C-1 Subcommittee Update on CLO C-1 Factors Modeling

December 15, 2025

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Chairperson, Academy C-1 Subcommittee

American Academy of Actuaries

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Introduction

- The C-1 Subcommittee & the NAIC's Structured Securities Group (SSG) have collaborated to build a working model for CLO C-1.
- CUSIP-level *hypothetical* C-1 factors are shown, but these are only generated as an intermediate step—the ultimate goal is to produce factors based on comparable attributes, not to model each individual CLO on an ongoing basis.
- These early results are broadly consistent with work done by SSG in the CLO Ad Hoc group, showing low risk for senior tranches but potential cliff risk for junior tranches.
- Key modeling decisions are still under review, and we are showing six deals—results are likely to evolve as the model is refined and applied to the broader universe of CLOs owned by life insurers.

Methodology Summary

- Objective: Define several risk buckets for CLOs according to comparable attributes and then assign a C-1 factor to each bucket.
- CLO collateral credit modeling is largely consistent with C-1 corporate bond modeling.
- Projection of CLO cash flows is largely consistent with SSG modeling in the CLO Ad Hoc group, with the primary exception being the CLO collateral credit modeling.
- Conversion of CLO cash flows into C-1 factors is consistent with C-1 corporate bond methodology where possible, with additional modeling to address the fact that missed payments on CLOs do not necessarily trigger defaults.

Anticipated Project Timeline

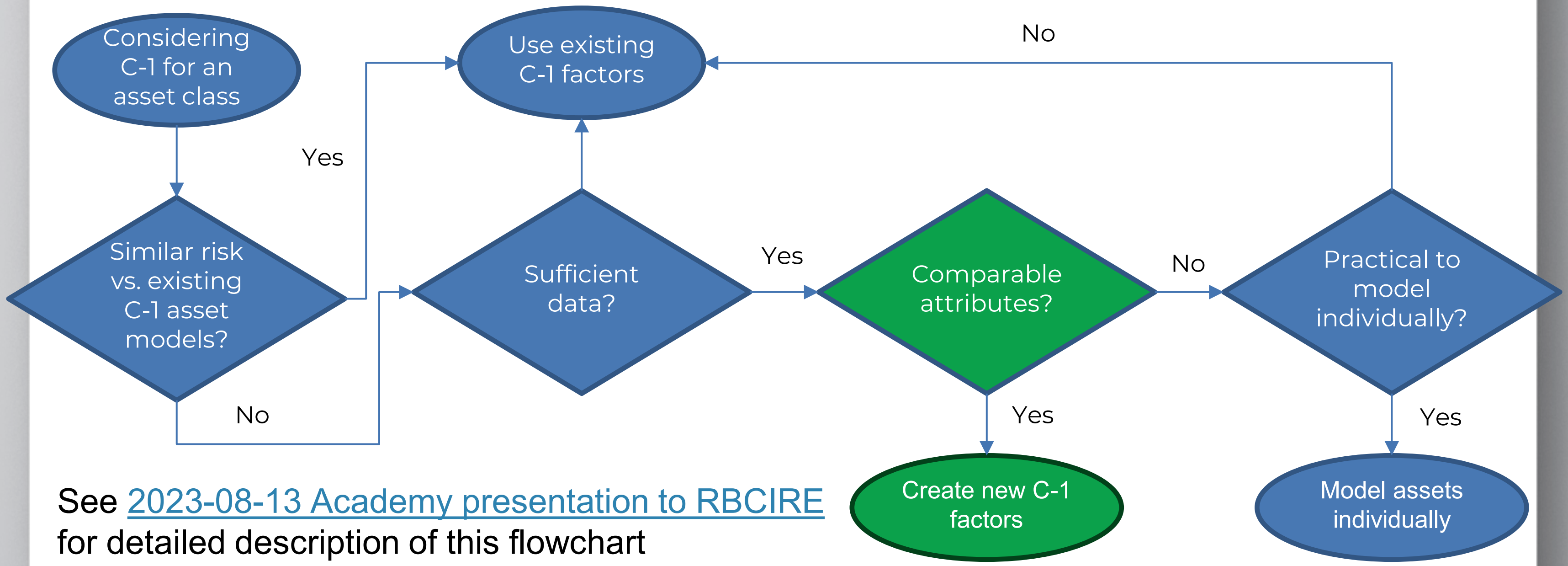
WE ARE HERE

- Sept. 8, 2025—initial presentation of model
- Dec. 15, 2025—status update to regulators
- Early 2026—presentation of residual tranche results, portfolio adjustment factor, model refinements, identification of potential comparable attributes, and resulting factors
- Q1 2026—incorporation of modifications requested by regulators, if any
- Q2 2026—If significant changes are not requested by regulators, expectation is for final factors to be available for exposure by April 30, 2026

Acknowledgments

- ACLI—use of C-1 corporate bond model developed by Moody’s for ACLI
- Moody’s—access to CLO deal data, collateral data, historical default rate data, and CDOnet
- S&P—historical recovery data and frequent discussions with structured finance analytical professionals
- Bridgeway Analytics—frequent discussions on credit modeling, structured finance, and help in understanding the ACLI & Moody's corporate bond model
- SSG—modeling advice and running CDOnet
- NAIC accounting staff—guidance on CLO statutory accounting

C-1 Modeling Framework Flowchart



See 2023-08-13 Academy presentation to RBCIRE for detailed description of this flowchart

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Project Status Update as of Dec. 15, 2025

The Academy has accomplished 2 milestones:

1. Finalize key assumptions in the CLO modeling framework based on the model decisions selected for reconsideration and discussed in the Sept. 8, 2025, meeting.
2. Identify the full universe of CLO deals to be modeled.

Summary of Sensitivity Testing

Results for Baa and below are highly reactive to all sensitivities considered

The Academy recommends retaining baseline assumptions relating to correlations within the collateral pool (between loans and between default and severity) to be consistent with C-1 bond factors, as the differences between CLO collateral and senior unsecured bonds are not great enough to justify a different modeling approach.

The Academy may recommend changes to recovery assumptions and prepay speeds/purchase prices if more time were available to better specify these assumptions. But these sensitivities run in opposite directions, so leaving both at their baseline may be expedient for completing the project in time for 2026 implementation.

1. Key Modeling Assumptions Reconsidered

Selected Model Decisions to be Reconsidered

Model Assumption/Parameter	Potential Change	Modeling Decision or Sensitivity
% Variance Explained by Systematic Error	May reduce from 10% to reflect below-IG nature of collateral (e.g., 5%)	Sensitivity tests #1, #2, and #3
Collateral Reinvestment Price & Prepay	Allow for prepayment and reinvestment at less than par	Sensitivity tests #6 and #7
Projection Horizon	Adjust results for tranches that pay off in less than 10 years (senior tranches)	To be determined
Statistical Safety Level	Showing results for CTE-90, but the level is for regulators to decide	Currently using CTE-90
Relationship between default rates and severities	Change correlation between defaults and severities from zero to positive	Sensitivity test #4
Reinvestments—General Approach	See appendix	Implemented methodology in appendix
Reinvestments—Aligning with Reinvestment Period	Stop reinvesting recovered principal after 2-3 years when generating default vector	Implemented 2.5y reinvestment horizon
Rank Order of Collateral Scenarios	Identify patterns of default timing that result in greater CLO losses	No change
Risk Premium	Derive risk premia from CLO loss distribution instead of from bond factors	To be determined

Decision to Retain Baseline Assumptions/Approach

Model Assumption/Parameter	Sensitivity #	Reason to Retain Baseline
% Variance explained by systemic risk	1, 2, 3	Consistency with C-1 bond factors
Relationship between default rates and severities	4	Consistency with C-1 bond factors
Recoveries	5	Baseline is derived using actual data, whereas alternative approach is sensitive to statistical fitting methodology
Collateral Reinvestment Price & Prepay	6, 7	Alternative approach used was unrealistically credit-supportive by allowing deep discount purchases during the entire investment period and produced widely variable results across deals
Recoveries and reinvestment/prepay	8, 9 (combining 5 with each of 6 and 7)	Sensitivities from 5 and 6 move in opposite directions, although not entirely offsetting

DRAFT/PRELIMINARY RESULTS, SUBJECT TO CHANGE

Sensitivity—Systemic Risk

		1	2
After-Tax C-1 / Tranche Rtg	**Baseline Dec '25**	**5% Corr**	**20% Corr**
Aaa	0.00%	0.00%	0.00%
Aa2	0.00%	0.00%	0.05%
A2	0.04%	0.01%	1.24%
Baa2	0.89%	0.04%	8.17%
Baa3	2.34%	0.80%	12.58%
Ba3	30.72%	20.18%	52.93%

*Results are preliminary and subject to change. This is only 6 deals—results may change when all CLOs held by life insurers are included. Baa2 tranche is from only one deal and is therefore potentially especially unrepresentative due to its small sample size.

Systemic risk is modeled with pairwise correlation between loans.

Baseline correlation is 10%.

Li and Chen (2018) reference 2%, 35% and 51% in 1-yr, 5-yr and 10-yr correlations for B-rated issuers.

Qi et al (2019) reference 2%, 10% and 9% in 1-yr, 5-yr and 10-yr correlations for B-rated issuers.

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Sensitivity—Copula

		3
After-Tax C-1 / Tranche Rtg	**Baseline Dec ’25**	**Clayton Copula**
Aaa	0.00%	0.00%
Aa2	0.00%	0.00%
A2	0.04%	0.08%
Baa2	0.89%	2.21%
Baa3	2.34%	7.57%
Ba3	30.72%	34.04%

*Results are preliminary and subject to change. This is only 6 deals—results may change when all CLOs held by life insurers are included. Baa2 tranche is from only one deal and is therefore potentially especially unrepresentative due to its small sample size.

Baseline assumption = Gaussian Copula

Clayton Copula may capture asymmetric distribution of the default correlations and has fatter tails.

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Sensitivity—Correlation in Severities

		4
After-Tax C-1 / Tranche Rtg	Baseline Dec '25	Corr Severities
Aaa	0.00%	0.00%
Aa2	0.00%	0.00%
A2	0.04%	0.29%
Baa2	0.89%	3.73%
Baa3	2.34%	8.51%
Ba3	30.72%	42.38%

*Results are preliminary and subject to change. This is only 6 deals—results may change when all CLOs held by life insurers are included. Baa2 tranche is from only one deal and is therefore potentially especially unrepresentative due to its small sample size.

Baseline assumption is no correlation.

Sensitivity test correlated recovery rates, using Gaussian Copula with 10% correlation.

Note: If recoveries are correlated with rate of default (e.g., high default environments have lower recoveries), then recoveries will be correlated with one another.

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Sensitivity—Recovery Average

		5
After-Tax C-1 / Tranche Rtg	Baseline Dec '25	Lower Recovery
Aaa	0.00%	0.00%
Aa2	0.00%	0.00%
A2	0.04%	1.77%
Baa2	0.89%	21.73%
Baa3	2.34%	19.62%
Ba3	30.72%	59.09%

*Results are preliminary and subject to change. This is only 6 deals—results may change when all CLOs held by life insurers are included. Baa2 tranche is from only one deal and is therefore potentially especially unrepresentative due to its small sample size.

Baseline assumption S&P average loss given default (LGD): 27% for senior secured, 60% for senior unsecured.

A higher LGD is tested: 36% for senior secured, 54% for senior unsecured (despite being lower for senior unsecured, this is higher overall because most loans in CLOs are senior secured).

However, in both cases simple averages are not the input to the model. Decile data published by S&P was used so that the tail could be captured. The averages for the sensitivity are fitted to the shape of the S&P deciles by least-squares optimization.

DRAFT/PRELIMINARY RESULTS, SUBJECT TO CHANGE

Sensitivity—Collateral Repurchase Price and Prepayment

		6	7
After-Tax C-1 / Tranche Rtg	Baseline Dec '25	Prepay & Discount A	Prepay & Discount B
Aaa	0.00%	0.00%	0.00%
Aa2	0.00%	0.00%	0.00%
A2	0.04%	0.07%	0.07%
Baa2	0.89%	0.00%	0.00%
Baa3	2.34%	0.55%	0.37%
Ba3	30.72%	10.15%	6.67%

*Results are preliminary and subject to change. This is only 6 deals—results may change when all CLOs held by life insurers are included. Baa2 tranche is from only one deal and is therefore potentially especially unrepresentative due to its small sample size.

Baseline scenario models no prepayments and no repurchase discounts. Sensitivities model historically low prepayment speeds and purchase prices, consistent with stressed credit environments.

Sensitivity A = prepay and purchase price equal to CTE(10) of historical data: 11.8% prepayment rate, 82.5 price.

Sensitivity B = prepay and repurchase price equal to VaR(0.5) of historical data: 8.7% prepayment rate, 72.0 price.

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Sensitivity—Recovery, Prepayment and Repurchase Price

		8	9
After-Tax C-1 / Tranche Rtg	**Baseline Dec ’25**	**5 & 6**	**5 & 7**
Aaa	0.00%	0.00%	0.00%
Aa2	0.00%	0.00%	0.00%
A2	0.04%	0.20%	0.11%
Baa2	0.89%	0.00%	0.00%
Baa3	2.34%	5.51%	3.43%
Ba3	30.72%	31.12%	23.27%

*Results are preliminary and subject to change. This is only 6 deals—results may change when all CLOs held by life insurers are included. Baa2 tranche is from only one deal and is therefore potentially especially unrepresentative due to its small sample size.

Combination of lower recovery averages along with prepayment and repurchase discounts.

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Sensitivity #6—Widely Varying Results Across Deals

	Prepay & Discount A						
After-Tax C-1 / Tranche Rtg	Average	Carlyle 2021-1	Strata II	Ares 52	Magne-tite 27	OHA 3	Ancho-rage 17
Aaa	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Aa2	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
A2	0.07%	0.00%	0.00%	0.00%	0.00%	0.41%	0.00%
Baa2	0.00%	0.00%	n/a	n/a	n/a	n/a	n/a
Baa3	0.55%	0.00%	1.89%	0.83%	0.00%	0.60%	0.00%
Ba3	10.15%	0.00%	15.43%	31.11%	5.45%	1.22%	7.66%

*Results are preliminary and subject to change. This is only 6 deals—results may change when all CLOs held by life insurers are included. Baa2 tranche is from only one deal and is therefore potentially especially unrepresentative due to its small sample size.

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Sensitivity #7—Widely Varying Results Across Deals

	Prepay & Discount B						
After-Tax C-1 / Tranche Rtg	Average	Carlyle 2021-1	Strata II	Ares 52	Magne-tite 27	OHA 3	Ancho-rage 17
Aaa	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Aa2	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
A2	0.07%	0.00%	0.00%	0.00%	0.00%	0.41%	0.00%
Baa2	0.00%	0.00%	n/a	n/a	n/a	n/a	n/a
Baa3	0.37%	0.00%	0.81%	0.79%	0.00%	0.60%	0.00%
Ba3	6.67%	0.00%	10.00%	28.68%	0.01%	1.22%	0.13%

*Results are preliminary and subject to change. This is only 6 deals—results may change when all CLOs held by life insurers are included.

2. Full Universe of CLO Deals

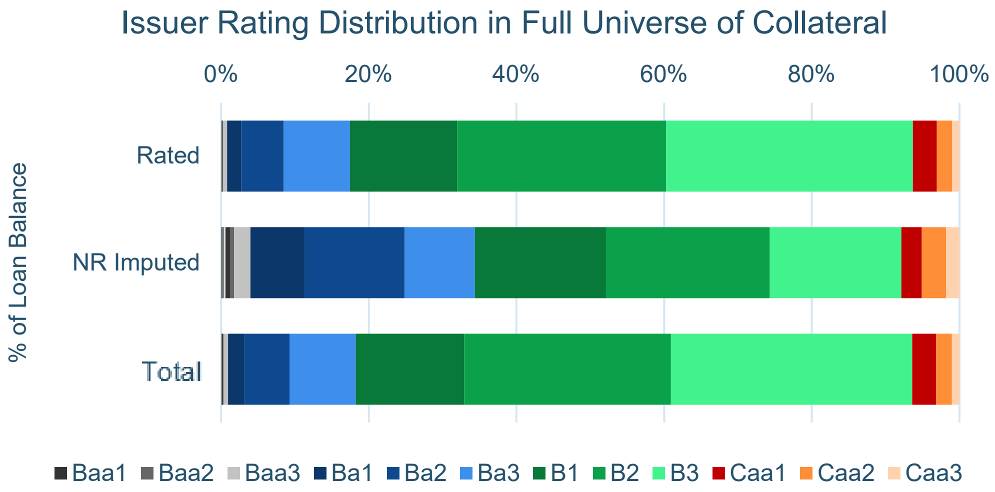
Scope of Full Universe of CLO Deals

Deal or Subset	As of 9/30/24				As of 12/31/24			
	Balance ($mn)	CLO Deals (#)	Loans (#)	Unique Issuers (#)	Balance ($mn)	CLO Deals (#)	Loan Count	Unique Issuers
867331201	496.9	1	474	381	491.6	1	1,088	382
867578342	598.6	1	499	435	596.3	1	1,259	436
867567170	436.8	1	307	268	428.1	1	751	272
830960738	684.3	1	365	329	660.9	1	417	330
830871594	424.7	1	348	295	387.4	1	354	299
867931338	389.6	1	171	153	371.3	1	309	153
Sample Deals	**2,910.2**	**6**	**2,193**	**927**	**2,935.5**	**6**	**4,178**	**936**
Full Universe					**1,046,300.2**	**2,674**	**1,175,515**	**2,544**

Issuer Rating Distribution in Collateral Loans

- Issuer rating is used for default modeling, which is the worse between S&P and Moody's.

- When issuers were not rated (5% of loan balance), issuer rating is approximated using average security rating, rounded down to the nearest notch.



*Issuer rating shown. When comparing issuer and loan rating, S&P ratings are the same for 98% of the balance. Moody's ratings are the same for 57% and within 1 notch for 94% of the loan balance.

Questions

Contact:

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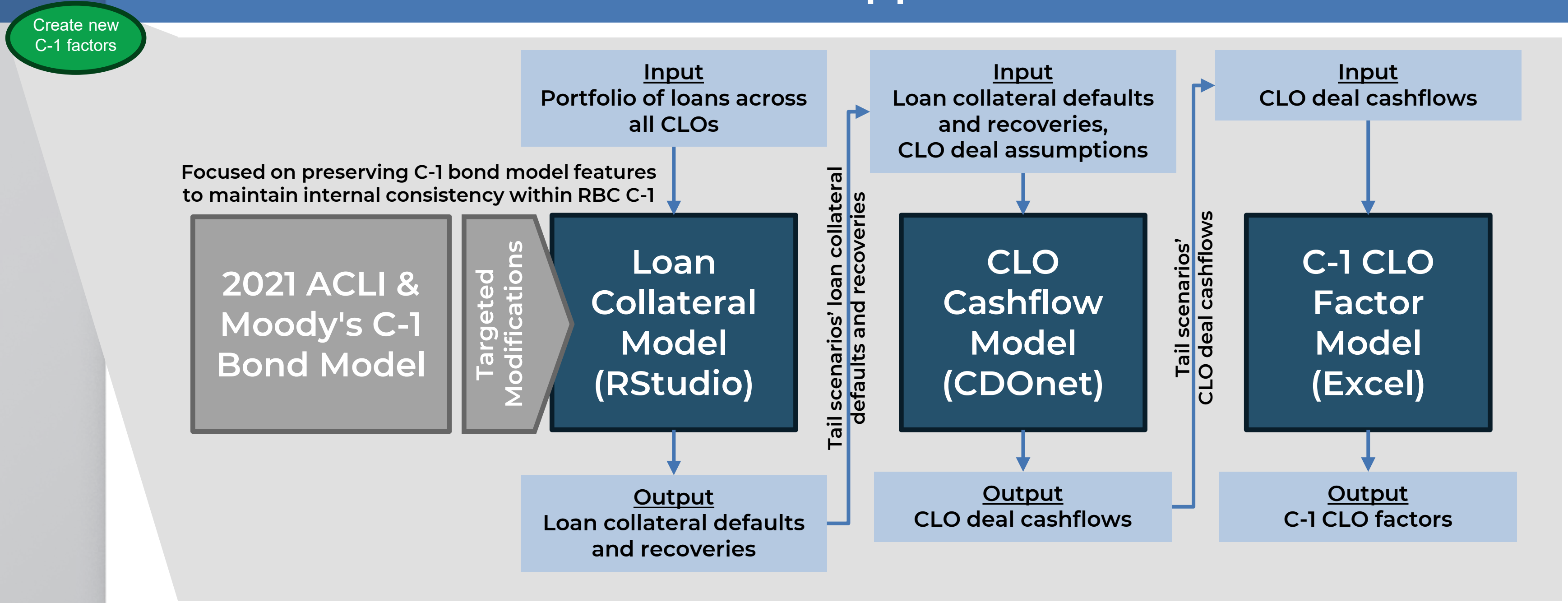
Appendix A—
CLO C-1 Factors Modeling Framework

Overview of C-1 CLO Factors Approach



CTE-90 Tail Metric for C-1 CLO Factors

Create new C-1 factors

2021 ACLI & Moody's C-1 Bond Stochastic Model

Target Mods

Loan Collateral Stochastic Model (RStudio)

Loan collateral losses at VaR(x) x = 90, 91, ... 98, 98.5, 99, 99.25, 99.5, 99.75, 99.9, 99.95, 99.99,

CLO Cash Flow Deterministic Model (CDOnet)

CLO cashflows at VaR(x) x = 90, 91, ... 98, 98.5, 99, 99.25, 99.5, 99.75, 99.9, 99.95, 99.99,

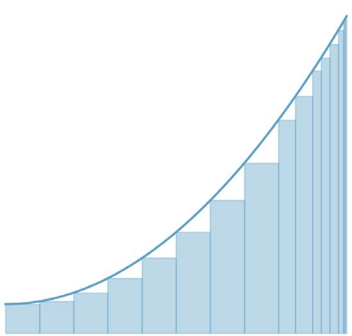
C-1 CLO Factor Deterministic Model (Excel)

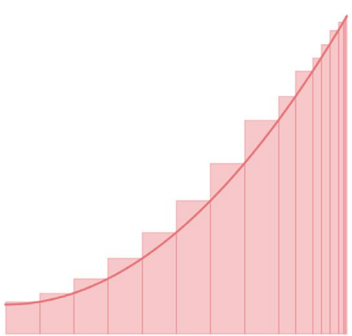
C-1 CLO Factor at CTE-90

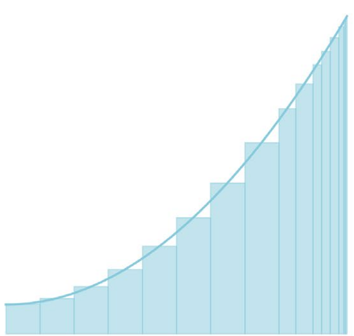
The CLO cash flow and the C-1 CLO Factor Models use deterministic inputs; CTE is estimated from VaR metrics selected using a scenario compression method to manage computational time

Scenario Compression for CTE-90 Estimation

- Breaks percentiles into 16 buckets
- Percentiles get closer together at the right tail as the RBC charges increase more steeply







Approach used

	Weights		
Percentile	Left	Right	Midpoint
99.99	0.5%		0.3%
99.95	0.5%	0.5%	0.5%
99.90	1.5%	0.5%	1.0%
99.75	2.5%	1.5%	2.0%
99.50	2.5%	2.5%	2.5%
99.25	2.5%	2.5%	2.5%
99.00	5.0%	5.0%	3.8%
98.50	5.0%	5.0%	5.0%
98.00	10.0%	10.0%	7.5%
97.00	10.0%	10.0%	10.0%
96.00	10.0%	10.0%	10.0%
95.00	10.0%	10.0%	10.0%
94.00	10.0%	10.0%	10.0%
93.00	10.0%	10.0%	10.0%
92.00	10.0%	10.0%	10.0%
91.00	10.0%	10.0%	10.0%
90.00		10.0%	5.0%

Targeted Modifications—Loan Collateral Model Parameters

Model Parameter	ACLI & Moody's C-1 Bond Model	Loan Collateral Model
Simulations	10,000	Kept the same
Projection Years	10 years	Kept the same
Time Step	Annual	Monthly
Target Risk Metric	VaR(96), selected based on the greatest PV of losses in excess of accumulated risk premium	VaR(x) where x = 90, 91, …. 98, 98.5, 99, 99.25, 99.5, 99.75, 99.9, 99.95, 99.99, selected based on the PV of losses*
Discounting	Discount Rate = 3.47% (pre-tax) 2.74% (post-tax)	Kept the same pre-tax*
Output	C1 bond factors = PV of losses in excess of risk premium / Amount exposed	Undiscounted defaults and recoveries by deal and by credit rating

*Discounting only used to identify the scenario at the Target Risk Metric.

Loan Collateral Model (RStudio)

Targeted Modifications—Loan Collateral Model Assumptions

Model Assumption	ACLI & Moody's C1 Bond Model	Loan Collateral Model
Default Rates	Empirical distribution by issuer rating based on Moody's data	Kept the same
Recovery Rates	Empirical distribution by economic state based on Moody's data for senior unsecured bonds	Empirical distribution by payment priority (sr. unsecured, sr. secured, 2nd lien) based on S&P data
Economic State Transition Matrix	Based on original Academy's work	Not used
% Variance Explained by Systematic Error	10%	Kept the same, results in implicit diversification benefit
Tax Adjustment	Tax Rate = 21% Recovery Rate = 80%	Not used*
Reinvestment	Surplus used to purchase identical bond after default	Modeled to align with reinvestments in CLO cash flow Model (CDOnet)

*Tax Adjustment used in a downstream step of the overall CLO model process

Reinvestments in Loan Collateral Model

**Reinvestment modeling
is a key methodological choice that impacts credit losses**

- Credit losses may occur from existing loans or from future reinvestments.
- The tail scenarios are selected in the loan collateral model (RStudio), before modeling the CLO cash flows.
- To maximize alignment between collateral modeling and CLO cash flow modeling, loan collateral losses are modeled consistent with CDOnet assumptions:
    a) Only maturities and recoveries from default are reinvested (i.e., no prepayments)
    b) Reinvestment distributions are
        30% B1 | 30% B2 | 40% B3
        92.5% Sr. Secured | 7.5% Sr. Unsecured

Loan Collateral Model (RStudio)

Reinvestment Methodologies Considered

Approach used for Sept. 8, 2025 results

	Reinvestment Amount at t	Loss from Reinvestment	Modeled Loan Universe	Pros	Cons
1	Deterministic	Deterministic empirical distribution	[933 x 3] existing loans at t=0	• Simple	• Understates tail risk, loss curve is an average scenario, not Xth percentile • The systematic error is not captured in the reinvestments
2	Based on stochastic scenario	Deterministic average of stochastic simulations, staggered to start at time t	[933 x 3] existing loans at t=0	• Simple	• Overestimates tail risk by compounding of Xth percentile on top of Xth percentile • Misalignment of systematic error, which should follow time from projection t • Exacerbates misalignment in VaR(X) for deal A vs. VaR(X) for deal B
3	Based on stochastic scenario	Stochastic simulation	[933 x 3] existing loans at t=0 + [933 x 3 x 120] hypothetical loans for t=0 through 120	• Most mathematically accurate	• Most computationally expensive • Creates an open-ended universe of loans and issuers, which may introduce unwarranted diversification benefits

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Loan Collateral Model (RStudio)

Reinvestment Methodologies Considered

Approach used for Dec. 15, 2025 results

	Reinvestment Amount at t	Loss from Reinvestment	Modeled Loan Universe	Pros	Cons
4	Based on stochastic scenario	Deterministic, average of stochastic simulations, aligned by projection year, based on original credit rating at t=0	[933 x 3] existing loans at t=0	• Computationally feasible • Alignment of systematic error • Closed-ended universe of loans and issuers	• Does not account for credit migration that happens between t=0 and reinvestment time t • Reinvestments limited to existing pool of loans and issuers that have not defaulted at time t
5	Based on stochastic scenario	Deterministic, average of stochastic simulations, aligned by projection year, based on simulated credit rating at t=t	[933 x 3] existing loans at t=0, each with a simulated credit rating at each time step t	• Same as approach 4 • Addresses credit migration limitation in approach 4	• Introduces model risk by modeling credit migration from complexity and reliance of credit migration data • Same as above, reinvestments limited to existing pool of loans and issuers that have not defaulted at time t

Step-by-Step Description of Loan Collateral Model

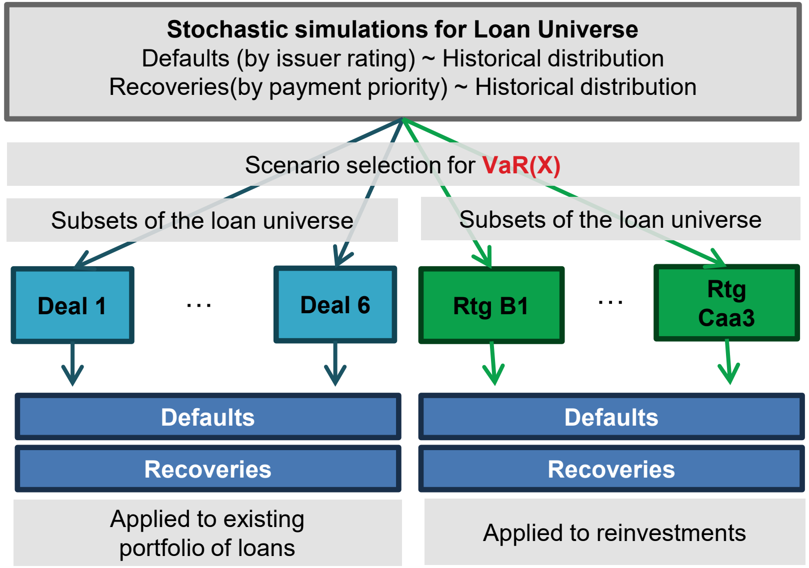
Data Dimensions

10,000 scenarios
x [933] unique issuers
x [3] payment priorities
x 120 months

1 scenario x [933] unique issuers x [3] payment priorities x 120 months

1 scenario x [N] x 10 yrs
where [N] = 6 for the number of sample CLO deals + 9 for the number of credit ratings with defaults

Step in Loan Collateral Model



Description

- Random draw to determine default indicator of 1 or 0 for each loan
- If default = 1, additional random draw determines recovery amount

- **VaR(X)** scenario selected across loan universe based on PV of total losses of existing loans and reinvestments

- For given **VaR(X)** scenario, losses for existing loans and for reinvestments are derived by identifying the corresponding subsets within the loan universe

- Output defaults and recoveries applied to existing portfolio and reinvestment

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CLO Cashflow Model Assumptions & Parameters

Model Assumption/Parameter	SSG Approach in CLO Ad Hoc Group	Academy Approach
Collateral Prepayment	No prepay, consistent with rating agencies	Kept the same
Collateral Reinvestment Price	At par, consistent with rating agencies	Kept the same
Reinvestment Timing & Quality	Reinvestments are made into existing collateral pool specific to each deal	Reinvestments made into newly issued loans, quality not deal-specific
Recovery Lag	6 months	Immediate recovery, consistent with S&P recovery data
Default Vectors	10 default & recovery scenarios, weighted to minimize difference between CLO C-1 and collateral C-1 across deals	17 tail scenarios drawn from loan collateral model (10,000 total scenarios) to inform an estimation of CTE-90; CLO/collateral C-1 equivalence not enforced
All Other CDOnet Parameters	Various less impactful modeling choices that need to be made	Kept the same

C-1 CLO Factor Model (Excel)

Converting CLO Cash Flows Into C-1 Factors

Objectives	Approach: Consistency with C-1 Bond Factors	Approach: Prioritizing Estimation of Portfolio Tail Events
• Consistency with C-1 bond factors approach except for risk measure (CTE-90 vs. VaR-96) • Prioritize estimating risk consistent with a portfolio tail event instead of estimating each security's specific tail risk	• 10-year projection • Risk premium by CLO tranche rating equal to C-1 bond factor risk premium • Statutory losses (simplified SSAP 43 impairment modeling used for CLOs) • Greatest present value of accumulated deficiency (GPVAD) • Difference: tax loss occurs at the earlier of a full impairment or a tranche defaulting at maturity (in bond model, tax loss always occurs at time of default)	• Rank order of scenarios determined based on PV of losses on the combined collateral pool instead of being reordered for each CLO or each CLO tranche • Leads to greater dispersion of modeled C-1 factors across CLOs, but averages across deals will represent risk of a diversified CLO portfolio • Updates to Portfolio Adjustment factor for CLOs will be considered in next steps

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Simplified SSAP 43 Impairment Modeling—Details

- Per previously identified principles, capital is downstream from accounting.
- C-1 corporate bond model assumes statutory losses occur only upon default.
- For most CLOs, default only occurs at maturity when the final payment cannot be made.
- However, in many cases it is clear years before that a default will occur—in this case, a statutory loss may result from an impairment prior to default.
- This model's simplistic approach is to check for an impairment any time an interest payment is missed (in other words, any time the CLO PIKs).
- At that time, the model assumes the insurer has full knowledge of future cash flows and performs a perfectly accurate impairment analysis (in the tail scenarios that drive C-1 results, this effectively pulls statutory losses forward in time in the model).
- If a security's book yield is significantly higher than the C-1 discount rate and the C-1 risk premium is low, this approach could underestimate C-1. If book yield is low relative to risk premium, this approach could overestimate C-1.
- This is all a practical expedient—the Academy has been unable to identify a more realistic way of conducting an "inner loop" impairment analysis, and we estimate the effect of this simplification to be minor.

Appendix B—Loan Collateral Model

Moody's C-1 Bond Model Summary

Inputs	Calculations: Stochastic Simulations	Calculations: C-1 Bond Factors
• Default rates by rating and tenor, from Moody's historical study 1983-2020 • Recovery rates by economic state, from Moody's historical study 1987-2020 • Economic states transition matrices with starting state of contraction	For simulation *i*, year *t*: • 1 of 4 discrete economic states sampled from Markov-Chains • Default indicator sampled from a distribution by issuer rating and tenor, with a Gaussian Copula function where 90% of the variance is idiosyncratic and 10% is systematic • Loss rate = 1 – recovery rate, sampled from a discrete distribution by economic state	• C-1 bond factor = VaR(96) PV of simulated C-1 losses • PV of simulated C-1 losses = NPV of simulated C-1 losses over 10 yrs discounted at a flat 2.74% post-tax rate • Simulated C-1 loss for year *t* = simulated post-tax loss – risk premium where risk premium = expected loss + 0.5*std dev by issuer rating, representing losses covered in reserves Losses expressed as a % of t=0 book value

Moody's C-1 Bond Model Validation

	C-1 Bond Model Rerun												Original C-1
	Seed 1	**Seed 2**	**Seed 3**	**Seed 4**	**Seed 5**	**Seed 6**	**Seed 7**	**Seed 8**	**Seed 9**	**Seed 10**	**Avg**	**Std Dev**	**Model Output**
Aaa	**0.158%**	0.163%	0.149%	0.148%	0.152%	0.170%	0.159%	0.158%	0.158%	0.152%	0.157%	0.007%	**0.158%**
Aa1	**0.271%**	0.274%	0.271%	0.256%	0.271%	0.280%	0.261%	0.272%	0.269%	0.266%	0.269%	0.007%	**0.271%**
Aa2	**0.419%**	0.439%	0.435%	0.431%	0.440%	0.440%	0.425%	0.434%	0.429%	0.430%	0.432%	0.007%	**0.419%**
Aa3	**0.545%**	0.539%	0.520%	0.521%	0.530%	0.537%	0.531%	0.537%	0.516%	0.540%	0.532%	0.010%	**0.523%**
A1	**0.683%**	0.670%	0.659%	0.669%	0.675%	0.643%	0.649%	0.677%	0.651%	0.649%	0.663%	0.014%	**0.657%**
A2	**0.800%**	0.824%	0.815%	0.833%	0.806%	0.815%	0.816%	0.823%	0.807%	0.818%	0.816%	0.010%	**0.816%**
A3	**1.023%**	1.007%	0.999%	0.997%	1.004%	1.005%	1.026%	1.012%	0.993%	0.997%	1.006%	0.011%	**1.016%**
Baa1	**1.226%**	1.242%	1.241%	1.237%	1.222%	1.217%	1.235%	1.220%	1.213%	1.201%	1.225%	0.014%	**1.261%**
Baa2	**1.553%**	1.527%	1.512%	1.556%	1.558%	1.529%	1.544%	1.540%	1.549%	1.580%	1.545%	0.019%	**1.523%**
Baa3	**2.186%**	2.183%	2.172%	2.174%	2.173%	2.136%	2.168%	2.112%	2.182%	2.209%	2.170%	0.027%	**2.168%**
Ba1	**3.168%**	3.181%	3.187%	3.154%	3.143%	3.136%	3.206%	3.143%	3.177%	3.179%	3.167%	0.023%	**3.151%**
Ba2	**4.619%**	4.651%	4.614%	4.630%	4.562%	4.741%	4.613%	4.571%	4.640%	4.652%	4.629%	0.050%	**4.537%**
Ba3	**5.680%**	5.874%	5.864%	5.862%	5.853%	5.871%	5.799%	5.868%	5.853%	5.882%	5.841%	0.061%	**6.017%**
B1	**7.268%**	7.352%	7.453%	7.389%	7.337%	7.400%	7.409%	7.373%	7.380%	7.275%	7.364%	0.058%	**7.386%**
B2	**9.290%**	9.497%	9.688%	9.361%	9.198%	9.543%	9.512%	9.221%	9.365%	9.274%	9.395%	0.159%	**9.535%**
B3	**12.307%**	12.509%	12.290%	12.612%	12.471%	12.423%	12.358%	12.372%	12.315%	12.606%	12.426%	0.120%	**12.428%**
Caa1	**16.360%**	16.804%	16.562%	16.771%	17.181%	16.815%	16.855%	16.785%	16.647%	16.707%	16.749%	0.212%	**16.933%**
Caa2	**23.458%**	23.451%	23.822%	23.355%	23.535%	23.333%	23.648%	23.524%	23.838%	23.404%	23.537%	0.180%	**23.798%**
Caa3	**32.762%**	32.490%	32.605%	33.417%	33.069%	33.056%	32.883%	33.030%	33.289%	32.927%	32.953%	0.286%	**32.975%**

Moody's C-1 Bond Model Validation

	C-1 Bond Model Rerun – Original C-1 Model Output											Original C-1
	Seed 1	**Seed 2**	**Seed 3**	**Seed 4**	**Seed 5**	**Seed 6**	**Seed 7**	**Seed 8**	**Seed 9**	**Seed 10**	**Avg**	**Model Output**
Aaa	**0.000%**	0.005%	-0.009%	-0.010%	-0.006%	0.012%	0.001%	0.000%	0.000%	-0.006%	-0.001%	**0.158%**
Aa1	**0.000%**	0.003%	0.000%	-0.015%	0.000%	0.009%	-0.010%	0.001%	-0.002%	-0.005%	-0.002%	**0.271%**
Aa2	**0.000%**	0.020%	0.016%	0.012%	0.021%	0.021%	0.006%	0.015%	0.010%	0.011%	0.013%	**0.419%**
Aa3	**0.022%**	0.016%	-0.003%	-0.002%	0.007%	0.014%	0.008%	0.014%	-0.007%	0.017%	0.009%	**0.523%**
A1	**0.026%**	0.013%	0.002%	0.012%	0.018%	-0.014%	-0.008%	0.020%	-0.006%	-0.008%	0.006%	**0.657%**
A2	**-0.016%**	0.008%	-0.001%	0.017%	-0.010%	-0.001%	0.000%	0.007%	-0.009%	0.002%	0.000%	**0.816%**
A3	**0.007%**	-0.009%	-0.017%	-0.019%	-0.012%	-0.011%	0.010%	-0.004%	-0.023%	-0.019%	-0.010%	**1.016%**
Baa1	**-0.035%**	-0.019%	-0.020%	-0.024%	-0.039%	-0.044%	-0.026%	-0.041%	-0.048%	-0.060%	-0.036%	**1.261%**
Baa2	**0.030%**	0.004%	-0.011%	0.033%	0.035%	0.006%	0.021%	0.017%	0.026%	0.057%	0.022%	**1.523%**
Baa3	**0.018%**	0.015%	0.004%	0.006%	0.005%	-0.032%	0.000%	-0.056%	0.014%	0.041%	0.002%	**2.168%**
Ba1	**0.017%**	0.030%	0.036%	0.003%	-0.008%	-0.015%	0.055%	-0.008%	0.026%	0.028%	0.016%	**3.151%**
Ba2	**0.082%**	0.114%	0.077%	0.093%	0.025%	0.204%	0.076%	0.034%	0.103%	0.115%	0.092%	**4.537%**
Ba3	**-0.337%**	-0.143%	-0.153%	-0.155%	-0.164%	-0.146%	-0.218%	-0.149%	-0.164%	-0.135%	-0.176%	**6.017%**
B1	**-0.118%**	-0.034%	0.067%	0.003%	-0.049%	0.014%	0.023%	-0.013%	-0.006%	-0.111%	-0.022%	**7.386%**
B2	**-0.245%**	-0.038%	0.153%	-0.174%	-0.337%	0.008%	-0.023%	-0.314%	-0.170%	-0.261%	-0.140%	**9.535%**
B3	**-0.121%**	0.081%	-0.138%	0.184%	0.043%	-0.005%	-0.070%	-0.056%	-0.113%	0.178%	-0.002%	**12.428%**
Caa1	**-0.582%**	-0.138%	-0.380%	-0.171%	0.239%	-0.127%	-0.087%	-0.157%	-0.295%	-0.235%	-0.193%	**16.933%**
Caa2	**-0.340%**	-0.347%	0.024%	-0.443%	-0.263%	-0.465%	-0.150%	-0.274%	0.040%	-0.394%	-0.261%	**23.798%**
Caa3	**-0.213%**	-0.485%	-0.370%	0.442%	0.094%	0.081%	-0.092%	0.055%	0.314%	-0.048%	-0.022%	**32.975%**

Appendix C—
Cash Flow Model

Further Details on CLO Cashflow Modeling in CDOnet

Except where otherwise noted in this presentation, CDOnet parameters and assumptions are set according to the methodology described on the SSG CLO webpage:

https://content.naic.org/industry/structured-securities/collateralized-loan-obligations

Appendix D—
Correlation of Defaults and Recoveries

Sensitivities Considered

Potential Sensitivity	Rationale	Source
Use the Clayton Copula instead of Gaussian Copula to capture asymmetric distribution of the default correlations. Parametrize and compare the cumulative distributions (dots of r_i 's) generated by Gaussian vs. Clayton Copulas.	In the left tail, correlations are higher ($0<r_i<1$, random numbers generated are more clustered near 0), representing highly stressed credit markets. Limitation: assume no autocorrelation between ρ(t-1) and ρ(t)	European Security and Markets Authority. (2019). Leveraged loans, CLOs – trends and risks. Das and Geng. (2004). Correlated Default Processes: A Criterion-Based Copula Approach.

Sensitivities considered

Potential Sensitivity	Rationale	Source
Sensitivity test of pair-wise correlations **ρ** = 0.05, 0.2, and 0.4 under the Gaussian Copula. It is more important to test this assumption for loans than bonds due to potentially more systemic risk among leveraged loans (higher leverage, lower credit rating, more intermediaries, opacity) vs. bonds.	ρ = 0.02, 0.35 and 0.51 referenced by Li & Chen as the 1-year, 5-year and 10-year correlations respectively, for approximately B-rated issuers (Altman's Z-scores of 1.2 to 2.8), from 1992 – 2013 based on S&P's Compustat database. ρ = 0.02, 0.10 and 0.09 referenced by Qi et al. as the 1-year, 5-year, and 10-year correlations respectively, for B-rated bonds over a longer time horizon 1970 – 2014 based on Moody's Corporate Default Risk Service database (DRS). Limitation: Does not capture tail dependence or asymmetric distribution of correlations.	Li and Chen. (2018). The domino effect of credit defaults: test of asymmetric default correlations using realised default data. Applied Economics. Qi et al. (2019). Default correlation: rating, industry ripple effect, and business cycle. Applied Economics. Financial Stability Board. (2019). Vulnerabilities associated with leveraged loans and collateralized loan obligations.

Sensitivities considered

Potential Sensitivity	Rationale	Source
Test lower recoveries (i.e., higher LGD) averages	S&P LGD distributions are more dated and materially lower than historical averages from JPM and Moody's. Limitations: variation of LGD across sectors/industries, year of default or issuance, correlation with defaults are not accounted for.	Jantzen et al. (2025). J.P. Morgan Default Monitor September 2025.
Discrete economic state model Two states: low defaults, severities, and correlations vs. high defaults, severities, and correlations. Dependence between defaults and recoveries is built-in by their dependence on the economic state.	Would need to have two sets of assumptions of defaults by rating and severities. Normal state: correlation between defaults, between defaults and recoveries of 0.1, 0.3 respectively Stressed state: 0.4, 0.5 respectively.	Bruche and Gonzalez-Aguado. (2008). Recovery Rates, Default Probabilities and the Credit Cycle. CEMFI, Madrid. Moody's Analytics. (2021). Assessment of the Proposed Revisions to the RBC C1 Bond Factors.

Sensitivities Considered

Potential Sensitivity	Rationale	Source
Continuous economic state model: Recoveries are also dependent on a common systematic factor $\mathbf{Zi}_{\ t}$ (economic state) from the reduced form default model: i) Linear $R_{i\ t} = uR + \beta_R * \mathbf{Z}_{\mathbf{i},\mathbf{t}} + \sigma_R * \eta_{i,t}$ $\eta_{i,t}$ is standard normal idiosyncratic shocks ii) Beta (α_i,β_i) recovery model, conditional on $Z_{i,t}$, where α_i, β_i can be calculated from u_R and σ_R	From Moody's Structured Finance 2024 paper, across seniorities (s): For first lien, $u_R = 0.6$, $\sigma_R = 0.25$ Senior secured, $u_R = 0.45$, $\sigma_R = 0.30$ Senior unsecured, $u_R = 0.35$, $\sigma_R = 0.30$ Subordinate, $u_R = 0.25$, $\sigma_R = 0.25$	Altman. (2024). Forecasting Credit Cycles: The Case of the Leveraged Finance Market in 2024 and Outlook. The Journal of Risk and Financial Management. Moody's Analytics. (2025). Moody's Ratings Structured Finance team. (2024). Ratings Methodology: Corporate Synthetic CDOs.

Hypothetical Impact of Sensitivities on Bond Factors

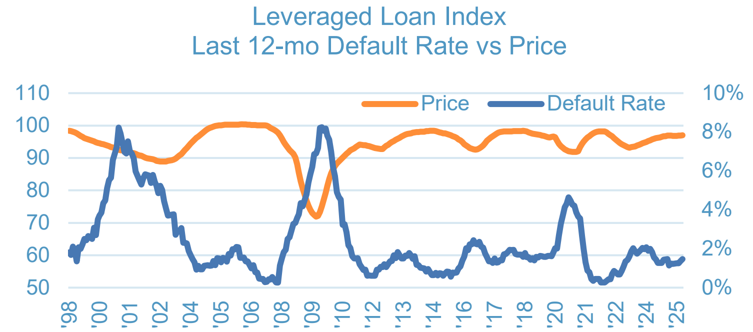
	Guassian				Clayton			
Systemic Risk	5	10	20	40	5	10	20	40
Aaa	0.15%	0.16%	0.16%	0.18%	0.18%	0.16%	-0.03%	-0.05%
Aa1	0.26%	0.27%	0.31%	0.37%	0.33%	0.38%	0.14%	-0.08%
Aa2	0.41%	0.45%	0.54%	0.81%	0.60%	0.85%	0.96%	-0.14%
Aa3	0.48%	0.53%	0.69%	0.98%	0.80%	1.18%	1.40%	0.00%
A1	0.59%	0.66%	0.90%	1.52%	0.95%	1.51%	2.23%	1.01%
A2	0.68%	0.82%	1.15%	2.16%	1.26%	2.05%	3.29%	3.29%
A3	0.80%	0.99%	1.50%	2.64%	1.53%	2.53%	4.13%	6.46%
Baa1	0.96%	1.23%	1.86%	3.35%	1.89%	3.13%	5.48%	9.20%
Baa2	1.19%	1.53%	2.40%	4.32%	2.39%	4.03%	7.05%	13.48%
Baa3	1.60%	2.14%	3.47%	6.11%	3.18%	5.25%	9.71%	17.02%
Ba1	2.24%	3.10%	4.96%	9.32%	4.42%	7.31%	13.31%	22.86%
Ba2	3.33%	4.64%	7.39%	13.09%	6.17%	9.97%	16.72%	27.95%
Ba3	4.10%	5.77%	8.81%	15.59%	7.37%	11.41%	18.36%	31.28%
B1	5.32%	7.44%	11.23%	18.99%	8.83%	13.72%	21.43%	34.96%
B2	6.94%	9.48%	14.19%	23.55%	10.67%	16.04%	25.21%	39.12%
B3	9.05%	12.53%	17.50%	28.04%	13.60%	19.58%	28.69%	44.52%
Caa1	13.04%	17.23%	23.50%	34.82%	17.34%	23.93%	35.04%	50.14%
Caa2	18.95%	23.80%	30.62%	43.70%	22.92%	30.33%	42.23%	57.75%
Caa3	27.46%	32.86%	42.33%	55.81%	30.34%	37.81%	49.02%	66.69%

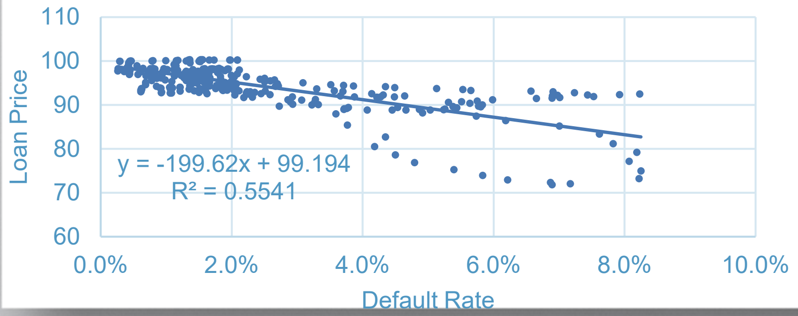
Bond factors assuming a Gaussian Copula and 10% systemic risk are shown in the highlighted column (note that these corresponding results differ slightly from published factors due to changes in the random seed).

The impact of changing the systemic risk and copula model are shown here—higher systemic risk and Clayton Copula would lead to hypothetically higher C-1 factors for bonds.

Appendix E—
Loan Defaults and Prepayments

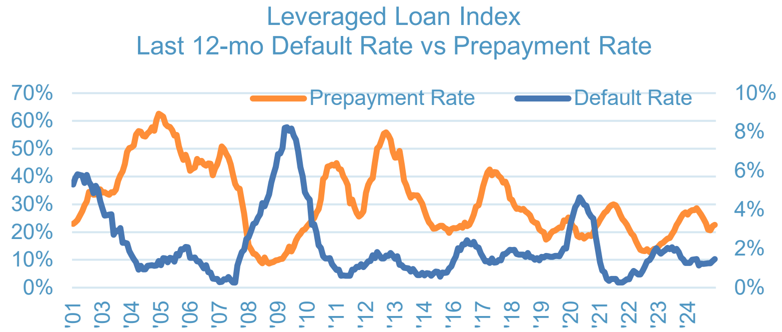
Relationship of Last 12-Month Default Rate and Loan Price

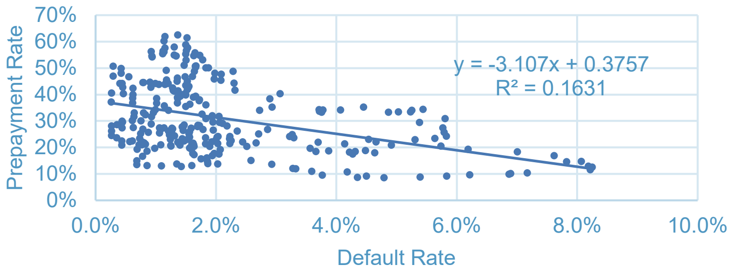




- Data from Pitchbook/LCD dating back to 11/30/1997
- Data strongly supports some level of discount relative to par on reinvestment, with moderate support for specific relationship
- Relationship shown here is across all loan ratings
  - ✓ Relationship could differ by rating with tradeoffs for collateral modeling practicality and further reduction in R^2 at rating specific levels

Relationship of Last 12-Month Default Rate and Loan Price





- Data from Pitchbook/LCD dating back to 1/1/2000
- Data strongly supports some level of prepayment in all markets with weaker support for specific relationship
- Relationship shown here is across all loan ratings
  - ✓ Relationship could differ by rating with tradeoffs for collateral modeling practicality and further reduction in R^2 at rating specific levels

Implementation Questions

What granularity of assumption to use?

- ✓ Loan rating specific default/prepayment and default/loan price relationships driving different prepayment and loan prices by rating for each of the 17 scenarios?
- ✓ Single prepayment and loan price assumption used across all 17 scenarios using average rating of collateral pool?
- ✓ Somewhere in between?

How to calculate "average" relationship

- ✓ "Average" prepayment or loan price should the relative probability weighted average of only the scenario weights that have positive tranche losses
- ✓ Implies different weighting for different tranches (if AAA tranche only had loss in most severe scenario it should be 100% weighted to that scenario and if residual tranche had losses in all scenarios should be relative probability weighted average across all 17)