, y, representing the economy
- Use the  $\varepsilon_i$  variables and y to produce n correlated, normally distributed random variables,  $x_1$  to  $x_n$ , with the formula  $x_i = \sqrt{\rho}y + \sqrt{1 \rho}\epsilon_i$
- Use the cumulative normal function to map the  $x_i$  variables to corresponding variables in the range of 0 to 1, denoted  $u_1$  to  $u_n$
- Map each  $u_i$  variable to a corresponding default time  $(\tau_i)$  using the credit's survival function



### **Basic CDO Structure -- Tranching**



#### **Underlying Assets**

**Securities** 

### **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

# **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™ 6.3
  - Moody's: CDOROM<sup>™</sup> ver. 2.13
  - Fitch: Portfolio Credit Model 2.4.4

#### **Easy Problem: Model the Universe with Just Six Numbers**

- $N = 10^{36}$  the ratio of the strength of the electrical force to the gravitational force
- ε = 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<sup>-5</sup> 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

# **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

# **Things Can Go Wrong: Model Risk**

- Models are naturally appealing and produce reliable results under normal conditions
- But, models are weak under unusual or extreme conditions, when critical assumptions break down



# Things Can Go Wrong: Model Risk (cont.)

- Biased development samples
- Wrong distributions
- Non-stationary processes
  - the world is less wellbehaved than we would have it
- Missing variables
  - omitting the unquantifiable
- Don't be fooled by fancy models



# **Hard Problem: Correlation**

- Hard to measure correlation
  among rare events
- Probably not stable over time (i.e., time varying)
- Possibly regime switching
- Substantial danger from under-estimating
- Skora was among the first to highlight the issue: "Correlation – The Hidden Risk in Collateralized Debt Obligations," *Derivatives* Strategy, Nov 1998



#### Annual Issuer-Weighted Corporate Bond Default Rates 1920-2004



- lf it happened once before, it can happen again
- Averages obscure extremes
- Focus on peaks, not averages
- Could a given tranche have withstood the relevant periods of stress over the past 20 years?

#### Annual Issuer-Weighted Corporate Bond Default Rates, Europe vs. N. Amer. 1985-2004



62

### **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**



#### **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/portfolio-space-shuttle.html

### **Key Scenario Testing**



# **Key Scenario Testing**

#### Test: Mike Operation: Ivy Date: **31 October 1952** Yield: **10.4 Megatons**

#### 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. A 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 the Mike shot was immense. Stabilized, it reached 135,000 ft high, and stretched 60 miles in diameter, which eventually spread over 1,000 miles.

Mike destroyed the entire Elugelab island. The crater formed as a result of the explosion measured 6,240ft (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.

Source: http://zvis.com/nuclear/detonation/ivymike/ivymike1.shtml

# Conclusion

- Mortgage credit analysis is based on fundamental factors
- MBS credit analysis builds on mortgage credit analysis, adding structural considerations and rating calibration
- CDO credit analysis is simulation based and relies on mathematical abstractions and assumptions
- Apply caution using simulation models, question assumptions, and supplement with scenario analysis

# Appendix: Rating Agency CDO Methodology Evolution

# **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<sup>™</sup>
  - Corporate correlation: 30% intra-industry, <u>0% inter-industry</u>
    - 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.	<b>0.55</b> (0.518, 0.568)			
Bank Cards	<b>0.22</b> (0.208, 0.233)	<b>0.17</b> (0.162, 0.179)		
Auto Loans	<b>0.37</b> (0.356, 0.390)	<b>0.21</b> (0.201, 0.219)	<b>0.48</b> (0.464, 0.492)	
RMBS	<b>0.13</b> (0.124, 0.133)	<b>0.07</b> (0.069, 0.076)	<b>0.18</b> (0.172, 0.185)	<b>0.06</b> (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 (19 Jun 2006) (percent)										
	AAA	AA+	AA	AA-	A+	А	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.										

## **S&P Methodology Evolution (8)**

- Ghetti, B., et al., CDO Spotlight Update to General Cash Flow Analytics Criteria for CDO Securitizations (17 Oct 2006)
- Albulescu, H., et al., CDO Spotlight: Updated Global Recovery Rates for Use in Cash Flow CDOs (23 Jul 2007)
- Jordan, P., et al., Correlation and Recovery Assumptions Revised for CDOs of ABS Backed by RMBS (4 Feb 2008)
- Ghetti, B., et al., Advance Notice of Proposed Criteria Change: Market Conditions Negatively Impact CDOs of Structured Finance Securities (30 Dec 2008)
- Chang, W., et al., Request for Comment: Update to Global Methodologies and Assumptions for Corporate Cash Flow CDO and Synthetic CDO Ratings (18 Mar 2009)
- Albulescu, H., et al., Update to Global Methodologies and Assumptions for Corporate Cash Flow and Synthetic CDOs (17 Sep 2009)
- Ghetti, B., et al., Global CDOs of Pooled Structured Finance Assets: Methodology and Assumptions (21 Feb 2012)
- Ghetti, B., et al., Update To Global Methodologies and Assumptions for Corporate Cash Flow and Synthetic CDOs (1 Aug 2014)

### **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	
Aal	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	Саа	6,500	
Baa2	360	Са	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 Trans-actions 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

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

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

- **O** = average probability of default
- D = diversity score
- j = no. of defaults in  $j^{\text{th}}$  scenario
- $P_i$  = probability of scenario *j*

 $E_i$  = expected loss in scenario *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 <u>uncorrelated</u> 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

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

- 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 (14 Jun 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<sup>™</sup>
  - Assumed pair-wise correlations generate the single correlation parameter within CDOROM<sup>™</sup>
    - simulates losses
    - applies moment matching scheme to match skew of CBM loss distribution to that of CDOROM<sup>™</sup> simulated loss distribution

# **Moody's Methodology Evolution (9)**

- Kim, T., Moodys 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

## **Moody's Methodology Evolution (10)**

- Marjolin, B., Moody's Approach To Modelling "Exotic" Synthetic CDOs with CDOROM™ (1 Feb 2007)
- Froeba, M., and Nazarian, D., Moody's Approach to Adapting U.S. Cash-Flow CLO Rating Methodology to PDR/LGD Initiative (20 Feb 2007)
- Rubock, D., US CMBS and CRE CDO: Moody's Approach to Rating Commercial Real Estate Mezzanine Loans (27 Mar 2007)
- Metz, A., and Sieler, J., Corporate Asset Correlations Update:
- A Summary of Changes and Their Rationale (26 Aug 2009)
- Bunja, R., and Beauchesne, H., *Moody's Approach to Rating Corporate Collateralized Synthetic Obligations* (14 Sep 2009)

#### Moody's Methodology Evolution (11)

- Levidy, N., and Gerdes, M., Moody's Approach to Rating Commercial Real Estate CDOs (21 Jul 2011)
- Mogunov, L., Moody's Approach to Rating SF CDOs (8 May 2012)
- Yuen, J., et al., Moody's Approach to Rating Corporate Synthetic Collateralized Debt Obligations (19 Nov 2013)
- Nazarian, D., and Torres, R., *Moody's Global Approach to Rating Collateralized Loan Obligations* (27 Feb 2014)
- Veliev, O., et al., Moody's Approach to Rating SF CDOs (6 Mar 2014)

#### **Hierarchy of Issues and Concepts**

