NATIONAL ASSOCIATION OF INSURANCE COMMISSIONERS

Life Actuarial (A) Task Force and Life RBC (E) Working Group Exposure 10/18/23: GOES Corporate Model Decision

The questions below regarding the GOES corporate model are being released for a public comment period. Please send comments to Scott O'Neal (soneal@naic.org) by close of business 11/7/2023.

1. Bearing in mind that there will be updated quantitative comparisons of the corporate models[1], please indicate whether you are currently supportive of utilizing the Conning GEMS® corporate model, the American Academy of Actuaries Economic Scenario Subcommittee's corporate model (see Attachment A), and/or believe either model may be appropriate. Please provide a rationale, including what you see as the relative strengths and weaknesses of each of the models.
2. Please note and explain any material deficiencies in the current documentation provided for the Conning GEMS® corporate model see (Attachments B and C). Straightforward, specific illustrations of the practical impact of any deficiencies are encouraged. Additional documentation is available at https:\naic.conning.com/scenariofiles.

[1] The Conning GEMS® model is currently being recalibrated to align with the exposed acceptance criteria that were developed by the American Academy of Actuaries Economic Scenario Subcommittee and later modified by regulators from the Life Actuarial (A) Task Force and Life RBC (E) Working Group. Quantitative comparisons of the two corporate models will be provided once the recalibration of the Conning GEMS® is completed.

Attachment A

Corporate Credit & Bond Fund Returns —

Stylized Facts, Acceptance Criteria, and a Simplified Model

Jason Kehrberg, MAAA, FSA
Chairperson, Economic Scenario Generator Work Group (ESGWG)

Hal Pedersen, MAAA, ASA
Member, Economic Scenario Generator Work Group (ESGWG)

Iouri Karpov, MAAA, FSA
Member, Economic Scenario Generator Work Group (ESGWG)

National Association of Insurance Commissioners (NAIC) Life Actuarial (A) Task Force (LATF)
December 11, 2022

American Academy of Actuaries

1. Background
2. Stylized Facts
3. Acceptance Criteria
4. A Simplified Model
5. Discussion and Q&A
6. Appendices

1.

Background

LATF asked the ESGWG to deliver a series of presentations focused on proposing qualitative **Stylized Facts** and quantitative **Acceptance Criteria** for the three major components of an ESG used for statutory reporting purposes: **Interest Rates**, **Equity Returns**, and **Corporate Bond Fund Returns**

Prior presentations in this series:

- A Framework for Working with ESGs (8/8/22)
- ESG Governance Considerations (8/8/22)
- Equity Returns—Stylized Facts (8/9/22)

This and future presentations in this series:

- **Corporate Credit & Bond Fund Returns—Stylized Facts, Acceptance Criteria, and a Simplified Model**
- Interest Rates—Stylized Facts and Acceptance Criteria
- Equity Returns—Acceptance Criteria

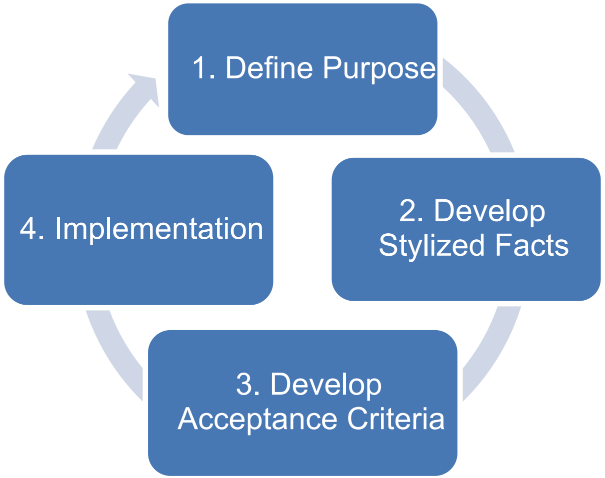
This presentation proposes **Stylized Facts** and **Acceptance Criteria** for Corporate Credit Spreads and Bond Index Fund Returns that (a) are independent of any specific ESG model, (b) can be used to identify and evaluate candidate ESG models, and (c) can be used to evaluate a set of stochastic scenarios.

In addition to Stylized Facts and Acceptance Criteria, this presentation also proposes a **Simplified Model**.

- Regulators expressed interest in the ESGWG proposing an alternative corporate bond fund return model that is **fully documented** so that the model can be appropriately reviewed and understood.
- Like GEMS, the simplified model simulates **four** U.S. corporate bond fund indices→

Label	Bond Fund Index
IG 1-5	U.S. Corp. Investment Grade 1-5 year
IG 5-10	U.S. Corp. Investment Grade 5-10 year
IG Long	U.S. Corp. Investment Grade Long (10+ year)
HY	U.S. Corp. High Yield (Below Investment Grade)

A framework for developing, implementing, and evaluating ESGs and the scenario sets they produce



1. **Define Purpose**: The intended purpose of the ESG informs the economic variables to be simulated and the relative importance of their "stylized facts."
2. **Develop Stylized Facts** Stylized facts describe properties of the economic variables to be simulated. They are based on historical market data and economic theory and are prioritized relative to the defined purpose at hand. The establishment of stylized facts is critical for selecting candidate ESG models and a key prerequisite for the development of acceptance criteria.
3. **Develop Acceptance Criteria** A set of quantitative metrics or target values at different time horizons or in different economic conditions used to ensure the scenarios produced by the ESG are consistent with defined stylized facts.
4. **Implementation** : ESG models are selected based on their ability to reflect defined stylized facts, then calibrated in accordance with acceptance criteria. Scenario sets are validated against defined acceptance criteria. This is an iterative process. It is important to periodically review and recalibrate the ESG as market conditions change over time.

2.

Stylized Facts

Stylized Facts have been grouped into 6 categories with 1 to 3 Stylized Facts each:

- 3 categories for **Corporate Credit Spreads**
- 3 categories for **Bond Index Fund Returns**

Corporate Credit Spreads

1. General nature of credit markets and credit spreads
2. Relation across qualities and maturities
3. Relation to other market variables

Bond Index Fund Returns

4. General nature of bond index funds
5. Bond index fund return dynamics
6. Relation to other asset classes

1. Corporate Credit Spreads—General nature of credit markets and credit spreads

a. Credit markets tend to be cyclical with elevated defaults and migrations at the end of credit cycles. Credit-related losses tend to be “lumpy” or episodic.

b. Credit spreads are positive and have a strong tendency to revert to long-term normative levels (generally within three to four years).

c. Credit spreads exhibit volatility clustering (i.e., regimes of high and low volatility), and volatility has a strong tendency to revert to long-term normative levels.

American Academy of Actuaries

a. As a bond's credit quality decreases credit spreads, spread volatility, and the risk of loss increase.
b. Longer maturity bonds generally have higher credit spreads than shorter maturity bonds. However, the credit spreads on shorter maturity bonds are more sensitive to current market conditions, so during market stresses credit spreads on shorter maturity bonds may increase more than credit spreads on longer maturity bonds.
c. Credit spreads for different qualities and maturities tend to be strongly correlated (e.g., 80% or more).

3. Corporate Credit Spreads —Relation to other market variables

a. Credit spreads tend to be higher and more volatile in equity bear markets (i.e., strong positive correlation to equity volatility, strong negative correlation to equity returns).

b. Credit spreads tend to be negatively correlated with Treasury rates (i.e., flight to quality during market stress).

4. Bond Index Fund Returns —General nature of bond index funds

a. A corporate bond fund is generally actively managed (regularly rebalanced) to meet defined maturity and quality targets (e.g., 5- to 10-year investment grade bonds) by trading individual bonds into and out of the fund. Such trading tends to increase when the corporate bond market experiences high levels of credit migration.

5. Bond Index Fund Returns —Bond index fund return dynamics

a. Bond index fund total returns reflect the impact of risk-free rates (and changes in risk-free rates) as well as credit-related returns in "excess" of risk-free rates.

- **Total return** = Risk free return + Excess return
- **Excess return** = Spread-based return - Frictional costs
- **Spread-based return** reflects credit spread income and price returns (i.e., changes in market price due to spread movement).
- **Frictional costs** reflect costs due to defaults (net of recoveries), migrations (e.g., selling downgraded bonds at a loss when they no longer meet the fund's quality targets), and rebalancing.

b. Bond index fund returns vary with the credit cycle.

- **Spread-based return** tends to decline significantly when spreads explode but then recover as spreads mean revert and migrations/defaults occur (i.e., the portfolio is purged).
- **Frictional costs** (which are generally not recoverable) tend to cluster and accumulate rapidly as bonds migrate/default, with severity depending on the magnitude and duration of the credit cycle.

6. Bond Index Fund Returns —Relation to other asset classes

a. Bond funds have risk/reward relationships that are generally consistent with other asset classes over long horizons.
b. Credit spreads for bond funds held in the separate account should be consistent with economic assumptions for bonds held in the general account.

Goals related to bond fund scenarios from Conning/NAIC 12/17/20 presentation to LATF

Goals relating to equity and bond fund scenarios:

1. Returns should be provided for funds representative of those offered in U.S. insurance products.
2. The ESG should be calibrated using an appropriate historical period.

Goals relating to the bond fund scenarios:

8. The same model should be used to produce bond fund returns for the Basic and Robust Data Sets*, and the returns should reflect credit rating transitions, defaults, and dynamic spreads.
9. Separate yield curves should be generated by rating, and they should be linked to each other.
10. The spread between Treasuries and corporate bonds should be stochastic.
11. The ESG should include bond credit rating transitions and they should be dynamic.

* *Only goals that were related to the bond fund scenarios are listed above (goals 3-7 were only related to the equity scenarios).*

- These goals are generally consistent with the stylized facts presented on the prior two slides.
- Note that stylized facts are generally *prioritized* based on the intended application, but the stylized facts themselves are generally independent of the intended application (largely based on historical data, sometimes supplemented with forward looking views).
- Note that stylized facts and their prioritization are generally independent of the model since models differ in their ability to reflect the various market properties described by stylized facts.

3.

Acceptance Criteria

Given the intended purpose, acceptance criteria should be consistent with the Valuation Manual

VM-20 Section 9.F. prescribes deterministic tables of baseline defaults, current spreads, and ultimate spreads for projecting general account **individual bonds**.

- VM-20 prescribed spreads grade from current to ultimate over the first four years of the projection.
- VM-20 prescribed baseline default costs represent the annualized average default cost over the remaining life of a bond given its credit rating and weighted average life at the start of the projection.

The ESG produces bond fund returns for projecting separate account **bond funds**.

- These bond fund return scenarios should be consistent with VM-20's prescribed tables of spreads and defaults for use when projecting individual bonds in the general account.
- Bond fund indices experience significant frictional costs compared to individual bonds that are bought and held (largely from having to periodically rebalance bonds in the fund as they move outside the fund's target range for credit quality, or maturity).

Credit spread steady-state targets and mean reversion should be consistent with VM-20

Steady state credit spread targets:

- Determined by averaging VM-20 general account fixed income ultimate spreads at [12/31/21].

Steady state credit spread targets	IG 1-5	IG 5-10	IG Long	HY
Quality range	[Aa3/AA- to Baa1/BBB+]	[Aa3/AA- to Baa1/BBB+]	[Aa3/AA- to Baa1/BBB+]	[Ba3/BB- to B1/B+]
Maturity (WAL) range	[1 to 5 years]	[>5 to 10 years]	[>10 to 30 years]	[1 to 10 years]
Target (avg. VM-20 ult. spread at [12/31/21])	**107 bps**	**141 bps**	**163 bps**	**448 bps**

Mean reversion of credit spreads:

- VM-20 prescribes a 4-year grading period for general account fixed income spreads.
- Let "m" = the number of months into the projection when the average modeled credit spread is **halfway** between initial and steady state levels.
- Acceptance criteria: "m" should be between [22] and [26] (i.e., around two years).

American Academy of Actuaries

Target excess returns are derived from average VM-20 spreads and the historical relationship between excess returns and Option-Adjusted Spread (OAS)

Historical averages (1999 to 2021) from Bloomberg *(bps)*	IG 1-5	IG 5-10	IG Long	HY
Option Adjusted Spread *(OAS)*	124	156	1.80	534
Spread Return *(determined from OAS and duration series)*	129	168	1.95	559
Excess Return	98	100	88	311
Frictional Cost *(Spread Return-Excess Return)*	31	68	107	248

Historical OAS split – Frictional Cost vs. Excess Return	IG 1-5	IG 5-10	IG Long	HY
Frictional Cost % of OAS	25%	44%	60%	46%
Excess Return % of OAS	75%	56%	40%	54%

Steady state targets *(bps)*	IG 1-5	IG 5-10	IG Long	HY
Target OAS *(avg. VM-20 ult. spread at [12/31/21])*	107	141	163	448
Target Excess Return *(Target OAS * Excess Return % of OAS)*	80	79	66	240
Criteria for avg. annualized Excess Return in years [20-30]	80 ±[10]	79 ±[10]	66 ±[10]	240 ±[20]

- Frictional Cost % of OAS increases with fund maturity, as longer debt incurs higher migration costs in the IG corporate universe.
- IG 5-10 and HY both have maturities of about seven years as well as similar Frictional Cost % of OAS.
- Documentation on Bloomberg's excess return definitions/calculations (pp. 85-88 of linked doc)

American Academy of Actuaries

Proposed cap on maximum excess return

The acceptance criteria on the previous slide ensures the average (across all scenarios) modeled excess return in years [20-30] is close to the target excess return.

The additional guardrail below protects against overly optimistic risk/reward relationships in an individual scenario.

- Rationale: The high spreads observed during periods of market stress have generally been offset by increased frictional costs and decreased performance of bond index funds (especially for IG Long and HY). Over the long term the upside on credit returns appears limited (capped).
- Let “a” = Target OAS (i.e., average VM-20 ultimate spread at [12/31/21]) + [50 bps].
- Let “b” = any one scenario’s annualized excess return over years [0-30] of the projection, where initial spread level was set equal to ultimate target OAS
- “b” should not exceed “a”.

Illustrative application of additional guardrail *(bps)*	IG 1-5	IG 5-10	IG Long	HY
Target OAS *(avg. VM-20 ult. spread at [12/31/21])*	107	141	163	448
Target OAS + 50 bps *(“a”)*	157	191	213	498
Max annualized excess return over years [20-30]:				
Scenario Set *ABC (“b”)*	190	160	200	660
Scenario Set *XYZ (“b”)*	140	120	160	350

American Academy of Actuaries

Bond fund returns are correlated with equity returns and interest rates (and with other bond fund indices)

Modeled Spreads for bond indices should reflect a strong relationship to equity (SPX).

- Positive correlation of [60%±10%] to SPX Variance
- Negative correlation of [-60% ± 10%] to SPX Return

Credit risk tends to increase during volatile bear markets, which increases credit spreads.

Modeled Excess Returns for bond indices should also reflect a strong relationship to equity; but directionally inverse to Modeled Spreads.

- Negative correlation to SPX Variance
- Positive correlation to SPX Return

Frictional costs tend to increase during volatile bear markets, which also decreases excess returns.

Note: Acceptance criteria for the correlation of ***total*** bond index fund returns to equity and interest rates could also be developed.

Modeled Spreads and Excess Returns should reflect a very strong relationship across bond indices.

- Very similar dynamics → Correlations between bond fund indices should be greater than [80%].

Supporting Data:

Historical Correlations between Spread and Equity/Interest Rate Markets

	Int Rate Level	SPX Variance	SPX Return	IG 1-5 Spread	IG 5-10 Spread	IG Long Spread	HY Spread	Data Period
Int Rate Level	1.00							12/1960 – 12/2021
SPX Variance	0.02	1.00						12/1960 – 12/2021
SPX Return	-0.09	-0.68	1.00					12/1960 – 12/2021
IG 1-5 Spread	-0.18	0.52	-0.54	1.00				1/1990 - 12/2021
IG 5-10 Spread	-0.27	0.59	-0.63	0.92	1.00			1/1999 - 12/2021
IG Long Spread	-0.30	0.57	-0.60	0.82	0.94	1.00		1/1990 - 12/2021
HY Spread	-0.32	0.62	-0.67	0.80	0.87	0.84	1.00	11/1995 - 12/2021

American Academy of Actuaries

4.

A Simplified Model

American Academy of Actuaries

A simplified model for returns on corporate bond fund indices

The simplified model is consistent with Conning's previously presented goals and the ESGWG's recommended stylized facts and acceptance criteria.

The simplified model is fully documented, specified, and calibrated. It has been peer reviewed and is ready for implementation.

The model simulates excess returns on the same four corporate bond fund indices.

- Excess return = Spread-based return – Frictional costs.
- Ultimately, Total return (Treasury return + Excess return) would be simulated by adding excess returns to appropriately calculated and internally consistent returns on government bond funds of similar maturity profiles.

The model is simplified in that it implicitly reflects the impact of credit migration and defaults.

- For each of the funds in GEMS, the simplified model derives excess credit-related returns using stochastic credit spreads by rating but reflects the impact of credit migration, defaults, and recoveries as simplified frictional costs.
- The historically implied frictional cost is fitted using a linear functional relationship between the trailing OAS and the costs to rebalance the fund. This fitting approach ensures the frictional cost is positive and increases with the spread.

A simplified model for returns on corporate bond fund indices (cont.)

Steady-state credit spread targets and mean reversion speeds are consistent with 2VM general account fixed income spreads.

Duration is estimated as a function of bond maturity and bond yield.

- The model captures fluctuations in long maturity fund durations observed when the level of yield changes.

Modeled relationship between credit spreads

- We propose a single random driver for all the indices to ensure rational behavior of credit spreads and capture 90% of spread variation across the indices.

Relationship to Equity and Interest Rates

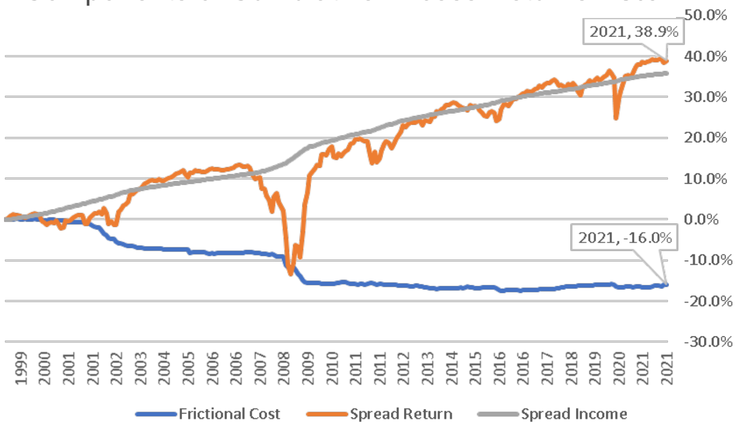
- Using a simplified correlation matrix, the model captures relationships between credit spreads, equity volatility, equity return, interest rate level, and interest rate volatility.
- This correlation matrix approach can be used to generate stochastic bond index fund excess returns which are consistent with any underlying stochastic interest rate and/or equity model.

Simplified decomposition of bond index excess return into spread return and frictional cost

$Excess\ Return = Spread\ Return - Frictional\ Cost$, where:

- $Spread\ Return_t = Spread_{t-1}\Delta t - Duration_{t-1}(Spread_t - Spread_{t-1})$ reflects the earned credit spread as well as the change in market price due to spread movement.
- $Frictional\ Cost$ reflects the effects of defaults, migrations, and otherwise forced rebalancing that occurs within the index fund.

Components of Cumulative Excess Returns: IG05

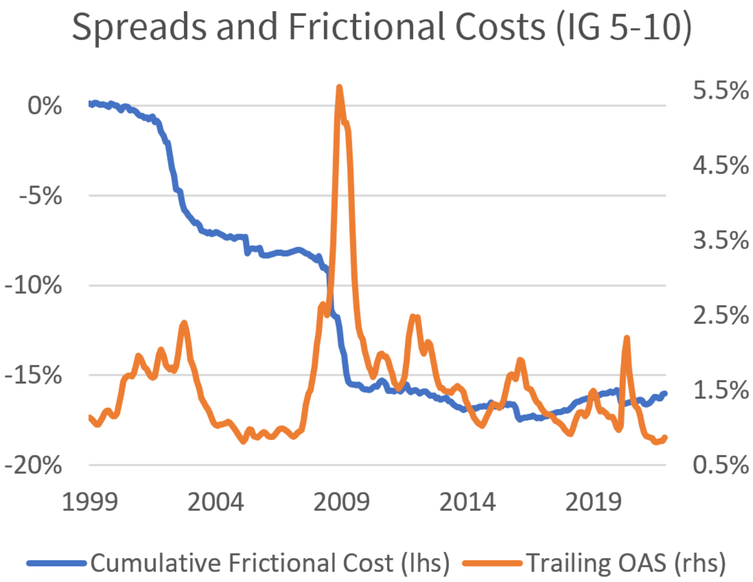


- Cumulative Excess Return from 1999 to 2021 was 22.9% (100bps/year), as a combination of 38.9% in spread return (average OAS of 168bps) offset by frictional losses of 16% (70bps/year).
- Spread Return was calculated using Bloomberg OAS and duration time series, while the implied Frictional Cost was calculated as Excess Return less Spread Return.
- Spread Return varies with level of spreads, but ultimately reverts to earned spread income.
- Frictional Cost tends to be relatively stable, with costs accruing aggressively in early 1990s, 2000s (.com bubble) and in 2008 (financial crisis) as defaults and migrations punctuate the end of a credit cycle.

OAS exhibits strong mean reversion, zero bound, and clustering. These dynamics, which drive the volatility of Excess Return, are native to a lognormal Ornstein-Uhlenbeck "OU" process.

Cumulative Frictional Cost exhibits a relatively smooth step-like progression with most of the costs occurring during periods of elevated spreads (e.g., during breaks in the credit cycle).

Note: The relationship between spreads, equity returns, and interest rates is captured by correlating the random factors based on the historical correlation of spread residuals.



Credit Spreads: Simplified model based on mean reverting stochastic processes for each credit rating.

$ls_t = \min(ls_{t-1} + \beta(\ln(\tau) - ls_{t-1}) + \sigma Z_{ls,t}, max\_spread)$ where $spread_t = e^{ls_t}$ subject to reasonable cap, $ls_0 = \ln(init\_spread)$, *tau* (τ) = Target OAS (adj), and *beta* (β) = mean reversion.

Frictional Cost: Simplified model based on trailing 3-month credit spreads.

$cost_t = a + m_1 \min(\bar{s}_t, \kappa) + m_2 \max(\bar{s}_t - \kappa, 0)$ where $\bar{s}_t = \frac{1}{3}\sum_{i=1..3} spread_{t-i}$ is the 3-month trailing avg spread, and a = drift.

Excess Return: Simplified model based on Excess Return = Spread Return – Frictional Cost.

$Excess\ Return_t = [spread_{t-1}\,\Delta t - \frac{1}{2}(Dur_t + Dur_{t-1})\,(spread_t - spread_{t-1})] - cost_t$ where:

Dur_t is duration of the underlying fund based on its assumed maturity and semi-annual coupon determined as $coup_t = UST_{t,mat} + spread_t$.

Dur_t is determined using the closed-form approximation $Dur_t = .5\,(cS_n + nx^n)$ where $c = \max\left(\frac{1}{2} coup_t, .000001\right)$, $n = 2 \times maturity$, $x = \frac{1}{1+c}$, and $S_n = \frac{x-(n+1)x^{n+1}+nx^{n+2}}{(1-x)^2}$ is the partial sum representing par-coupon durations, while nx^n represents the duration of the principal payment.

AMERICAN ACADEMY *of* ACTUARIES

Calibration of the Spread component

The Spread component is calibrated to monthly historical OAS data sourced from relevant Bloomberg indices using Maximum Likelihood Estimation (MLE).

Index	Bloomberg Ticker	Data Period	Avg. Quality	Avg. Maturity (years)	Avg. OAS (basis points)	Avg. VM-20 Ultimate Spreads at 12/2021 (basis points)
U.S. Corp. IG 1–5	BUC1TRUU	1/1990-12/2021	A2-Baa1	3	112	107
U.S. Corp. IG 5–10	BCR5TRUU	1/1999-12/2021	A2-Baa1	7	156	141
U.S .Corp. IG Long (10–30)	LD07TRUU	1/1990-12/2021	A2-Baa1	23	152	163
U.S. Corp. HY	LF98TRUU	11/1995-12/2021	Ba3–B2	7	509	448

- A single shared random factor is used for all four indices to ensure reasonable relationships between indices (captures 90% of spread variation across the indices).
- Spread mean reversion (β) was set to 3% for all four bond fund indices to ensure reasonable relationships between indices and consistency with VM-20's 4-year grading period.
- Spread volatility (σ) was adjusted accordingly to preserve historical steady state process variance.
- Spread targets (τ) were adjusted to ensure average modeled spreads align with Target OAS (average VM-20 ultimate spread at [12/31/21]).

American Academy of Actuaries

Calibration of the Frictional Cost component

The Frictional Cost component is calibrated to implied 3-month trailing frictional costs:

- Uses the same Bloomberg index data used to calibrate the Spread component.
- Implied frictional cost is determined as the difference between Bloomberg's excess return data and a spread return calculated using Bloomberg's historical duration and OAS data.

The calibration is performed using least squares optimization with constraints:

- Constraint: Drift (a) $\geq .0001$ (ensures a minimum cost).
- Constraint: Multipliers $m1 \geq 0$ for IG and $m1 \geq .001$ for HY (ensures dynamic behavior when spreads are low).
- A penalty function is used to constrain cumulative estimated cost to equal historical Frictional Cost during the calibration period (ensures modeled costs will be in line with historical spread levels).

Adjustment to drift in order to meet average Excess Return criteria:

- Drift parameter (a) was adjusted to directly match the middle of the excess return criteria band on slide 19.

American Academy of Actuaries

Proposed parameter values

Parameters for the simplified model of excess returns on bond index fund

Spread Model

	IG 1-5	IG 5-10	IG Long	HY
tau (τ, spread target)	0.00920	0.01298	0.01493	0.04134
beta (β, mean rev.)	0.03	0.03	0.03	0.03
sigma (σ, volatility)	0.13557	0.09756	0.10181	0.09565
maturity	3.0	7.0	23.0	7.0
max_spread	0.06900	0.05900	0.05000	0.18329
init_spread (12/31/20)	Market based inputs			
VM-20 spread target	0.01069	0.01408	0.01627	0.04475

Frictional Cost Model

	IG 1-5	IG 5-10	IG Long	HY
drift (a)	0.00012	0.00018	0.00019	0.00034
kappa (κ)	0.01239	0.01362	0.01556	0.03650
mult1 (m_1)	0.00000	0.00000	0.00448	0.00100
mult2 (m_2)	0.06265	0.13773	0.18706	0.12111

Parameters (correlations) for implementing the simplifie model alongside existing interest and equity models.

Simplified Corr. Matrix based on ACLI v1.3 & SLV Equity

	Rate Log Vol	Log Long Rate	SPX Log Vol	SPX Return	Credit Spread
Rate Log Vol	1.00				
Log Long Rate	0.00	1.00			
SPX Log Vol	0.00	0.00	1.00		
SPX Return	0.00	0.00	-0.63	1.00	
Credit Spread	0.20	-0.35	-0.55	-0.60	1.00

Simplified Corr. Matrix based on GEMS GFF rates & Heston Equity

	CIR ("level")	SPX Variance	SPX Return	Credit Spread
CIR ("level")	1.00			
SPX Variance	0.00	1.00		
SPX Return	0.00	-0.68	1.00	
Credit Spread	-0.25	0.60	-0.60	1.00

American Academy of Actuaries

Excess return cumulative wealth factors —comparison to GEMS

The simplified model satisfies the acceptance criteria by design (its parameters were explicitly set to meet the criteria).

However, since GEMS results were readily available, and as an additional reasonableness check, the next four slides provide a comparison to GEMS.

- GEMS excess returns were determined by taking total returns from the four corporate bond fund indices and subtracting total returns from government bond fund indices with similar maturity profiles.

Summary

- **IG 1-5** and **IG 5-10**: Simplified model and GEMS cumulative excess return distributions are relatively similar.
- **IG Long** Simplified model cumulative excess return distribution is generally lower than GEMS.
- **HY**: Simplified model cumulative excess returns are significantly lower than GEMS in the right tail of the distribution.

American Academy of Actuaries

Excess return cumulative wealth factors —IG 1-5

IG 1-5: Simplified

	Proj. year 1	5	10	15	20	25	30
Min	0.93	0.91	0.93	0.94	0.98	1.01	1.07
0.5%	0.97	0.96	0.99	1.01	1.04	1.08	1.11
1.0%	0.98	0.97	1.00	1.02	1.05	1.08	1.12
2.5%	0.98	0.98	1.01	1.04	1.06	1.10	1.13
5.0%	0.99	0.99	1.02	1.04	1.08	1.11	1.15
10.0%	0.99	1.00	1.03	1.05	1.09	1.13	1.17
25.0%	1.00	1.01	1.04	1.07	1.11	1.15	1.20
50.0%	1.00	1.02	1.05	1.09	1.14	1.19	1.23
75.0%	1.00	1.02	1.07	1.11	1.17	1.22	1.27
90.0%	1.01	1.03	1.08	1.13	1.19	1.25	1.30
95.0%	1.01	1.03	1.09	1.15	1.20	1.26	1.33
97.5%	1.01	1.04	1.09	1.16	1.22	1.28	1.34
99.0%	1.01	1.04	1.10	1.17	1.24	1.30	1.36
99.5%	1.01	1.04	1.11	1.17	1.25	1.31	1.38
Max	1.01	1.06	1.14	1.23	1.29	1.38	1.46

IG 1-5: GEMS

	Proj. year 1	5	10	15	20	25	30
Min	0.92	0.91	0.93	0.96	0.98	1.00	1.03
0.5%	0.96	0.96	0.99	1.02	1.04	1.07	1.10
1.0%	0.97	0.97	1.00	1.03	1.05	1.08	1.12
2.5%	0.97	0.98	1.01	1.04	1.07	1.10	1.13
5.0%	0.98	0.99	1.02	1.05	1.08	1.11	1.14
10.0%	0.99	1.00	1.03	1.06	1.09	1.12	1.16
25.0%	1.00	1.01	1.04	1.07	1.11	1.14	1.18
50.0%	1.00	1.02	1.05	1.09	1.12	1.16	1.20
75.0%	1.00	1.03	1.06	1.10	1.14	1.19	1.23
90.0%	1.01	1.03	1.07	1.11	1.16	1.21	1.27
95.0%	1.01	1.03	1.07	1.12	1.17	1.23	1.29
97.5%	1.01	1.03	1.08	1.13	1.19	1.25	1.32
99.0%	1.01	1.04	1.08	1.14	1.20	1.28	1.35
99.5%	1.01	1.04	1.09	1.15	1.22	1.30	1.38
Max	1.01	1.05	1.11	1.21	1.33	1.53	1.75

Excess return cumulative wealth factors —IG 5-10

IG 5-10: Simplified

Proj. year	1	5	10	15	20	25	30
Min	0.85	0.76	0.75	0.80	0.84	0.92	0.93
0.5%	0.93	0.88	0.91	0.93	0.96	1.00	1.06
1.0%	0.94	0.90	0.93	0.95	0.99	1.03	1.08
2.5%	0.95	0.93	0.95	0.99	1.02	1.06	1.10
5.0%	0.96	0.95	0.97	1.01	1.05	1.09	1.13
10.0%	0.97	0.97	1.00	1.03	1.07	1.12	1.16
25.0%	0.99	1.00	1.03	1.07	1.11	1.15	1.20
50.0%	1.00	1.02	1.06	1.10	1.14	1.19	1.23
75.0%	1.01	1.04	1.08	1.12	1.17	1.21	1.26
90.0%	1.02	1.05	1.09	1.13	1.18	1.23	1.28
95.0%	1.02	1.05	1.10	1.14	1.19	1.24	1.30
97.5%	1.03	1.06	1.10	1.15	1.20	1.25	1.31
99.0%	1.03	1.06	1.11	1.16	1.21	1.26	1.32
99.5%	1.03	1.07	1.11	1.16	1.21	1.27	1.33
Max	1.04	1.08	1.13	1.18	1.24	1.29	1.37

IG 5-10: GEMS

Proj. year	1	5	10	15	20	25	30
Min	0.86	0.81	0.78	0.83	0.87	0.89	0.91
0.5%	0.91	0.88	0.92	0.95	0.98	1.02	1.06
1.0%	0.92	0.91	0.94	0.97	1.00	1.04	1.08
2.5%	0.94	0.93	0.96	1.00	1.03	1.07	1.12
5.0%	0.95	0.95	0.98	1.02	1.06	1.10	1.14
10.0%	0.97	0.97	1.01	1.04	1.08	1.13	1.17
25.0%	0.99	1.00	1.04	1.08	1.13	1.17	1.22
50.0%	1.00	1.03	1.07	1.12	1.17	1.22	1.28
75.0%	1.01	1.04	1.09	1.14	1.20	1.26	1.32
90.0%	1.02	1.05	1.10	1.16	1.22	1.29	1.36
95.0%	1.02	1.06	1.11	1.17	1.24	1.31	1.38
97.5%	1.02	1.06	1.12	1.18	1.25	1.32	1.40
99.0%	1.02	1.06	1.12	1.19	1.26	1.34	1.43
99.5%	1.02	1.06	1.13	1.20	1.27	1.36	1.45
Max	1.02	1.07	1.16	1.25	1.36	1.45	1.62

Excess return cumulative wealth factors —IG Long

IG Long: Simplified

Proj. year	1	5	10	15	20	25	30
Min	0.61	0.57	0.56	0.59	0.55	0.65	0.63
0.5%	0.77	0.68	0.70	0.71	0.74	0.76	0.81
1.0%	0.80	0.71	0.73	0.75	0.78	0.80	0.84
2.5%	0.84	0.76	0.79	0.81	0.84	0.87	0.90
5.0%	0.87	0.82	0.84	0.86	0.89	0.92	0.95
10.0%	0.90	0.87	0.89	0.92	0.95	0.99	1.02
25.0%	0.95	0.96	0.98	1.01	1.04	1.08	1.11
50.0%	1.01	1.03	1.07	1.10	1.13	1.17	1.21
75.0%	1.05	1.09	1.13	1.16	1.21	1.25	1.29
90.0%	1.09	1.14	1.18	1.21	1.26	1.31	1.36
95.0%	1.11	1.16	1.20	1.24	1.29	1.34	1.39
97.5%	1.12	1.18	1.22	1.26	1.32	1.36	1.42
99.0%	1.14	1.20	1.25	1.29	1.34	1.39	1.45
99.5%	1.15	1.21	1.26	1.30	1.36	1.41	1.48
Max	1.19	1.27	1.31	1.39	1.43	1.49	1.58

IG Long: GEMS

Proj. year	1	5	10	15	20	25	30
Min	0.73	0.63	0.60	0.68	0.71	0.78	0.78
0.5%	0.82	0.77	0.81	0.86	0.88	0.93	0.97
1.0%	0.84	0.80	0.84	0.89	0.92	0.98	1.02
2.5%	0.87	0.85	0.89	0.94	0.98	1.03	1.08
5.0%	0.90	0.88	0.93	0.98	1.03	1.08	1.13
10.0%	0.93	0.93	0.97	1.03	1.08	1.13	1.19
25.0%	0.97	0.99	1.04	1.10	1.15	1.22	1.28
50.0%	1.00	1.04	1.10	1.17	1.23	1.30	1.38
75.0%	1.03	1.08	1.15	1.22	1.30	1.38	1.46
90.0%	1.04	1.11	1.19	1.27	1.36	1.44	1.53
95.0%	1.05	1.12	1.21	1.29	1.38	1.48	1.57
97.5%	1.06	1.13	1.22	1.31	1.40	1.50	1.60
99.0%	1.06	1.14	1.24	1.33	1.43	1.54	1.64
99.5%	1.07	1.16	1.25	1.35	1.45	1.56	1.66
Max	1.08	1.19	1.30	1.41	1.55	1.63	1.80

American Academy of Actuaries

Excess return cumulative wealth factors —HY

HY: Simplified

	Proj. year						
	1	5	10	15	20	25	30
Min	0.62	0.52	0.53	0.65	0.72	0.94	0.96
0.5%	0.81	0.74	0.82	0.90	1.00	1.13	1.33
1.0%	0.83	0.78	0.87	0.96	1.08	1.20	1.39
2.5%	0.87	0.84	0.94	1.04	1.17	1.32	1.49
5.0%	0.90	0.90	0.99	1.11	1.25	1.40	1.58
10.0%	0.92	0.95	1.06	1.19	1.34	1.50	1.69
25.0%	0.97	1.04	1.16	1.30	1.46	1.65	1.85
50.0%	1.02	1.12	1.25	1.40	1.59	1.79	2.01
75.0%	1.06	1.18	1.33	1.49	1.69	1.91	2.15
90.0%	1.09	1.22	1.38	1.55	1.76	2.00	2.26
95.0%	1.11	1.24	1.40	1.59	1.80	2.05	2.31
97.5%	1.12	1.26	1.43	1.61	1.83	2.08	2.36
99.0%	1.14	1.27	1.45	1.64	1.87	2.12	2.41
99.5%	1.14	1.28	1.46	1.66	1.89	2.15	2.44
Max	1.18	1.33	1.51	1.73	1.98	2.24	2.60

HY: GEMS

	Proj. year						
	1	5	10	15	20	25	30
Min	0.81	0.88	0.96	1.07	1.20	1.40	1.58
0.5%	0.90	0.97	1.10	1.22	1.36	1.53	1.72
1.0%	0.92	0.99	1.11	1.24	1.40	1.57	1.76
2.5%	0.94	1.02	1.15	1.29	1.44	1.63	1.83
5.0%	0.97	1.04	1.17	1.32	1.48	1.68	1.90
10.0%	0.99	1.07	1.20	1.35	1.54	1.74	1.98
25.0%	1.02	1.11	1.25	1.42	1.62	1.86	2.13
50.0%	1.05	1.14	1.30	1.50	1.74	2.02	2.35
75.0%	1.06	1.17	1.37	1.62	1.91	2.25	2.64
90.0%	1.07	1.21	1.46	1.77	2.12	2.52	2.99
95.0%	1.07	1.24	1.54	1.89	2.28	2.74	3.26
97.5%	1.08	1.27	1.63	2.04	2.44	2.98	3.59
99.0%	1.08	1.33	1.76	2.19	2.70	3.28	4.02
99.5%	1.08	1.38	1.87	2.35	2.92	3.57	4.38
Max	1.09	1.66	2.41	3.19	4.13	5.63	7.16

5.

Discussion and Q&A

Thank You

Contact:

- Amanda Barry-Moilanen, Life Policy Analyst, barrymoilanen@actuary.org

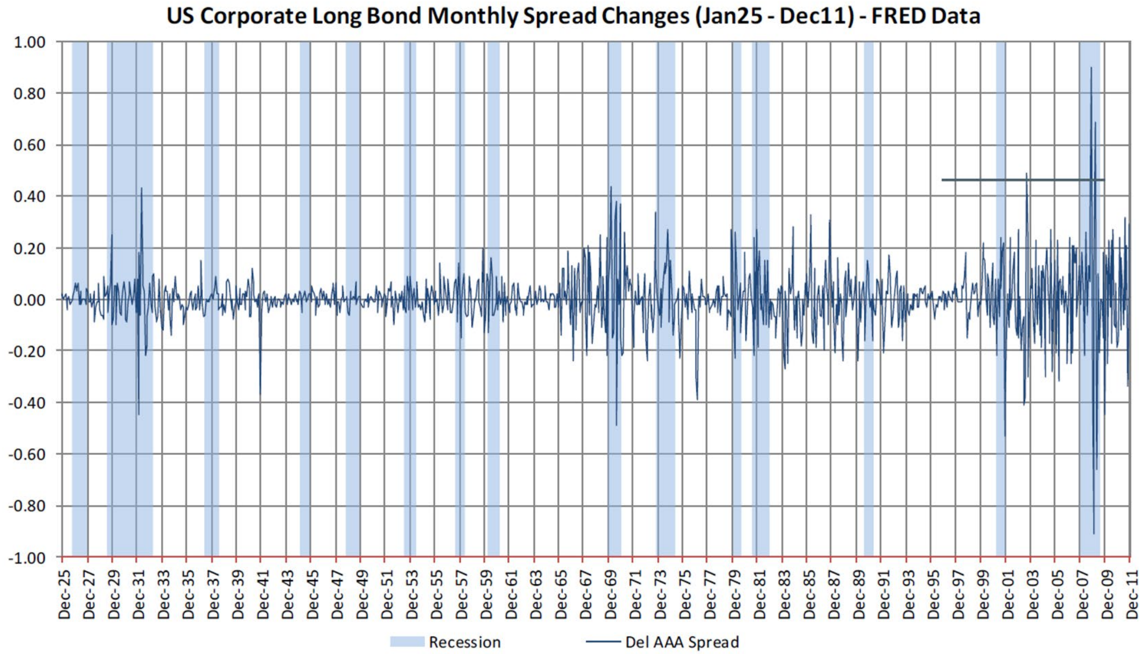
American Academy of Actuaries

6.1

Appendix 1:
Support for Stylized Facts

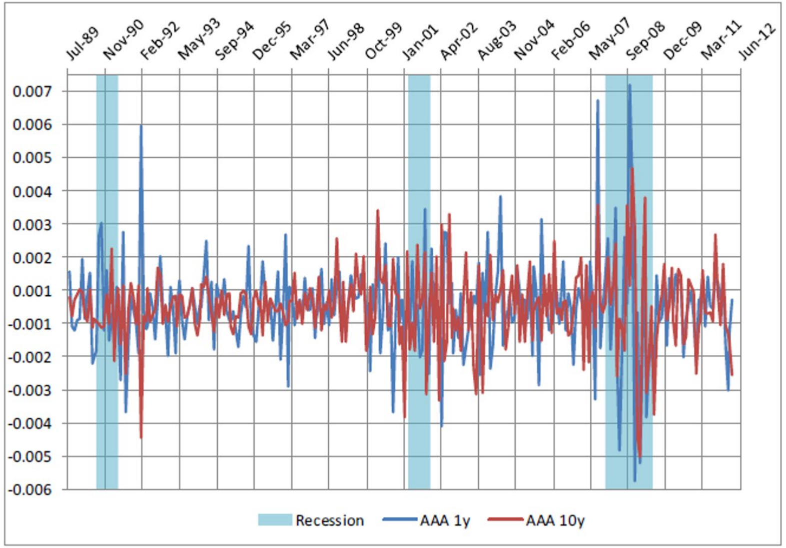
American Academy of Actuaries

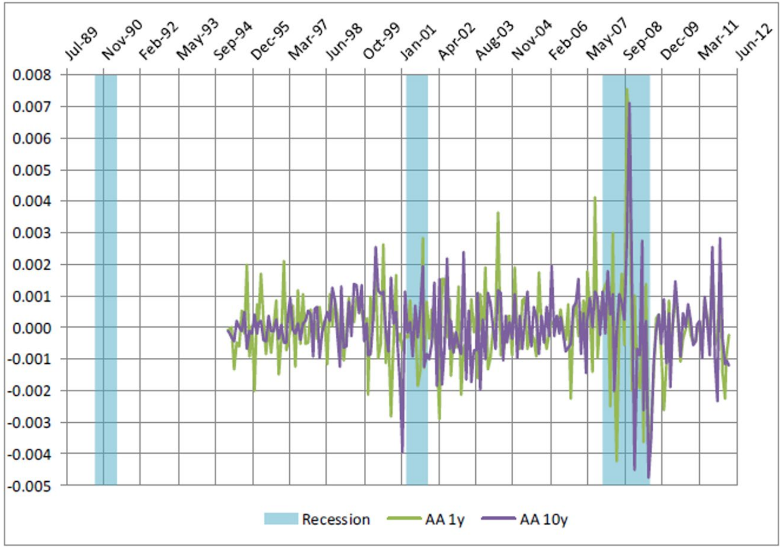
Support for Stylized Facts:
Monthly changes in U.S. credit spreads, 1925 –2011



Source: Economic Scenario Generators: A Practical Guide (SOA, 2016)

Support for Stylized Facts:
Monthly changes in U.S. credit spreads, 1989–2012 (AAA, AA)

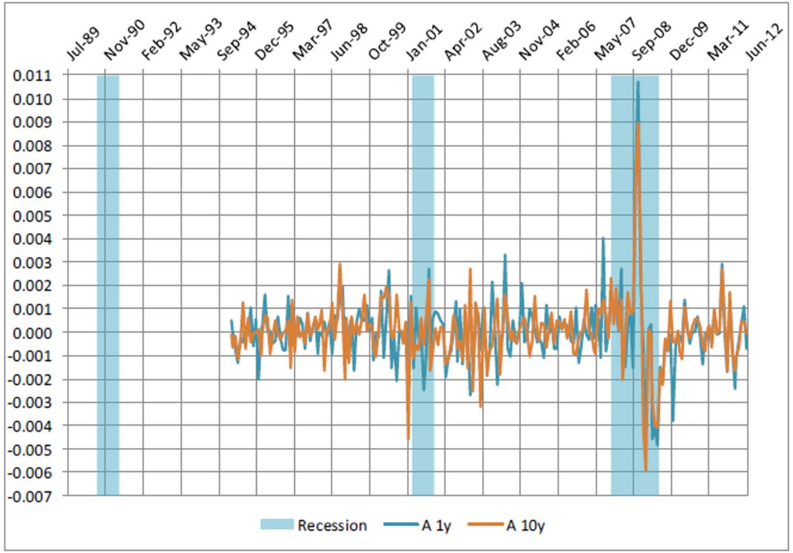


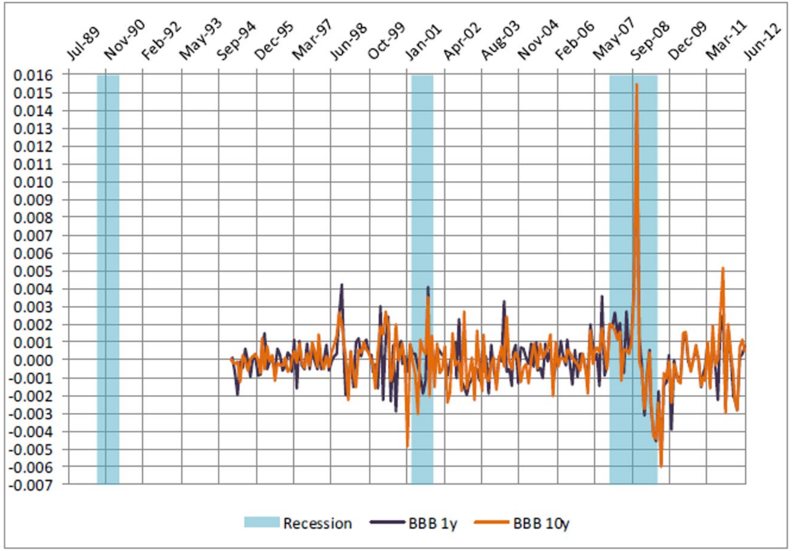


Source: Economic Scenario Generators: A Practical Guide (SOA, 2016)

American Academy of Actuaries

Support for Stylized Facts: Monthly changes in U.S. credit spreads, 1989–2012 (A, BBB)

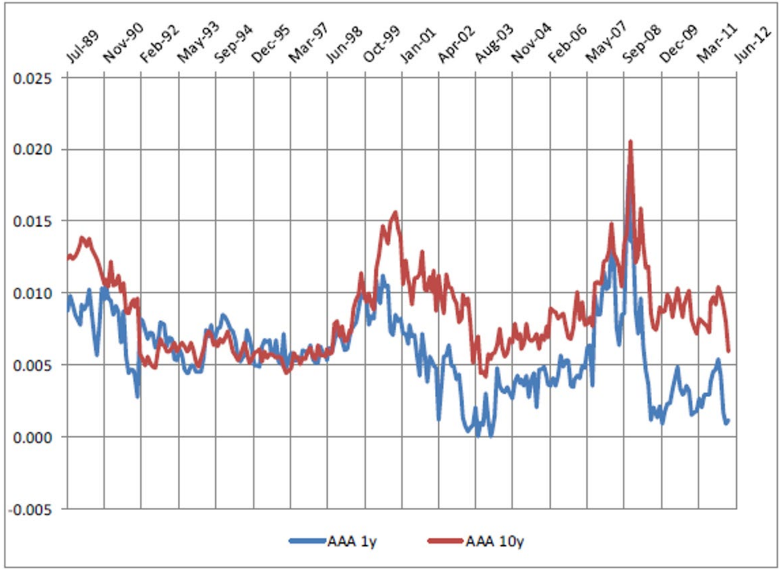




Source: Economic Scenario Generators: A Practical Guide (SOA, 2016)

American Academy of Actuaries

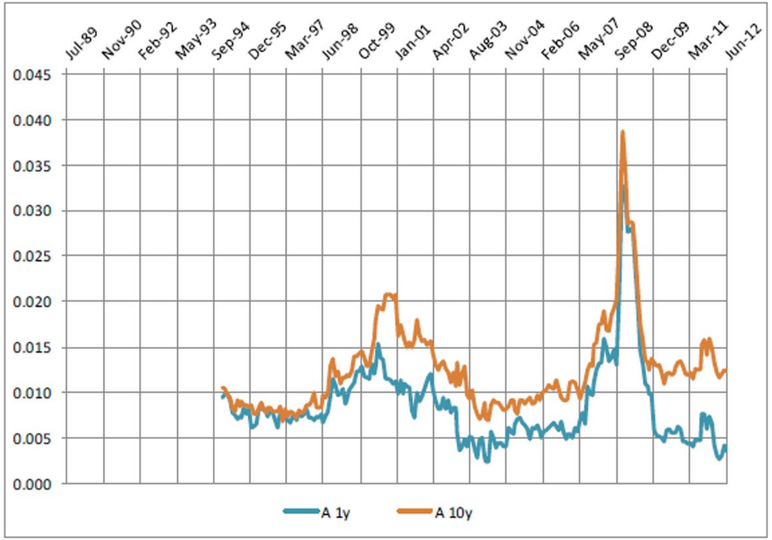
Support for Stylized Facts: Spreads for U.S. industrial zero -coupon bonds, 1989 –2012 (AAA, AA)

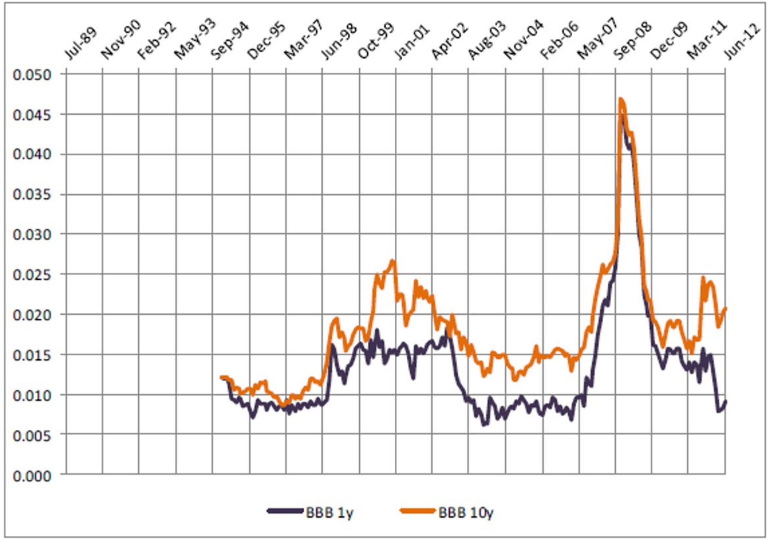


Source: Economic Scenario Generators: A Practical Guide (SOA, 2016)

AMERICAN ACADEMY of ACTUARIES

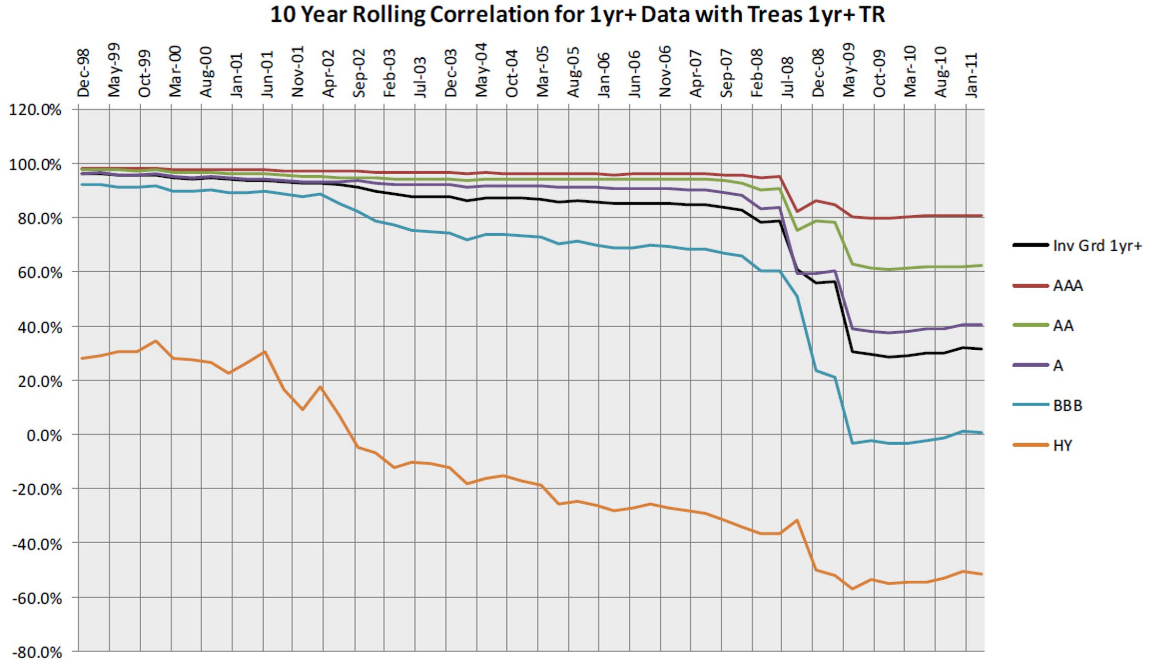
Support for Stylized Facts: Spreads for U.S. industrial zero-coupon bonds, 1989–2012 (A, BBB)





Source: Economic Scenario Generators: A Practical Guide (SOA, 2016)

Support for Stylized Facts: Correlations between corporate bonds and Treasuries, 1998 –2011



Source Economic Scenario Generators: A Practical Guide (SOA, 2016)

AMERICAN ACADEMY of ACTUARIES

6.2

Appendix 2: Support for Acceptance Criteria

Determining targets from VM-20 steady state spreads at 12/31/21

WAL	Aaa AAA	Aa1 AA+	Aa2 AA	Aa3 AA-	A1 A+	A2 A	A3 A-	Baa1 BBB+	Baa2 BBB	Baa3 BBB-	Ba1 BB+	Ba2 BB	Ba3 BB-	B1 B+	B2 B	B3 B-	Caa1 CCC+	Caa2 CCC	Caa3 CCC-	Ca CC
1	37.01	46.90	56.78	64.93	73.08	81.23	98.73	116.22	133.72	218.70	303.68	361.21	418.74	476.27	533.79	688.10	842.40	996.71	1151.02	1305.32
2	42.33	53.95	65.58	74.14	82.69	91.25	109.41	127.57	145.72	224.70	303.68	361.21	418.74	476.27	533.79	688.10	842.40	996.71	1151.02	1305.32
3	47.64	61.01	74.38	83.35	92.31	101.27	120.09	138.91	157.73	230.71	303.68	361.21	418.74	476.27	533.79	688.10	842.40	996.71	1151.02	1305.32
4	52.96	68.07	83.18	92.55	101.92	111.29	130.77	150.25	169.73	236.71	303.68	361.21	418.74	476.27	533.79	688.10	842.40	996.71	1151.02	1305.32
5	59.45	74.31	89.17	99.51	109.85	120.19	140.42	160.65	180.88	242.28	303.68	361.21	418.74	476.27	533.79	688.10	842.40	996.71	1151.02	1305.32
6	65.94	80.55	95.16	106.47	117.78	129.08	150.07	171.05	192.03	247.86	303.68	361.21	418.74	476.27	533.79	688.10	842.40	996.71	1151.02	1305.32
7	68.50	84.18	99.86	110.50	121.14	131.79	152.75	173.72	194.69	249.19	303.68	361.21	418.74	476.27	533.79	688.10	842.40	996.71	1151.02	1305.32
8	71.07	87.81	104.55	114.53	124.51	134.49	155.44	176.39	197.34	250.51	303.68	361.21	418.74	476.27	533.79	688.10	842.40	996.71	1151.02	1305.32
9	73.63	91.44	109.25	118.56	127.88	137.19	158.12	179.06	199.99	251.84	303.68	361.21	418.74	476.27	533.79	688.10	842.40	996.71	1151.02	1305.32
10	75.37	93.27	111.17	120.30	129.44	138.58	159.70	180.83	201.95	252.82	303.68	361.21	418.74	476.27	533.79	688.10	842.40	996.71	1151.02	1305.32
11	77.11	95.10	113.08	122.05	131.01	139.97	161.28	182.59	203.90	253.79	303.68	361.21	418.74	476.27	533.79	688.10	842.40	996.71	1151.02	1305.32
12	78.85	96.92	115.00	123.79	132.57	141.36	162.86	184.36	205.86	254.77	303.68	361.21	418.74	476.27	533.79	688.10	842.40	996.71	1151.02	1305.32
13	80.59	98.75	116.92	125.53	134.14	142.75	164.44	186.12	207.81	255.75	303.68	361.21	418.74	476.27	533.79	688.10	842.40	996.71	1151.02	1305.32
14	82.33	100.58	118.84	127.27	135.70	144.14	166.01	187.89	209.77	256.73	303.68	361.21	418.74	476.27	533.79	688.10	842.40	996.71	1151.02	1305.32
15	84.07	102.41	120.76	129.01	137.27	145.53	167.59	189.66	211.72	257.70	303.68	361.21	418.74	476.27	533.79	688.10	842.40	996.71	1151.02	1305.32
16	85.81	104.24	122.68	130.76	138.84	146.92	169.17	191.42	213.68	258.68	303.68	361.21	418.74	476.27	533.79	688.10	842.40	996.71	1151.02	1305.32
17	87.54	106.07	124.59	132.50	140.40	148.31	170.75	193.19	215.63	259.66	303.68	361.21	418.74	476.27	533.79	688.10	842.40	996.71	1151.02	1305.32
18	89.28	107.90	126.51	134.24	141.97	149.70	172.33	194.96	217.59	260.64	303.68	361.21	418.74	476.27	533.79	688.10	842.40	996.71	1151.02	1305.32
19	91.02	109.73	128.43	135.98	143.53	151.09	173.90	196.72	219.54	261.61	303.68	361.21	418.74	476.27	533.79	688.10	842.40	996.71	1151.02	1305.32
20	92.76	111.56	130.35	137.73	145.10	152.47	175.48	198.49	221.50	262.59	303.68	361.21	418.74	476.27	533.79	688.10	842.40	996.71	1151.02	1305.32
21	94.50	113.39	132.27	139.47	146.67	153.86	177.06	200.26	223.45	263.57	303.68	361.21	418.74	476.27	533.79	688.10	842.40	996.71	1151.02	1305.32
22	96.24	115.21	134.19	141.21	148.23	155.25	178.64	202.02	225.41	264.55	303.68	361.21	418.74	476.27	533.79	688.10	842.40	996.71	1151.02	1305.32
23	97.98	117.04	136.11	142.95	149.80	156.64	180.22	203.79	227.36	265.52	303.68	361.21	418.74	476.27	533.79	688.10	842.40	996.71	1151.02	1305.32
24	99.72	118.87	138.02	144.69	151.36	158.03	181.79	205.56	229.32	266.50	303.68	361.21	418.74	476.27	533.79	688.10	842.40	996.71	1151.02	1305.32
25	101.46	120.70	139.94	146.44	152.93	159.42	183.37	207.32	231.27	267.48	303.68	361.21	418.74	476.27	533.79	688.10	842.40	996.71	1151.02	1305.32
26	103.20	122.53	141.86	148.18	154.49	160.81	184.95	209.09	233.23	268.46	303.68	361.21	418.74	476.27	533.79	688.10	842.40	996.71	1151.02	1305.32
27	104.94	124.36	143.78	149.92	156.06	162.20	186.53	210.86	235.18	269.43	303.68	361.21	418.74	476.27	533.79	688.10	842.40	996.71	1151.02	1305.32
28	106.68	126.19	145.70	151.66	157.63	163.59	188.11	212.62	237.14	270.41	303.68	361.21	418.74	476.27	533.79	688.10	842.40	996.71	1151.02	1305.32
29	108.42	128.02	147.62	153.40	159.19	164.98	189.68	214.39	239.09	271.39	303.68	361.21	418.74	476.27	533.79	688.10	842.40	996.71	1151.02	1305.32
30	110.16	129.85	149.53	155.15	160.76	166.37	191.26	216.15	241.05	272.37	303.68	361.21	418.74	476.27	533.79	688.10	842.40	996.71	1151.02	1305.32

	Quality Range	WAL Range	Avg. Spread
IG 1-5	[9□ Ā – 99□ ÷]	[1 to 5 yrs]	107
IG 5-10	[9□ Ā – 99□ ÷]	[>5 to 10 yrs]	141
IG Long	[9□ Ā – 99□ ÷]	[>10 to 30 yrs]	163
HY	[B9□ Ā – □ ÷]	[1 to 10 yrs]	448

Source: VM-20 Tables H & I at 12/31/21

American Academy of Actuaries

Simulated Excess Returns compared to Targets

Average excess returns (from 20 to 30yr in the projection) are aligned with historically implied targets and meet acceptance criteria for average annualized Excess Return. Note that the cost drift parameters, *a*, have been adjusted to directly match the midpoint of the criteria range.

The standard deviation (volatility) of monthly excess returns in the scenarios scale with maturity and lower quality (as expected).

Steady state Targets *(bps)*	IG 1-5	IG 5-10	IG Long	HY
Target OAS *(avg. VM20 ult. spread at [12/31/21])*	107	141	163	448
Target Excess Return *(Target OAS * Excess Return % of OAS)*	80	79	66	240
Criteria for avg. annualized Excess Return in years [20-30]	80 ±[10]	79 ±[10]	66 ±[10]	240 ±[20]

Simulation results (10,000 scenarios)	IG 1-5	IG 5-10	IG Long	HY
Avg. annualized Excess Return (bps)	80	79	66	240
Std. dev. annualized Excess Return (bps) (over entire proj.)	1.61%	3.06%	8.57%	8.63%

Distribution of Annualized Returns vs. Maximum Target

Annualized cumulative excess returns over 30 years were simulated by setting initial spread level to target OAS (based on VM20 guidance).

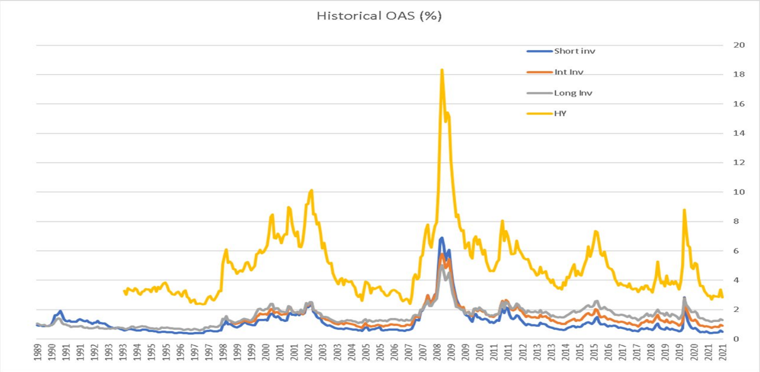
Based on this "steady-state" simulation, the maximum excess return across 10k scenarios in the Simplified Model is well within the proposed Excess Return Cap.

Annualized Cummulative Excess Return over 30 years

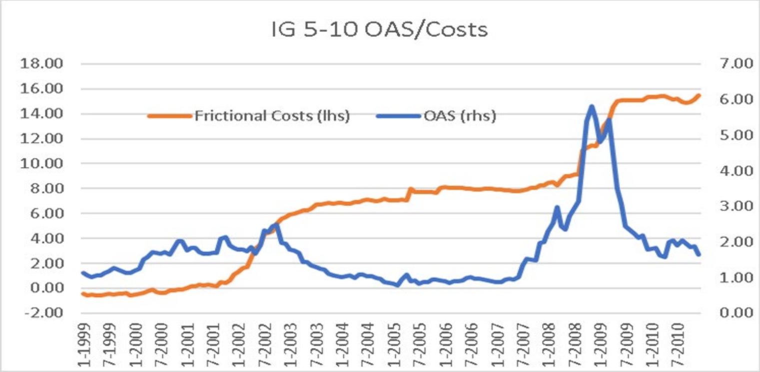
	min	1%	10%	50%	90%	99%	max	Excess Return Cap	Target OAS
IG 1-5	0.22%	0.38%	0.51%	0.70%	0.89%	1.03%	1.26%	1.57%	1.07%
IG 5-10	-0.25%	0.24%	0.49%	0.70%	0.83%	0.92%	1.05%	1.91%	1.41%
IG Long	-1.56%	-0.58%	0.05%	0.63%	1.01%	1.23%	1.52%	2.13%	1.63%
HY	-0.12%	1.09%	1.75%	2.33%	2.71%	2.93%	3.19%	4.98%	4.48%

Spread and frictional cost dynamics —History

- OAS exhibits mean reversion, 0 bound and clustering (OU process).
- Excess Return exhibits volatility driven by spread dynamics.



- Frictional Cost exhibits spikes at the break of the credit cycle when spreads are elevated.



Simplified Decomposition of Bond Fund Excess Return:

$\textit{Excess Return} = \textit{Spread Return} - \textit{Frictional Cost}$, where $\textit{Spread Return} = \textit{Spread}_{t-1}\Delta t - \textit{Duration}_{t-1}(\textit{Spread}_t - \textit{Spread}_{t-1})$

- *Spread Return* reflects the earned credit spread as well as the change in market price due to spread movement.
- *Frictional Cost* reflects the effects of defaults, migrations, and otherwise forced rebalancing that occurs within the bond fund.

American Academy of Actuaries

6.3

Appendix 3: Additional Detail on Simplified Model

Adjustments:

- Beta (β, mean reversion) set to 3% to ensure reasonable spread relationships between indices.
- Sigma (σ, volatility) adjusted to preserve steady state process variance: $\sigma^2/(2\beta-\beta^2)$.
- Tau (τ, spread target) is adjusted to ensure the steady state mean aligns with the VM-20 target and accounts for the convexity in the log-OU process.

Unadjusted (Historical) Parameters

	IG 1-5	IG 5-10	IG Long	HY
tau (τ)	0.01069	0.01408	0.01627	0.04475
beta (β)	0.02927	0.03613	0.01951	0.03443
sigma (σ)	0.13394	0.10690	0.08231	0.10235
maturity	3.0	7.0	23.0	7.0
max_spread	0.06900	0.05900	0.05000	0.18329
VM-20 target	0.01069	0.01408	0.01627	0.04475

Adjusted Parameters

	IG 1-5	IG 5-10	IG Long	HY
tau (τ)	0.00920	0.01298	0.01493	0.04134
beta (β)	0.03000	0.03000	0.03000	0.03000
sigma (σ)	0.13557	0.09756	0.10181	0.09565
maturity	3.0	7.0	23.0	7.0
max_spread	0.06900	0.05900	0.05000	0.18329
VM-20 target	0.01069	0.01408	0.01627	0.04475

Principle Components Analysis (PCA) Analysis

The PCA 1 (“Parallel”) factor accounts for 90% of historical variation across modeled indices.

→ Use a single random variable for all four indices to ensure reasonable relationships between indices.

Eigenvector decomposition	PCA1	PCA2	PCA3	PCA4
IG 1-5	0.4924	0.6729	0.4257	-0.3515
IG 5-10	0.5192	0.1522	-0.1594	0.8258
IG Long	0.5007	-0.1262	-0.7382	-0.4340
HY	0.4871	-0.7128	0.4985	-0.0787
Eigenvalue	3.5943	0.2093	0.1638	0.0325
R^2	89.9%	5.2%	4.1%	0.8%

Historical correlations between indices	IG 1-5	IG 5-10	IG Long	HY
IG 1-5	1.000			
IG 5-10	0.920	1.000		
IG Long	0.822	0.938	1.000	
HY	0.797	0.871	0.836	1.000

A simplified correlation matrix

Correlations between spread and equity/interest rate drivers are based on the historical correlation of spread residuals.

- Correlations between the bond indices were derived using overlapping historical periods from 1/1999 to 12/2021.
- Correlations with equity and interest rate factors were derived based on all available data above.
- Correlations below 11% were set to 0% for brevity.
- Correlations between credit and other market factors were averaged and rounded to nearest 5% for simplicity.

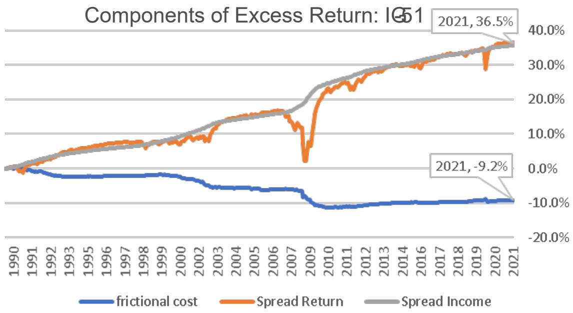
Historical Correlation Matrix

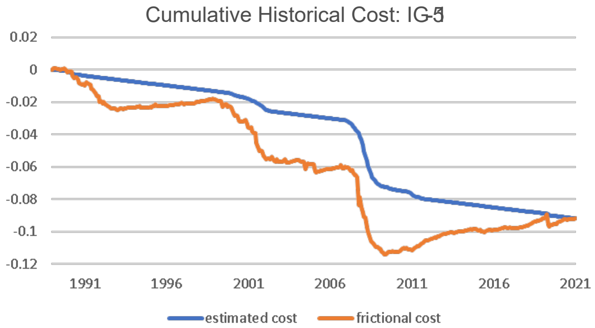
	CIR 1	CIR 2	CIR 3	SPX Var	SPX Ret	IG 1-5	IG 5-10	IG Long	HY
CIR 1	1.00								
CIR 2	0.00	1.00							
CIR 3	0.00	0.00	1.00						
SPXVar	0.00	0.00	0.00	1.00					
SPXRet	0.00	0.00	0.00	-0.68	1.00				
IG 1-5	0.00	0.00	-0.18	0.52	-0.54	1.00			
IG 5-10	0.00	0.00	-0.27	0.59	-0.63	0.92	1.00		
IG Long	0.00	0.00	-0.30	0.57	-0.60	0.82	0.94	1.00	
HY	0.00	0.00	-0.32	0.62	-0.67	0.80	0.87	0.84	1.00

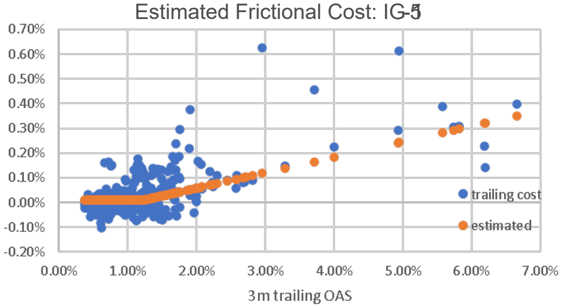
Simplified Correlation Matrix

	CIR 1	CIR 2	CIR 3	SPX Var	SPX Ret	Spread
CIR 1	1.00					
CIR 2	0.00	1.00				
CIR 3	0.00	0.00	1.00			
SPXVar	0.00	0.00	0.00	1.00		
SPXRet	0.00	0.00	0.00	-0.68	1.00	
Spread	0.00	0.00	-0.25	0.60	-0.60	1.00

Historical statistics: IG 1-5



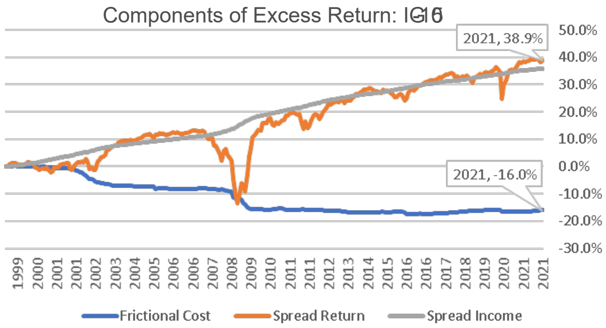


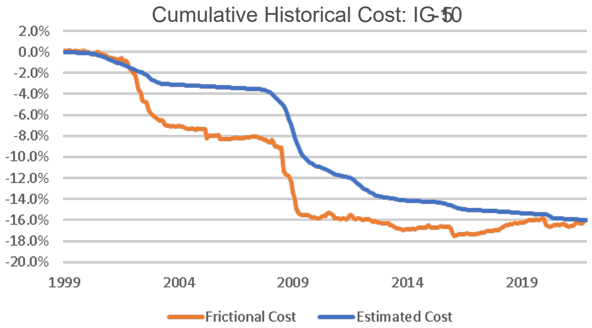


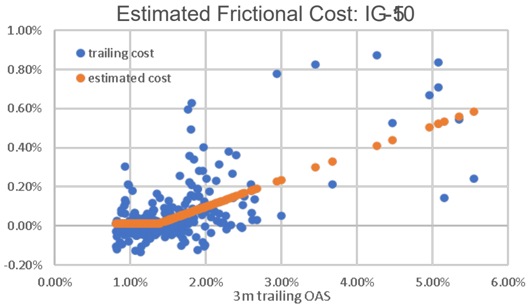
Frictional Cost Model Parameters: IG 1-5

	IG 1-5
min_cost (a)	0.00010
kappa (κ)	0.01239
mult1 (m_1)	0.00000
mult2 (m_2)	0.06265

Historical statistics: IG 5 -10





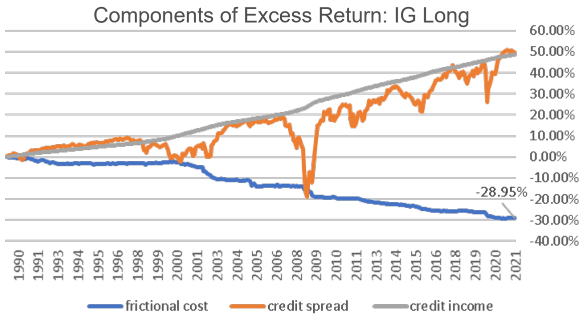


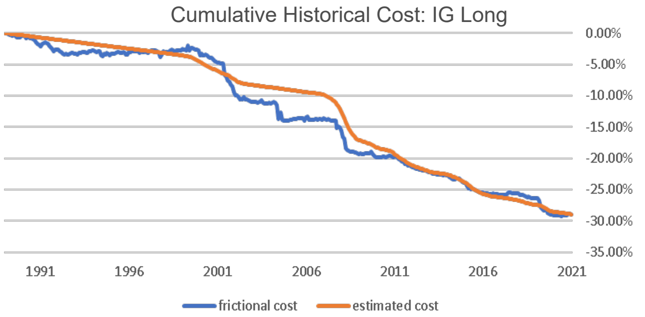
Frictional Cost Model Parameters: IG 5-10

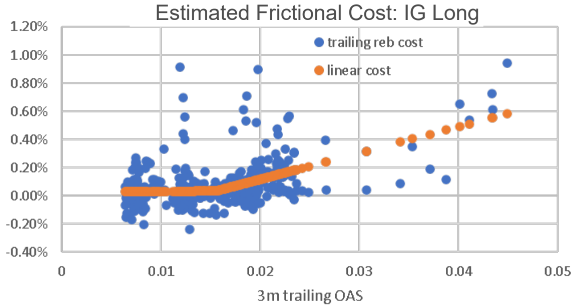
	IG 5-10
min_cost (a)	0.00010
kappa (κ)	0.01362
mult1 (m_1)	0.00000
mult2 (m_2)	0.13773

AMERICAN ACADEMY of ACTUARIES

Historical statistics: IG Long





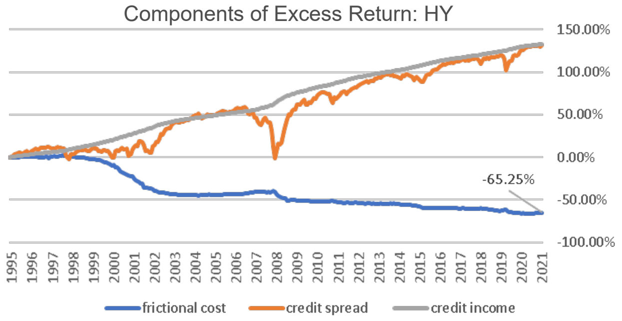


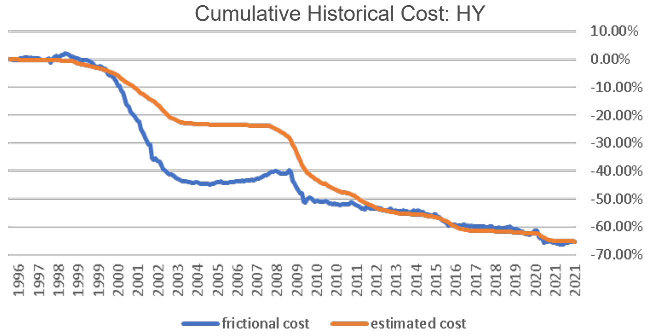
Frictional Cost Model Parameters: IG Long

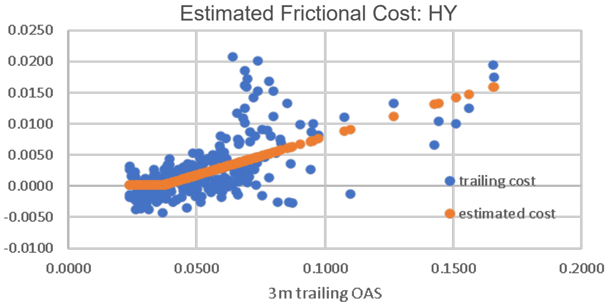
	IG Long
min_cost (a)	0.00010
kappa (κ)	0.01556
mult1 (m_1)	0.00448
mult2 (m_2)	0.18706

American Academy of Actuaries

Historical statistics: HY







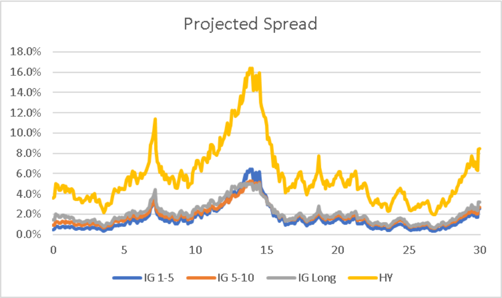
Frictional Cost Model Parameters: HY

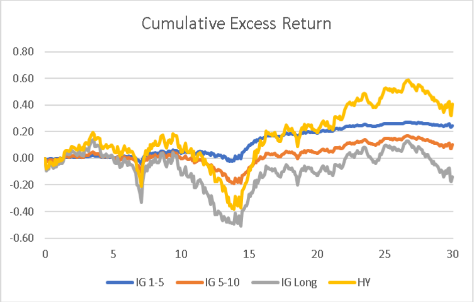
	HY
min_cost (a)	0.00010
kappa (κ)	0.03650
mult1 (m_1)	0.00100
mult2 (m_2)	0.12111

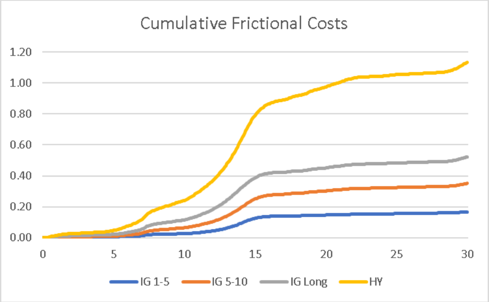
American Academy of Actuaries

Two sample scenarios: Tail 1% and Median

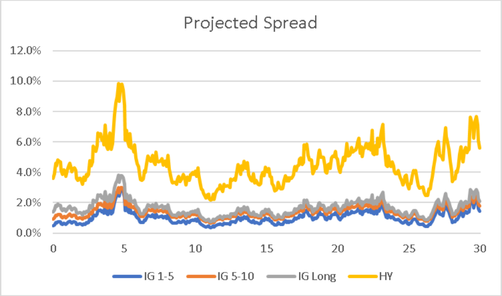
Tail 1% Scen #6187

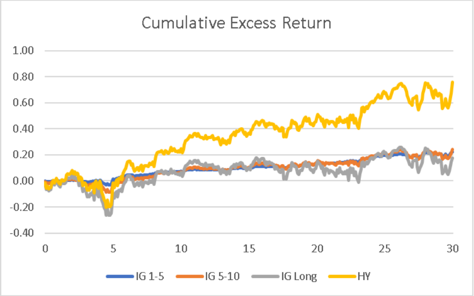


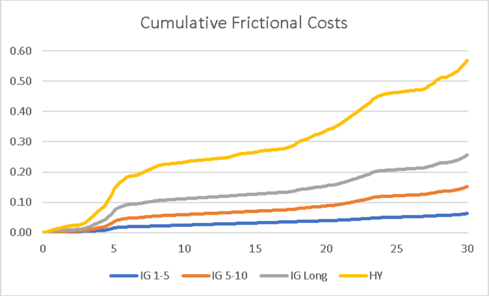




Median Scen #6731







American Academy of Actuaries

Attachment B

NAIC Scenario Set Technical Documentation

Corporate Yield Model

Table of Contents

1 NAIC Basic Data Set

The Basic Data Set provided free of charge to insurers is the standard scenario file set delivered as part of the NAIC scenario service. Users can access the scenarios online by downloading a file containing stochastic scenarios from the GEMS® Economic Scenario Generator (ESG) for real-world interest rates, equity and bond fund returns. The typical application for these scenarios is in calculations of life and annuity Statutory reserves according the Valuation Manual (e.g., VM-20, VM-21) and capital under the NAIC RBC requirements (e.g., C3 Phase 1, C3 Phase 2).

In this document the technical specification of the underlying stochastic model of the ESG used for producing corporate bond yields, spreads and returns on corporate bond funds for the Basic Data Set are described.

2 Corporate Yield Model

Corporate bonds have become an increasingly important asset class in the past decade. The drive into corporate debt has been driven in part by a sustained period of low yields. Scenarios for the yields and spreads on corporate bonds as well as corporate bond fund returns are simulated using a multi-factor model referred to as the Corporate Yield Model.

The model incorporates the following important features:

- Stochastic spreads
- Stochastic transition and default dynamics
- Real World and Risk Neutral versions
- Ability to produce the jump like behavior in spreads
- Mechanism for fitting the initial yield curves of corporate bonds across multiple ratings and tenors
- Pricing of bonds within an arbitrage free framework

2.1 Corporate Bond Spread – Stylized Facts

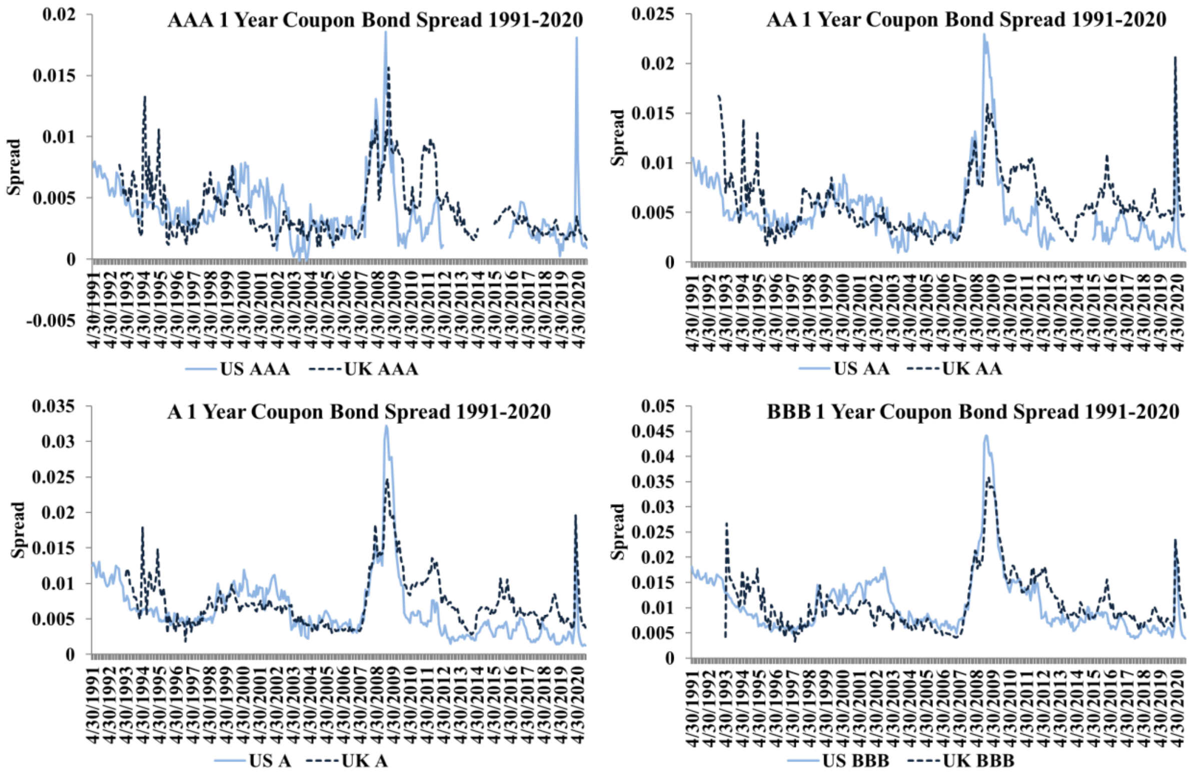


Figure 1 Spreads for US and UK AAA, AA, A and BBB rated bonds of 1-year maturity from 1991-2020, showing the sudden and rapid increases in spread experienced in 2008/2009 and early in 2020. (Source: Bloomberg/Conning)

The events of 2008 and several market events since were characterized by falling equity markets and increasing spreads on corporate bonds. Figure 1 shows the historical spreads on 1-year AAA, AA, A and BBB rated bonds from the United States and United Kingdom. While periods of high volatility had been observed before, the events of 2008 were unprecedented in the albeit short historical record. During this period spreads increased rapidly in most cases to levels which were over twice the highest levels previously experienced, and between 4 and 5 times the historical mean. Figure 1 also supports the argument that corporate bond spreads are stochastic and capable of exhibiting dislocations similar, but evolving more slowly, than those observed in the equity markets.

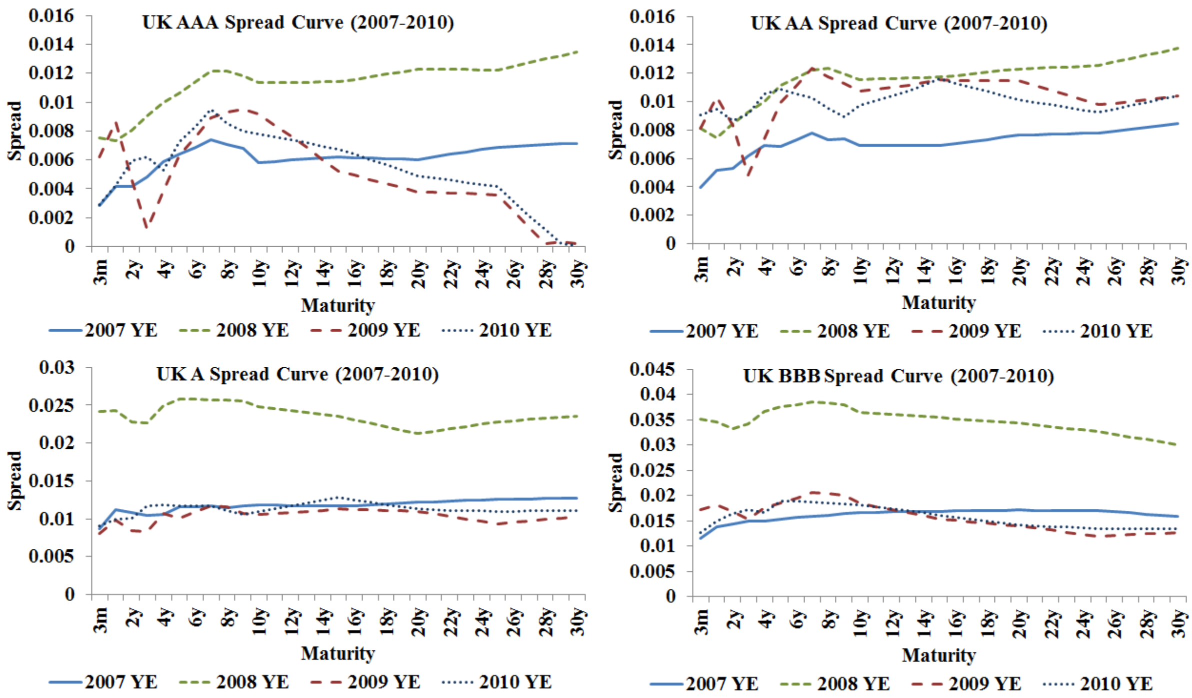


Figure 2 Spreads curves for UK AAA, AA, A and BBB rated bonds at year end 2007-2010, showing the extent of the difference between 2008 and other years. Also obvious is the extent to which market spread curves exhibit a range of shapes and are not smooth. (Source: Bloomberg/Conning)

Another important feature of the market is the correlation of credit spreads with other market sectors, in particular equities. Empirical evidence indicates that the lower the rating of a bond the more the bond behaves like an equity instrument. Consequently, one expects there to be an increasing correlation between corporate bond spreads and equity returns as ratings decline. This is indeed what is observed in the market data, in particular for lower credit ratings of corporate bonds.

Figure 2 shows the term structure of credit spreads for UK AAA, AA, A and BBB rated bonds at year end 2007, 2008, 2009 and 2010. Here again we can observe that the movement in spreads between 2007 and 2008 effected all ratings and tenors simultaneously. We also observe some possible liquidity effects in these curves, such as the AAA curve in 2009. Such discontinuities in the spread curves for some tenors require a special consideration, particularly in the context of fitting initial yield curves for the corporate bond markets.

This summarizes some of the main features of the market that a model of corporate bond yields and spreads would ideally exhibit.

2.2 Corporate Yield Model Specification

The GEMS Corporate Yield Model is a multifactor reduced form model allowing for the production and simulation of corporate bond yields, spreads, bond prices, transitions between rating classes and defaults. As a starting point for the model we assume that there are K rating classes {1, 2, . . . , K-1, K} where the absorbing state K is default. The rating classes used for the Basic Data Set are {AAA, AA, A, BBB, HIGH YIELD, DEFAULT}.

Two primary inputs govern the dynamics of the model.

1) K × K-generator matrix, $\mathscr{L}(t)$, for the rating transition and default.
2) A stochastic modulator μ(t) which multiplies the generator matrix $\mathscr{L}(t)$ at each time step.

The form of the generator matrix $\mathscr{L}(t)$ can be written as:

$$\mathcal{L}(t) = \begin{bmatrix} \lambda_{1,1}(t) & \lambda_{1,2}(t) & \lambda_{1,3}(t) & \cdots & \lambda_{1,K}(t) \\ \lambda_{2,1}(t) & \lambda_{2,2}(t) & \lambda_{2,3}(t) & \cdots & \lambda_{2,K}(t) \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ \lambda_{K-1,1}(t) & \lambda_{K-1,2}(t) & \lambda_{K-1,3}(t) & \cdots & \lambda_{K-1,K}(t) \\ 0 & 0 & 0 & \cdots & 0 \end{bmatrix}$$

With the dynamics of the model governed by the stochastic generator:

$$\mathcal{L}(t)\mu(t)$$

The generator matrix is a transformation of the corporate bond transition matrix which everyone familiar with the corporate bond markets knows. The relationship between the real-world transition matrix Q^{RW} and the generator matrix is:

$$Q^{RW} = e^{\mathcal{L}(t)}$$

The properties of the generator matrix are that the rows sum to zero, the diagonal elements are negative, and the off-diagonal elements take positive values. The generator matrix has useful properties in the context of stochastic modeling. In particular a generator matrix multiplied by a scalar, such as μ(t) is still a generator matrix. The same is not true of a transition matrix because the rows sum to 1.

In addition to the above the model incorporates the following characteristics.

1) A recovery of market value assumption for each rating class, defining the proportion of a bond's price prior to default that is recovered on default.
2) A mechanism for fitting the initial yield curves of corporate bonds for different ratings and tenor.
3) A jump process as one element of the stochastic modulator μ(t) allowing for the simulation of rapid increases in corporate bond spreads.
4) A correlation between the stochastic modulator μ(t) and the model of equity returns.

Figure 3 shows the GEMS simulated 1-year maturity spread for AAA, AA, A, BBB and High Yield bonds over a 30 year simulation horizon in quarterly time steps. The spread jump is clearly visible in this path, and as with real credit crises the shock is systemic, affecting assets of all ratings simultaneously. Models which do not incorporate such a jump process have difficulty in producing these levels of spreads without large increases in the overall volatility of spreads to unrealistic levels.

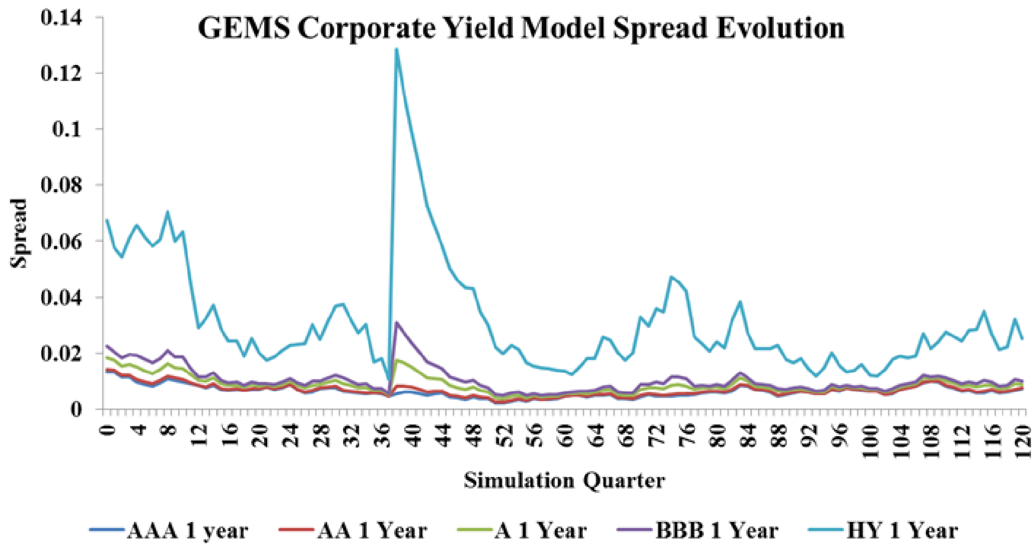


Figure 3 Simulated path from the GEMS Corporate Yield Model showing spreads on bonds of 1 year maturity for AAA, AA, A, BBB and High Yield rating classes. (source: Conning GEMS® ESG)

This jump process leads to bond returns which are fat tailed, capturing the types of extreme losses that can occur through spread movements as well as defaults. Figure 4 shows a Q-Q plot for A rated bond returns with maturity 3 to 5 years based on the output from the corporate yield model. If the returns were normally distributed, then the Q-Q plot would show a straight line. However, the left tail of the plot is observed to deviate significantly from a straight line, indicating a significantly heavy loss tail in the return distribution of the model.

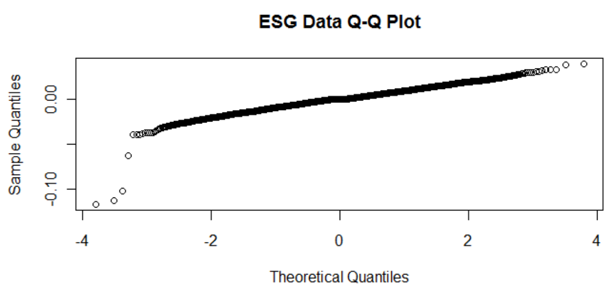


Figure 4 Q-Q Plot of A rated 3-5 year corporate bond returns. (Source: Conning GEMS® ESG).

3 Calibration Criteria

The calibration criteria for the models consists of a set of target values for the distributional properties of nominal interest rates at future time horizons. The precise methodology and final calibration targets are currently under discussion. More information will be added to this section when the details are known.

4 Summary

In this document the technical specification and the properties of the corporate spread and corporate bond fund returns model used to produce the NAIC Basic Data Set have been described. The GEMS® corporate yield model described represents an advanced modeling structure for this asset class which enables more realistic modeling of real world effects than is possible with a simpler model. Prior to scenario production the model is approximately fit to the initial market yield curve of corporate bonds across the five modelled rating categories for maturities 1 to 10 years. The statistical properties of the simulated model can also be customized to take account of specified or changing calibration criteria.

5 Additional Reading

Duffie and Singleton, ***Modeling Term Structures of Defaultable Bonds***, The Review of Financial Studies, 1999.

Lando, D. (2004). ***Credit Risk modeling***. Princeton University Press

6 Appendices

6.1 Appendix I – Relevant Tickers

The following tickers may be relevant as validation benchmarks for the stochastic output of the GEMS® interest rate model. Conning does not supply, distribute or directly derive the models from this data and is supplied here for guidance only.

Description	Ticker
AAA Industrial Coupon Yield, 3 month	BVCVPO3M Index
AAA Industrial Coupon Yield, 6 month	BVCVPO6M Index
AAA Industrial Coupon Yield, 1 year	BVCVPO01 Index
AAA Industrial Coupon Yield, 2 year	BVCVPO02 Index
AAA Industrial Coupon Yield, 3 year	BVCVPO03 Index
AAA Industrial Coupon Yield, 4 year	BVCVPO04 Index
AAA Industrial Coupon Yield, 5 year	BVCVPO05 Index
AAA Industrial Coupon Yield, 7 year	BVCVPO07 Index
AAA Industrial Coupon Yield, 8 year	BVCVPO08 Index
AAA Industrial Coupon Yield, 9 year	BVCVPO09 Index
AAA Industrial Coupon Yield, 10 year	BVCVPO10 Index
AAA Industrial Coupon Yield, 15 year	BVCVPO15 Index
AAA Industrial Coupon Yield, 20 year	BVCVPO20 Index
AAA Industrial Coupon Yield, 25 year	BVCVPO25 Index

AAA Industrial Coupon Yield, 30 year	BVCVPO30 Index
AA Industrial Yield, 3 month	IGUUID3M Index
AA Industrial Yield, 6 month	IGUUID6M Index
AA Industrial Yield, 1 year	IGUUID01 Index
AA Industrial Yield, 2 year	IGUUID02 Index
AA Industrial Yield, 3 year	IGUUID03 Index
AA Industrial Yield, 4 year	IGUUID04 Index
AA Industrial Yield, 5 year	IGUUID05 Index
AA Industrial Yield, 7 year	IGUUID07 Index
AA Industrial Yield, 8 year	IGUUID08 Index
AA Industrial Yield, 9 year	IGUUID09 Index
AA Industrial Yield, 10 year	IGUUID10 Index
AA Industrial Yield, 15 year	IGUUID15 Index
AA Industrial Yield, 20 year	IGUUID20 Index
AA Industrial Yield, 25 year	IGUUID25 Index
AA Industrial Yield, 30 year	IGUUID30 Index
A Industrial Yield, 3 month	BVCSUP3M Index
A Industrial Yield, 6 month	BVCSUP6M Index
A Industrial Yield, 1 year	BVCSUP1 Index
A Industrial Yield, 2 year	BVCSUP2 Index
A Industrial Yield, 3 year	BVCSUP3 Index
A Industrial Yield, 4 year	BVCSUP4 Index
A Industrial Yield, 5 year	BVCSUP5 Index
A Industrial Yield, 7 year	BVCSUP7 Index
A Industrial Yield, 8 year	BVCSUP8 Index
A Industrial Yield, 9 year	BVCSUP9 Index
A Industrial Yield, 10 year	BVCSUP10 Index
A Industrial Yield, 15 year	BVCSUP15 Index
A Industrial Yield, 20 year	BVCSUP20 Index
A Industrial Yield, 25 year	BVCSUP25 Index
A Industrial Yield, 30 year	BVCSUP30 Index
BBB Industrial Yield, 3 month	IGUUAD3M Index
BBB Industrial Yield, 6 month	IGUUAD6M Index
BBB Industrial Yield, 1 year	IGUUAD01 Index
BBB Industrial Yield, 2 year	IGUUAD02 Index
BBB Industrial Yield, 3 year	IGUUAD03 Index
BBB Industrial Yield, 4 year	IGUUAD04 Index
BBB Industrial Yield, 5 year	IGUUAD05 Index
BBB Industrial Yield, 7 year	IGUUAD07 Index
BBB Industrial Yield, 8 year	IGUUAD08 Index
BBB Industrial Yield, 9 year	IGUUAD09 Index
BBB Industrial Yield, 10 year	IGUUAD10 Index
BBB Industrial Yield, 15 year	IGUUAD15 Index
BBB Industrial Yield, 20 year	IGUUAD20 Index
BBB Industrial Yield, 25 year	IGUUAD25 Index
BBB Industrial Yield, 30 year	IGUUAD30 Index
BB Industrial Yield, 3 month	IGUUI53M Index

BB Industrial Yield, 6 month	IGUUI56M Index
BB Industrial Yield, 1 year	IGUUI501 Index
BB Industrial Yield, 2 year	IGUUI502 Index
BB Industrial Yield, 3 year	IGUUI503 Index
BB Industrial Yield, 4 year	IGUUI504 Index
BB Industrial Yield, 5 year	IGUUI505 Index
BB Industrial Yield, 7 year	IGUUI507 Index
BB Industrial Yield, 8 year	IGUUI508 Index
BB Industrial Yield, 9 year	IGUUI509 Index
BB Industrial Yield, 10 year	IGUUI510 Index
BB Industrial Yield, 15 year	IGUUI515 Index
BB Industrial Yield, 20 year	IGUUI520 Index
BB Industrial Yield, 25 year	IGUUI525 Index
BB Industrial Yield, 30 year	IGUUI530 Index

Disclosures/Confidentiality Notice

Conning (www.conning.com) is a leading investment management firm with a long history of serving the insurance industry. Conning supports institutional investors, including pension plans, with investment solutions and asset management offerings, award-winning risk modeling software, and industry research. Founded in 1912, Conning has investment centers in Asia, Europe and North America.

Attachment C

GEMS® Expert View Parameterization

United States Corporate Credit Targets

Prepared for the NAIC

Table of Contents

1 Introduction

Target-setting is the process of defining a range of desirable statistical properties (e.g., mean, standard deviation, skewness etc.) for the output of a model. These targets are used as guiding constraints during model estimation and help to ensure that model output and parameters are stable through time. In the GEMS® Expert View Parameterization, these targets are based upon historical behavior as well as a defined process of applying expert judgment. This document covers the methodology for setting corporate bond credit spread and transition and default probabilities for the United States economy.

Before defining a specific target-setting methodology for each asset class, a number of principles and requirements were set to guide the process. Ideally, any methodology would satisfy the following principles:

1) Enable the setting of long-term or steady-state targets for the mean and standard deviation of key variables
2) Any target-setting methodology should lead to targets that remain stable through time
3) The target-setting methodology should be consistent across economies and, by extension broadly applicable irrespective of geographic, economic, or other differences
4) The lack of availability of data should ideally not overly impede the setting of targets
5) Methodology should be justifiable based on the data available and the latest thinking in the academic literature
6) The methodology should lead to targets that are appropriate and meet the expectations of the many markets the GEMS® product serves
7) As much as possible, the methodology should be prescriptive, allowing targets to be set by following a well-defined procedure

While it may not always be possible to satisfy these requirements, they serve as useful guidance when differentiating between different target-setting methodologies.

2 GEMS® Expert View US Credit Spread Target-Setting Methodology

2.1 Choice of Data Window

In the case of corporate credit spreads, there is significantly less historical data than for many other asset classes (e.g., government bonds or equity). For the US, data is available from April 1991 and, with the exception of AAA ratings, is relatively complete for all rating classes through the 2008 financial crisis.

Due to the relative paucity of data, we use all credit spread data available to us for the analysis and inference of credit targets.

3 Corporate Credit Target-Setting Methodology

3.1 United States Credit Spread Targets

The process of setting corporate credit spread targets follows a well-prescribed methodology.

The first step in this process is to set targets for United States credit spread mean and standard deviation targets. Figure 1 shows US spread data from 1991 to 2018.

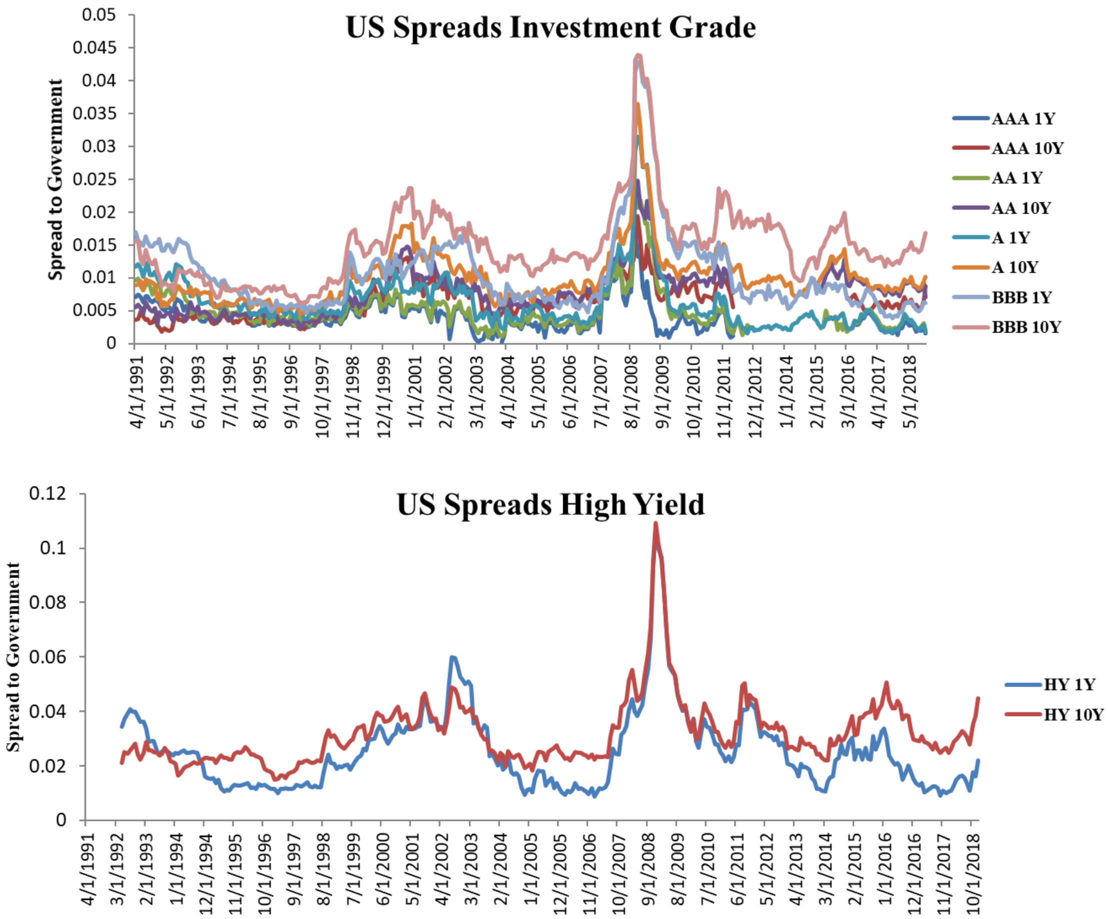


Figure 1: Historical US credit spreads on corporate bonds of different ratings and tenors separated by Investment Grade and High Yield (BB). Prepared by Conning, Inc. Source: ©2019 Bloomberg, L.P.

Looking at the data in Figure 1, we might split the historical data into 4 distinct periods:

1. A low-volatility period at the start of the available history from 1991–1998
2. A medium-volatility period prior to the 2007/2008 crisis between 1998–2006
3. A “jump” period characterized by rapidly increasing spreads, high spread levels, and high volatility between year-end 2006 and mid-2010
4. A second medium-volatility period which appears on inspection similar to the first. This period is from mid-2010 to the end of the historical series

It is our view that the targets for the mean should reflect the average expected behavior of credit spreads over the medium to long term. Given our observations 2 and 4 above, it would seem that the two medium-volatility periods are representative of what we might consider to be a "normal" market environment. If we look at the statistics for these two periods in Figure 2, we observe that the mean values were also broadly similar during these two periods.

		AAA 1Y	AAA 10Y	AA 1Y	AA 10Y	A 1Y	A 10Y	BBB 1Y	BBB 10Y	HY 1Y	HY 10Y
June 2010-2018	*Mean*	0.0028	0.0068	0.0033	0.0094	0.0035	0.0102	0.0083	0.0158	0.0225	0.0335
"Post Jump"	*Stdev*	0.0011	0.0014	0.0011	0.0013	0.0014	0.0018	0.0031	0.0031	0.0086	0.0068
	Max	0.0054	0.0100	0.0064	0.0129	0.0076	0.0152	0.0155	0.0237	0.0437	0.0507
Dec 1998-Dec 2006	*Mean*	0.0037	0.0073	0.0044	0.0081	0.0064	0.0105	0.0102	0.0155	0.0266	0.0312
"Ex-Low Vol Period"	*Stdev*	0.0019	0.0023	0.0017	0.0025	0.0024	0.0032	0.0033	0.0034	0.0128	0.0075
	Max	0.0074	0.0132	0.0082	0.0148	0.0111	0.0183	0.0176	0.0237	0.0601	0.0488

Figure 2: Statistical properties of US Credit spreads in two historical periods, 2010–2018 and 1998–2006. Prepared by Conning, Inc. Source: ©2019 Bloomberg, L.P.

This is particularly true for the 10-year tenor. For the 1-year tenor. the A-rated spreads show the most significant differences.

Taking this into account, the following methodology is applied to form targets for the mean spreads:

1. Investment-grade mean spreads are set at the midpoint between the measured values in the two "normal" periods.
2. 10-year HY spreads are set at the midpoint between measured values in the two "normal" periods.
3. The 1-year HY spreads are set at 65bps below the 10-year High Yield spread. This is close to the difference between the BBB 1-year and 10-year tenor (64bps) and ensures that the High Yield spread curve is not too steep relative to the steepness we observe in the data.

Applying this method leads to the following targets:

	Target Mean
AAA 1Y	0.00326
AAA 10Y	0.00706
AA 1Y	0.00385
AA 10Y	0.00875
A 1Y	0.00496
A 10Y	0.01033
BBB 1Y	0.00929
BBB 10Y	0.01566
HY 1Y	0.02584
HY 10Y	0.03234

Figure 3: Target mean credit spreads for US industrial sector corporate bonds of different ratings and tenors. Prepared by Conning, Inc.

Next, we move to the setting of targets for the standard deviation or volatility. For this we use the broadest possible view and take account of all the available data, setting the target at the historical value. This also requires the least amount of expert judgment and is perhaps the most justifiable approach to take in the absence of any evidence to the contrary. Including the 2008 crisis in the volatility measure will ensure that a reasonable and wide range of values is recreated by the simulation, including the moderate extremes (with tail events generated separately by the inclusion of a jump process in some of the models). The values have been checked for consistency (e.g., that the volatility increases with rating) and appear reasonable. The final mean and standard deviation targets are shown in Figure 4 below.

US Spread Targets	***Target Mean***	**Target Stdev**	**GEMS Official Target Mean**	**GEMS Official Target Stdev**
AAA 1Y	0.00326	0.00237	0.0043	0.0023
AAA 10Y	0.00706	0.00288	0.0064	0.0025
AA 1Y	0.00385	0.00322	0.0056	0.0031
AA 10Y	0.00875	0.00362	0.0075	0.0032
A 1Y	0.00496	0.00441	0.0076	0.0041
A 10Y	0.01033	0.00428	0.01	0.0041
BBB 1Y	0.00929	0.00632	0.012	0.006
BBB 10Y	0.01566	0.00607	0.0145	0.0057
HY 1Y	0.02584	0.01490	0.0431	0.0197
HY 10Y	0.03234	0.01244	0.0503	0.0176

Figure 4: Target mean and standard deviations for US credit spreads (industrial sector) on corporate bonds of different ratings and tenors. Prepared by Conning, Inc.

Disclosures/Confidentiality Notice

Conning (www.conning.com) is a leading investment management firm with a long history of serving the insurance industry. Conning supports institutional investors, including pension plans, with investment solutions and asset management offerings, risk modeling software, and industry research. Founded in 1912, Conning has investment centers in Asia, Europe and North America.

This document contains information that is confidential or proprietary to Conning and is provided solely for the benefit of the Conning client authorized to download the document, including those affiliates permitted under the applicable Software License Agreement. The document may be used for the client's internal use and for independent reviews by the client's auditors and regulatory bodies (“Permitted Third Parties”). Conning must, however, be notified in advance of all Permitted Third Parties to which the client intends to distribute the document and the purpose for such distribution. By accepting this document you agree that: (1) if there is any pre-existing contract containing disclosure and use restrictions between you and/or your company and Conning you and your company will use this information in reliance on and subject to the terms of any such pre-existing contract, as permitted by this notice or as may be required by law; or (2) if there is no contractual relationship between you and/or your company and Conning, you and your company agree to protect this information and not to reproduce, disclose or use the information in any way, except as may be required by law or as permitted by this notice. Except as set forth in this notice, no part of this document may be distributed by any means or used for any purpose except with Conning’s prior written authorization. Any third parties that are given access to the document are subject to the same terms of this notice. Any distribution of this document, in whole or in part, must always include this notice.