# Corporate Credit & Bond Fund Returns —

## Stylized Facts, Acceptance Criteria, and a Simplified Model


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# 1.

# Background



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## 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



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# Background (continued)

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.

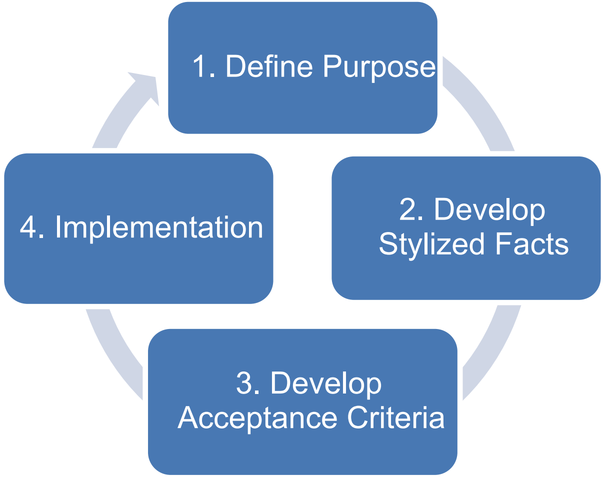
In addition to Stylized Facts and Acceptance Criteria, this presentation also proposes a **Simplified Model**.

- 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 (10-30 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



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## Groupings for 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.



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# 2. Corporate Credit Spreads —Relation across qualities and maturities



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).



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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).

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.

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



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# 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).



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# 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)



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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. VM20 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 |

# 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 |



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# 4.

## A Simplified Model

# 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.



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



Steady-state credit spread targets and mean reversion speeds are consistent with VM-20 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.

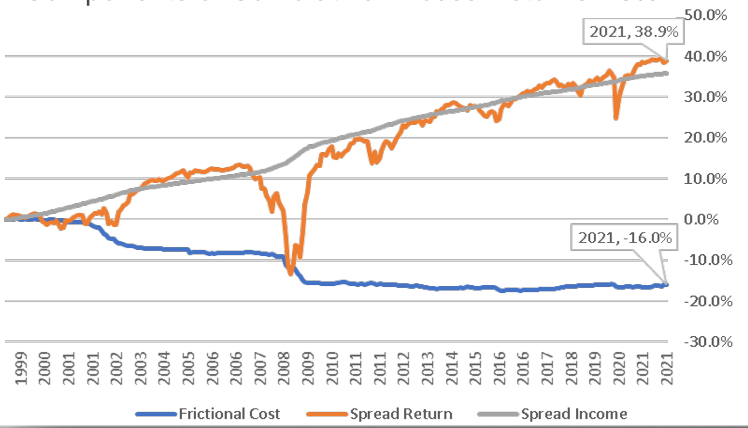
# Simplified decomposition of bond index excess return into spread return and frictional cost



$Excess\ Return = Spread\ Return - Frictional\ Cost$, 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.



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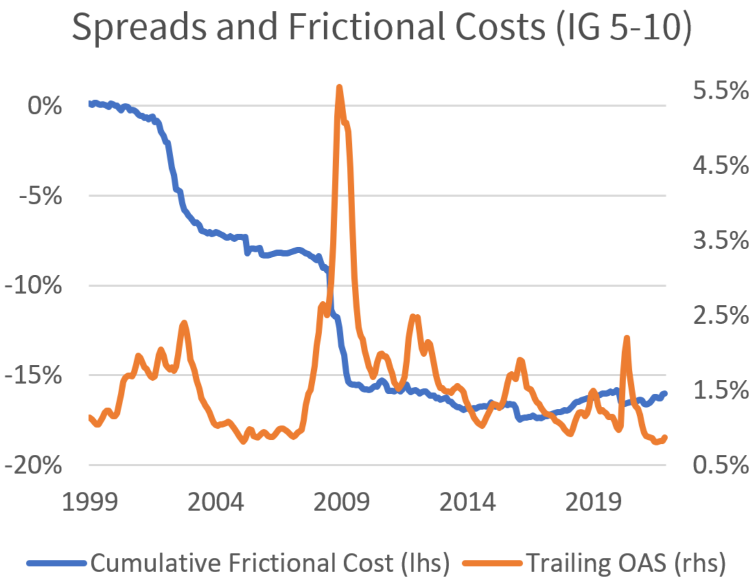
OAS exhibits strong mean reversion, zero bound, and clustering. These dynamics, which drive the volatility of Excess Return, are native to a lognormal Ornstein-Uhlenbeck "OU" process.

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.



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**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* $(\tau)$ = Target OAS (adj), and *beta* $(\beta)$ = 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.

# 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 12/202 (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 ($\beta$) 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 ($\sigma$) was adjusted accordingly to preserve historical steady state process variance.
- Spread targets ($\tau$) were adjusted to ensure average modeled spreads align with Target OAS (average VM-20 ultimate spread at [12/31/21]).

# 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.

# 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** ($\tau$, spread target) | 0.00920 | 0.01298 | 0.01493 | 0.04134 |
| **beta** ($\beta$, mean rev.) | 0.03 | 0.03 | 0.03 | 0.03 |
| **sigma** ($\sigma$, 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** ($\kappa$) | 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 simplified 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 |



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# 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.

# 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 |



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# 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 |

# 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



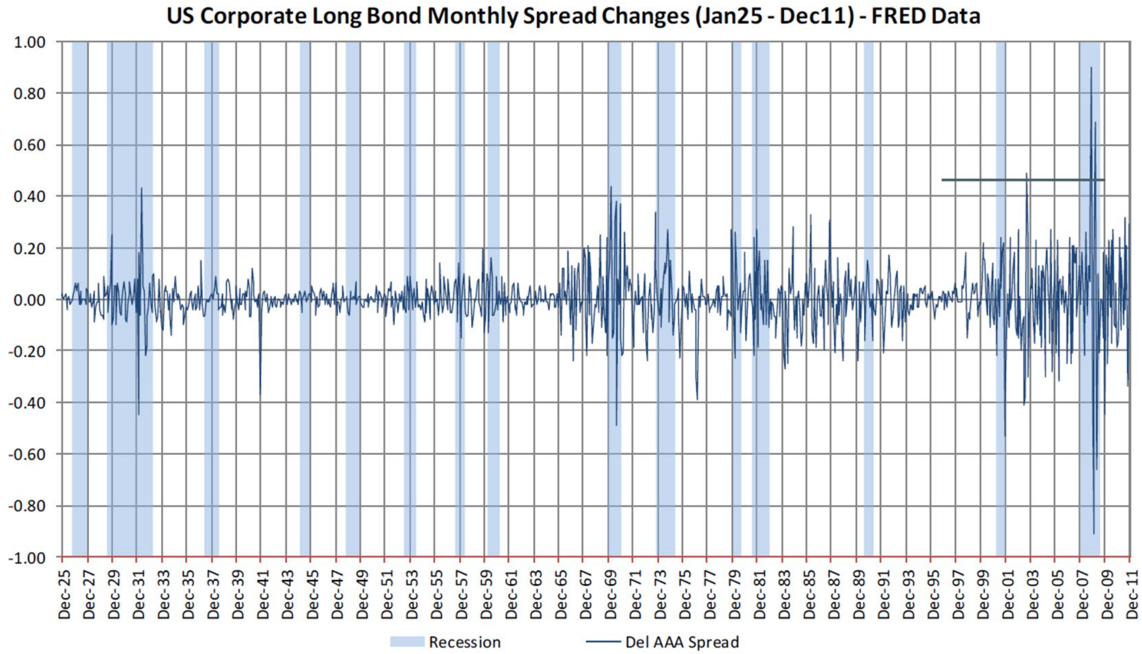
## Contact:


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

# 6.1

## Appendix 1:
## Support for Stylized Facts

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




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



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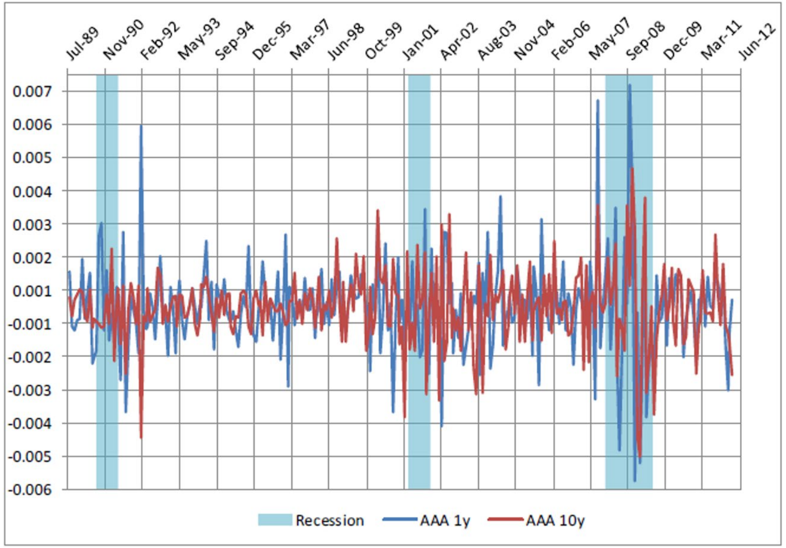
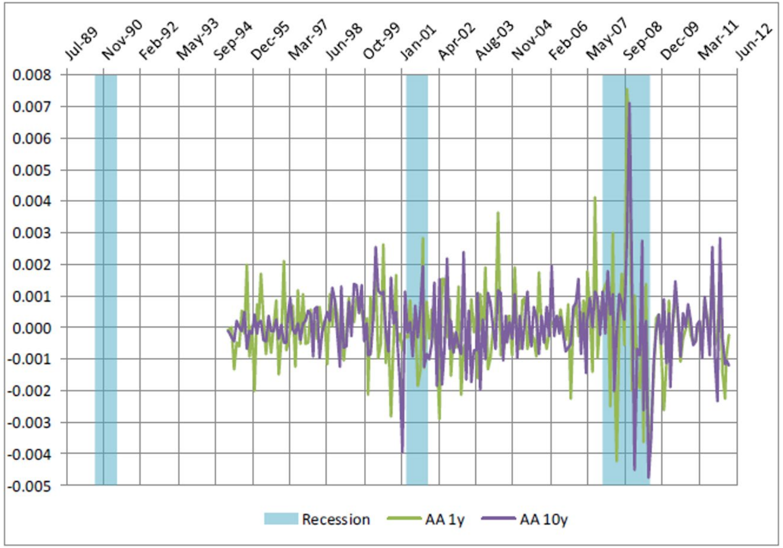
# Support for Stylized Facts:
# Monthly changes in U.S. credit spreads, 1989 –2012 (AAA, AA)



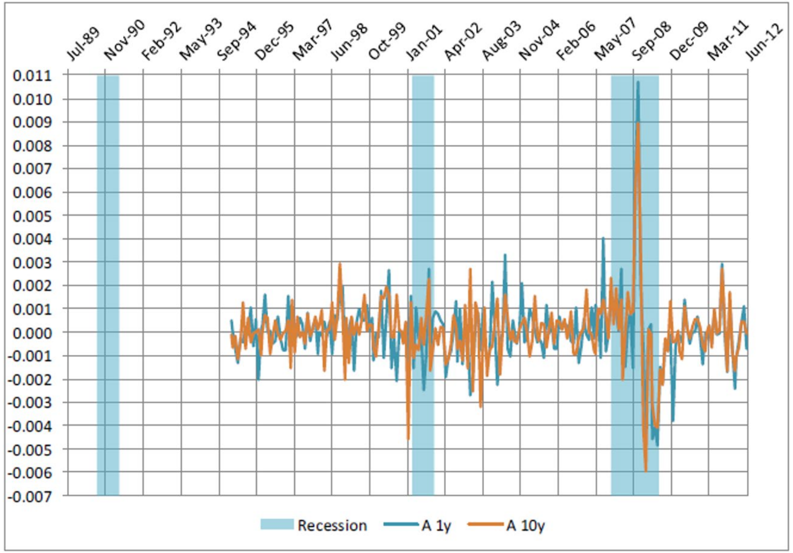


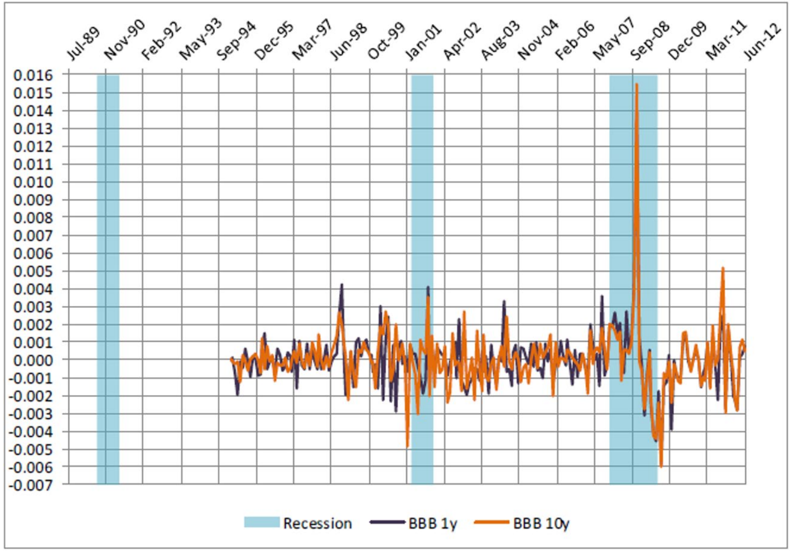




*Source: Economic Scenario Generators: A Practical Guide (SOA, 2016)*

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






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



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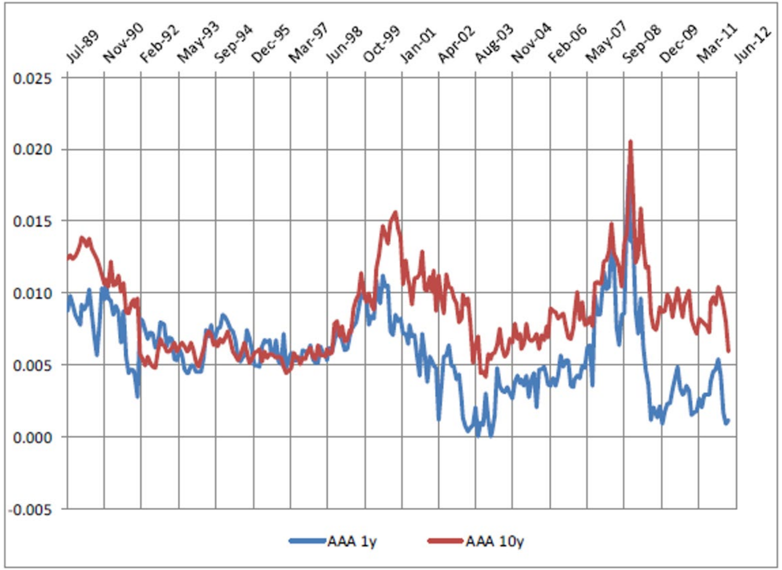
# Support for Stylized Facts:
# Spreads for U.S. industrial zero -coupon bonds, 1989 –2012 (AAA, AA)



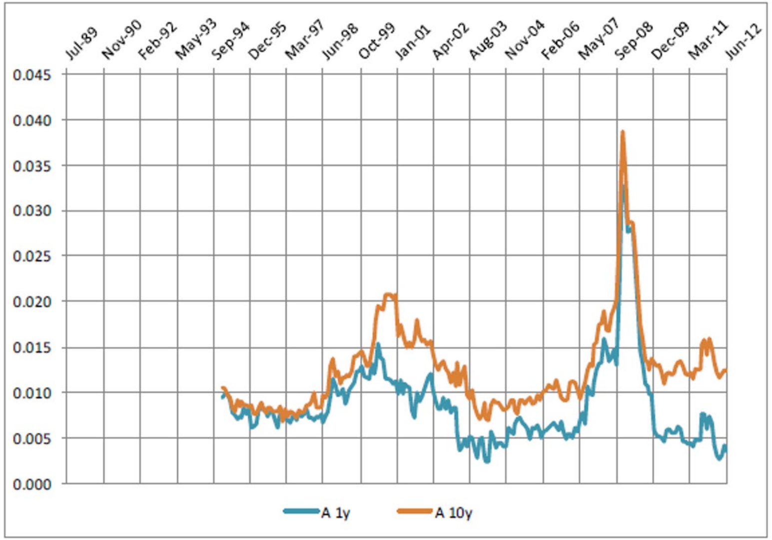


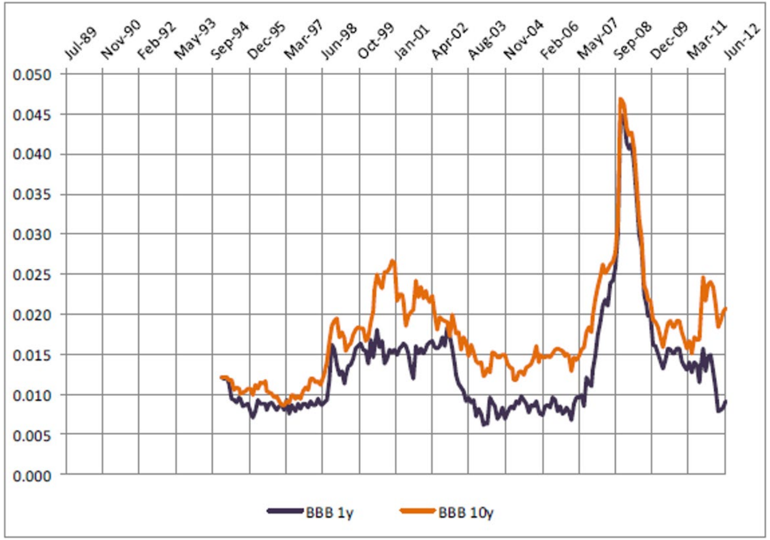


*Source: Economic Scenario Generators: A Practical Guide (SOA, 2016)*

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





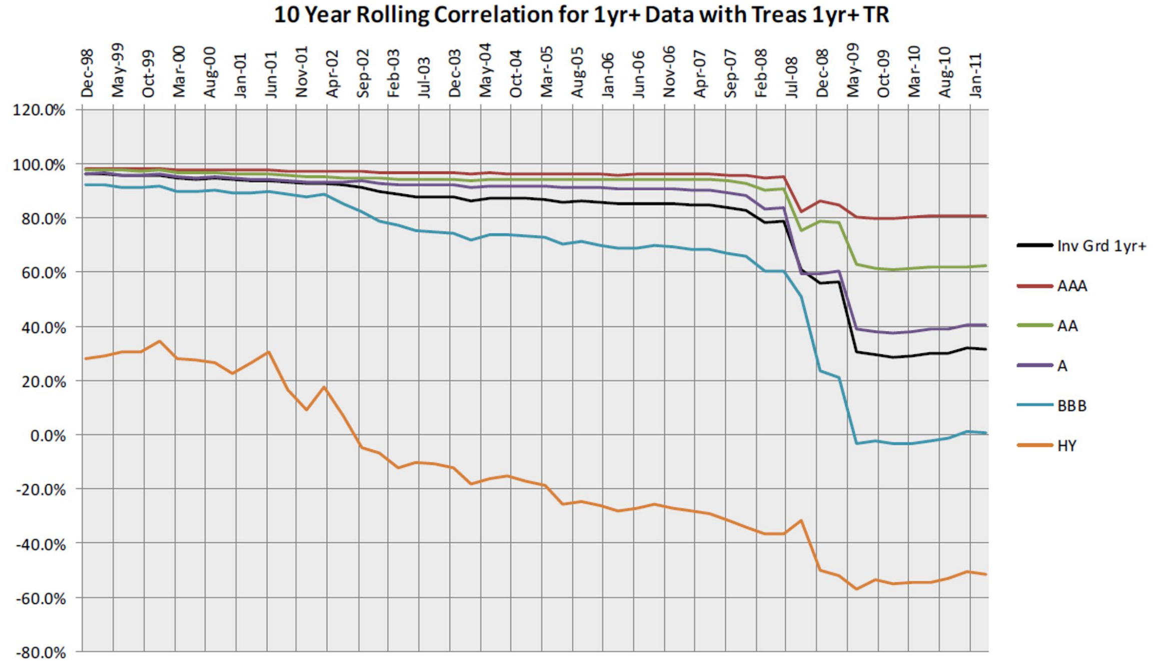

*Source: Economic Scenario Generators: A Practical Guide (SOA, 2016)*



AMERICAN ACADEMY of ACTUARIES

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






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

# 6.2

## Appendix 2:
## Support for Acceptance Criteria



AMERICAN ACADEMY of ACTUARIES

# 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*

# 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).

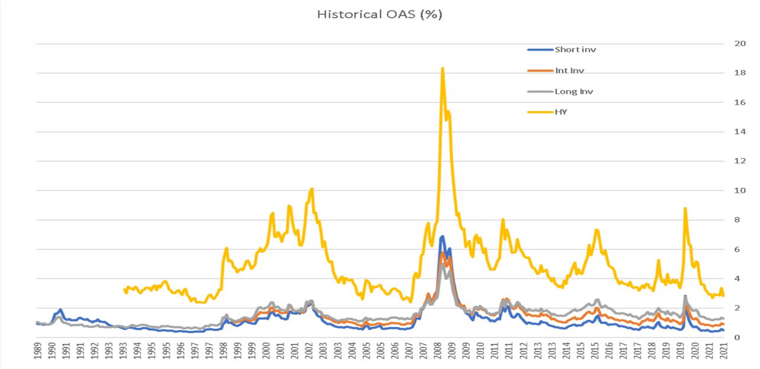
Based on this “steady-state” simulation, the maximum excess return across 10k scenarios in the Simplified Model is well within the proposed Excess Return Cap.

**Annualized Cummulative Excess  Return over 30 years**

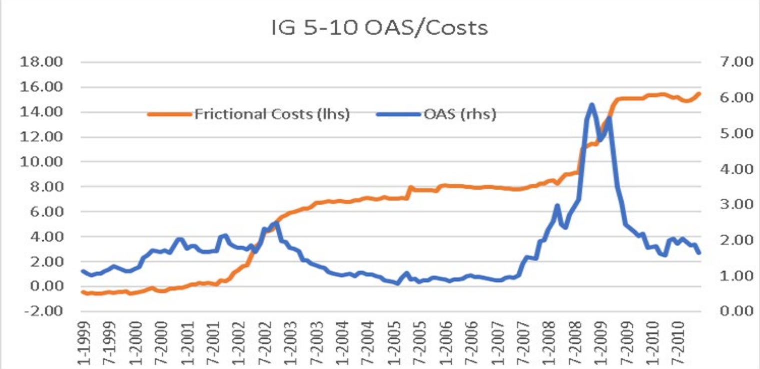
| | min | 1% | 10% | 50% | 90% | 99% | max | Excess Return Cap | Target OAS |
|---|---|---|---|---|---|---|---|---|---|
| **IG 1-5** | 0.22% | 0.38% | 0.51% | 0.70% | 0.89% | 1.03% | 1.26% | 1.57% | 1.07% |
| **IG 5-10** | -0.25% | 0.24% | 0.49% | 0.70% | 0.83% | 0.92% | 1.05% | 1.91% | 1.41% |
| **IG 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, 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:

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

- *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.

# 6.3

# Appendix 3: Additional Detail on Simplified Model

# Adjustments:

- Beta ($\beta$, mean reversion) set to 3% to ensure reasonable spread relationships between indices.
- Sigma ($\sigma$, volatility) adjusted to preserve steady state process variance: $\sigma^2/(2\beta-\beta^2)$.
- Tau ($\tau$, 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 ($\tau$) | 0.01069 | 0.01408 | 0.01627 | 0.04475 |
| beta ($\beta$) | 0.02927 | 0.03613 | 0.01951 | 0.03443 |
| sigma ($\sigma$) | 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 ($\tau$) | 0.00920 | 0.01298 | 0.01493 | 0.04134 |
| beta ($\beta$) | 0.03000 | 0.03000 | 0.03000 | 0.03000 |
| sigma ($\sigma$) | 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 |



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# 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.

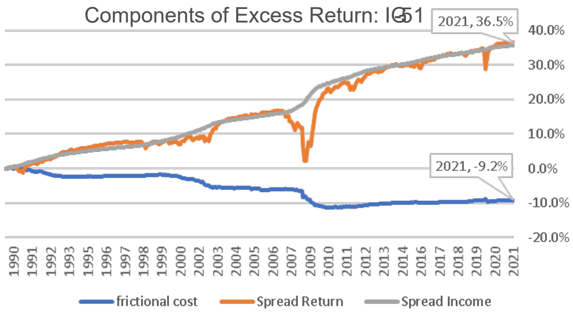
**Historical Correlation Matrix**

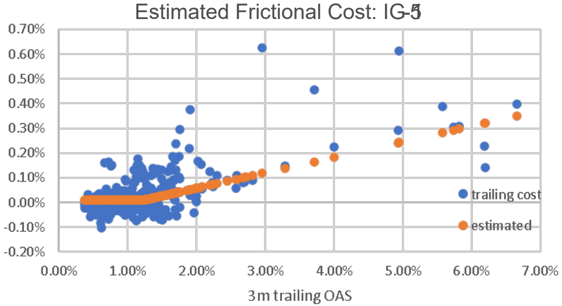
| | CIR 1 | CIR 2 | CIR 3 | SPX Var | SPX Ret | IG 1-5 | IG 5-10 | IG Long | HY |
|---|---|---|---|---|---|---|---|---|---|
| CIR 1 | 1.00 | | | | | | | | |
| CIR 2 | 0.00 | 1.00 | | | | | | | |
| CIR 3 | 0.00 | 0.00 | 1.00 | | | | | | |
| SPXVar | 0.00 | 0.00 | 0.00 | 1.00 | | | | | |
| SPXRet | 0.00 | 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 |

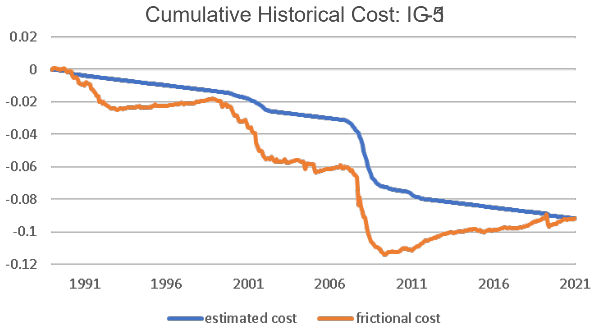
**Simplified Correlation Matrix**

| | 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 ($\kappa$) | 0.01239 |
| mult1 ($m_1$) | 0.00000 |
| mult2 ($m_2$) | 0.06265 |



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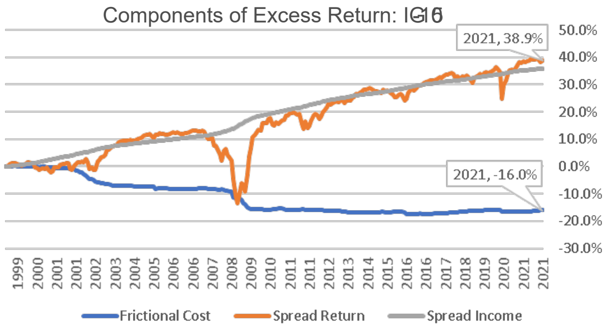
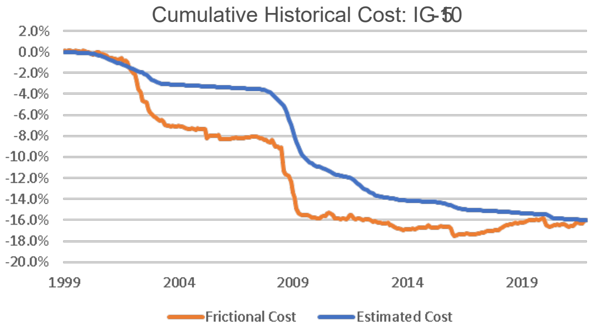
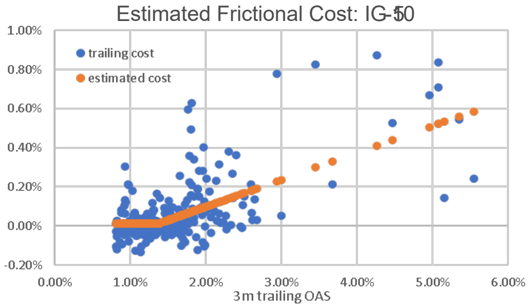
# Historical statistics: IG 5-10



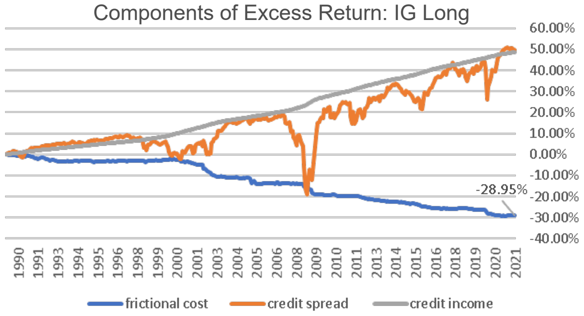



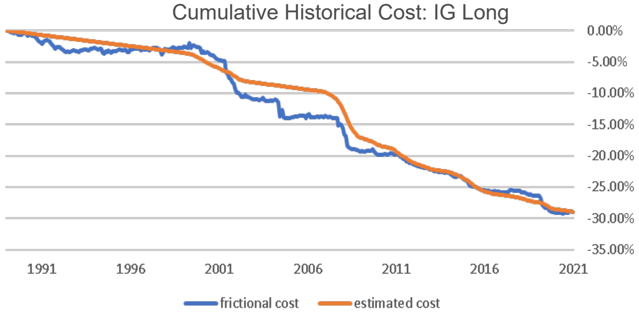

## Frictional Cost Model Parameters: IG 5-10

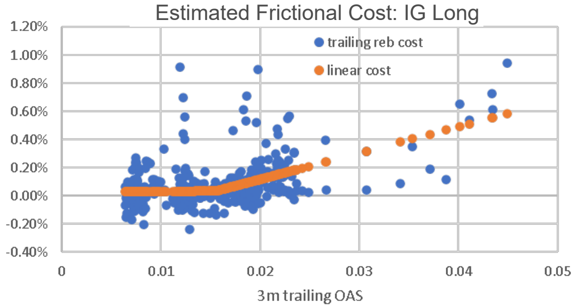
| | IG 5-10 |
|---|---|
| min_cost ($a$) | 0.00010 |
| kappa ($\kappa$) | 0.01362 |
| mult1 ($m_1$) | 0.00000 |
| mult2 ($m_2$) | 0.13773 |

# Historical statistics: IG Long






## Frictional Cost Model Parameters: IG Long

| | IG Long |
|---|---|
| min_cost ($a$) | 0.00010 |
| kappa ($\kappa$) | 0.01556 |
| mult1 ($m_1$) | 0.00448 |
| mult2 ($m_2$) | 0.18706 |



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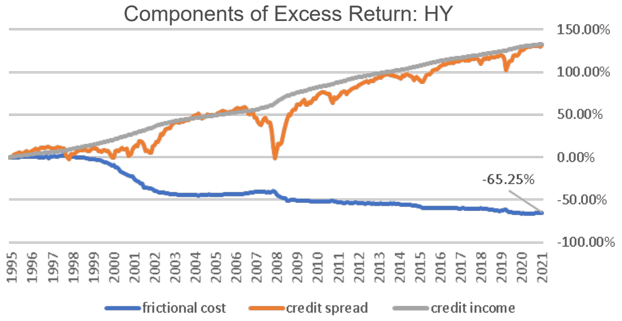
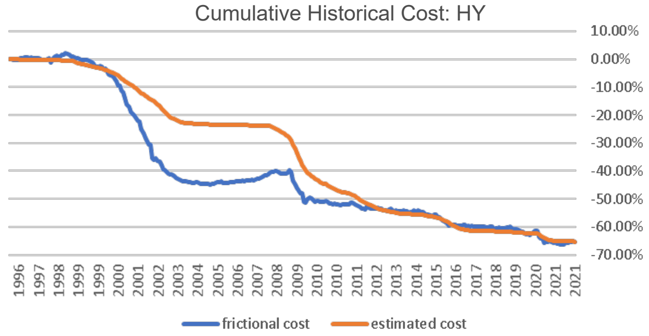
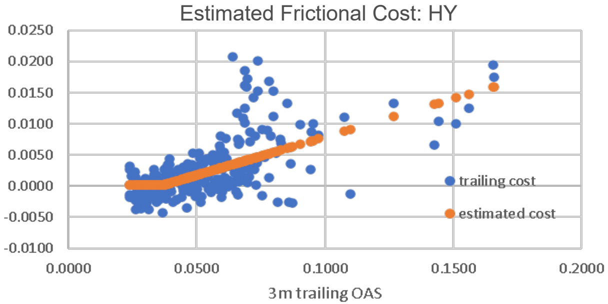
# Historical statistics: HY




## Frictional Cost Model Parameters: HY

| | HY |
|---|---|
| min_cost ($a$) | 0.00010 |
| kappa ($\kappa$) | 0.03650 |
| mult1 ($m_1$) | 0.00100 |
| mult2 ($m_2$) | 0.12111 |



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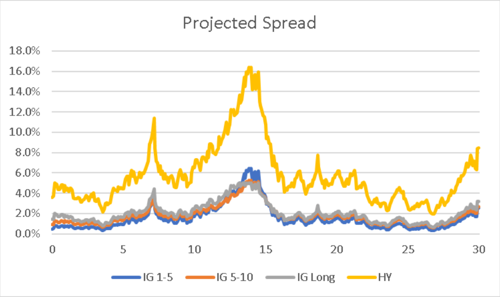
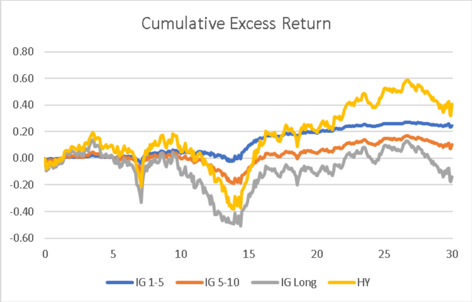
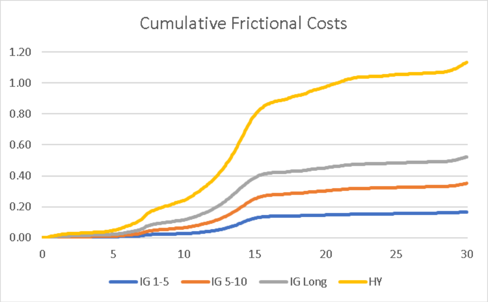
# Two sample scenarios: Tail 1% and Median

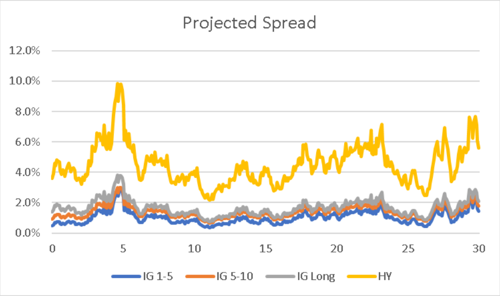
Tail 1%
Scen
#6187

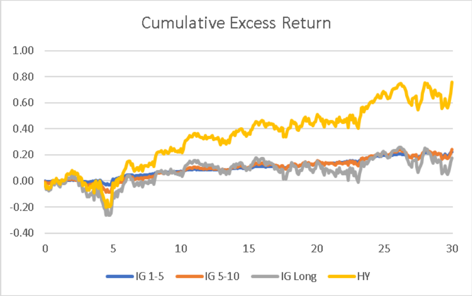


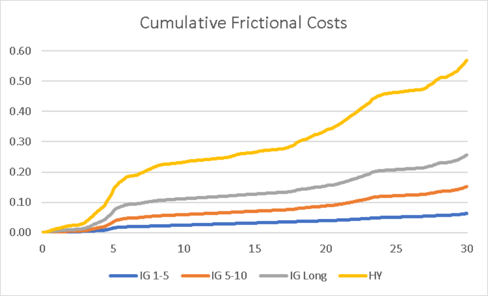




Median
Scen
#6731



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