

December 2025

Pricing Embedded Corporate Bond Optionality

US High Yield Corporate Bonds and Investment Grade Corporate-issued Municipals

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Calibrating a 1-factor Hull-white model using QuantLib

- Calibrated using helper code from Juniperhills' blog with Normal swaption volatilities as of 11/28/25.
- Ran three scenarios: 1) calibrate both 'a' (mean reversion intensity) and σ
 - 2) calibrate σ while holding 'a' fixed at 0.05
 - 3) calibrate 'a' while holding σ fixed at 0.01
- Case 2, calibrating σ while holding 'a' fixed at 0.05 produced the lowest initial and final RMSE.

Scenario Description	Mean Reversion (a)	Volatility (σ)	Initial RMSE	Final RMSE	Improvement
Case 1: Global Calibration(Unconstrained)	0.1489	0.0006	108.9 bps	0.1 bps	99.90%
Case 2: Calibrate Sigma (Fixed Reversion)	0.0500	0.0005	4.8 bps	0.1 bps	98.40%
Case 3: Calibrate Reversion(Fixed Sigma)	2.8378	0.0100	126.1 bps	1.7 bps	98.70%

Target: 3 US HY corporate bonds with par calls starting in Dec '25 or Dec '26.

- Range Resources ('Ba2/BB+') faces an active premium call at 102.75.
- HanesBrands ('B3') had a high call option value because of soon to close acquisition by Gildan. The call was announced on 12/1/25 to be redeemed on 12/11/25 at 105.316 (according to BBG's estimate).
- Viking Cruises ('Ba2/BB') is in a noncall period until July '26.

Issuer	Ticker	ISIN	Coupon	Maturity	Issue Date	Amount Issued	Refinitiv OAS	Z-Spread	Call Option Value	Market Price
Range Resources Corp	RRC	US75281ABH14	8.250	1/15/2029	1/8/2021	600,000,000	18.64	405	387	101.875
HanesBrands Inc	HBIX	US410345AQ54	9.000	2/15/2031	2/14/2023	600,000,000	103.07	413	310	105.250
Viking Cruises Ltd	VIKVC	US92676XAG25	9.125	7/15/2031	6/30/2023	720,000,000	119.07	394	274	107.000

1. Load market data and first calibrate the model to the risk-free curve

- Inputs: Loaded dataframe with the identified bonds and respective call schedules. Loaded the SOFR OIS curve and Refinitiv's swaption vol cube into dataframes.
- Bootstrapped a SOFR curve using QuantLib's PiecewiseLogCubicDiscount algorithm and stored it as yield_curve_handle
- Ran a HW calibration function through a pricing loop to price the bonds relative to the risk-free curve by incorporating the swaption vol as an exogenous input. Calibrated for sigma while holding 'a' fixed.
 - Identifies coterminal swaptions that align with the bond's call schedule to correctly match market volatility. Jamshidian engine then calculates the price of these swaptions with a closed-form solution.
 - Levenberg Marquardt optimization method is then used to calibrate the volatility to the market price.

Ticker	ISIN	Market Price	Model Dirty Price	Model Clean Price	Model Error	Calibrated Sigma
RRC	US75281ABH14	101.875	104.961	101.867	-0.007998	0.008659
HBIX	US410345AQ54	105.25	108.098	105.470	0.21986	0.009181
VIKVC	US92676XAG25	107	111.184	107.759	0.759142	0.009176

2. Compute the implied OAS by calibrating to market bid prices

- Calibrating to bid prices since Refinitiv's OAS model defaults to bid prices. Justified by risk management perspective since this is a more realistic price that can be transacted.
- Brent's method to solve to $1e-6$ accuracy. A trial curve to discount the bond's cash flows is processed through the solver to find the implied OAS using a grid of future interest rates (as generated by a trinomial tree) until the model matches the market price. HW model parameters held fixed.
- Output: HW model is more closely calibrated to market price with modest error vs. Refinitiv's OAS model. A straight bond is priced using the implied OAS and then used to compute the call option value.

Ticker	Straight Price	Market Price	Implied Price	Model Error	Implied OAS (bps)	Refinitiv OAS (bps)	Call Option Value	Calibrated Sigma
RRC	114.832	101.875	101.875	1.22E-06	-6.35	18.64	12.96	0.008659
HBIX	121.421	105.250	105.250	2.21E-10	99.79	103.07	16.17	0.009181
VIKVC	122.574	107.000	107.000	-4.67E-07	115.60	119.07	15.57	0.009176

3. Recompute using Bloomberg BVAL mid prices

- Bloomberg BVAL tended to price the bonds higher than Refinitiv.
- Calibration followed the same steps except Bloomberg's swaption vol cube was loaded.
- Output: HW model achieved price convergence but faced higher divergence from Bloomberg's OAS estimation.
 - Deeply negative OAS may be difficult to price for bonds with upcoming calls. If the market expects the call to be exercised and immaterial default risk, then OAS could trade negative.

Ticker	Straight Price	Market Price	Implied Price	Model Error	Implied OAS (bps)	BBG OAS (bps)	OAS Difference	Call Option Value	Calibrated Sigma
RRC	119.423	102.049	102.049	0.000003	-143.9	-117	-26.9	17.4	0.008632
HBIX	130.554	105.616	105.616	0.000000	-66.0	-50	-16.0	24.9	0.009188
VIKVC	125.114	107.291	107.291	0.000000	71.2	79	-7.8	17.8	0.009179

4. Extending the analysis to municipal bonds issued by corporations

- Target: Waste Management (WM) regularly issues municipal bonds that have long final maturities but contain mandatory put provisions that result in the bonds being remarketed every few years, resulting in ~3 year life of the put option.
 - The bonds also contain call options prior to the mandatory put so that WM retains significant optionality to refinance the debt at attractive rates.
- Calibration used the same Bloomberg swaption vol cube but used the Bloomberg AAA municipal bond curve in lieu of the SOFR OIS curve.
- Output: The initial calibration to the risk-free curve resulted in high model error. Subsequent calibration to impute OAS found substantial value for the mandatory put and modest value for the call option.

1. Calibrated to AAA risk-free curve

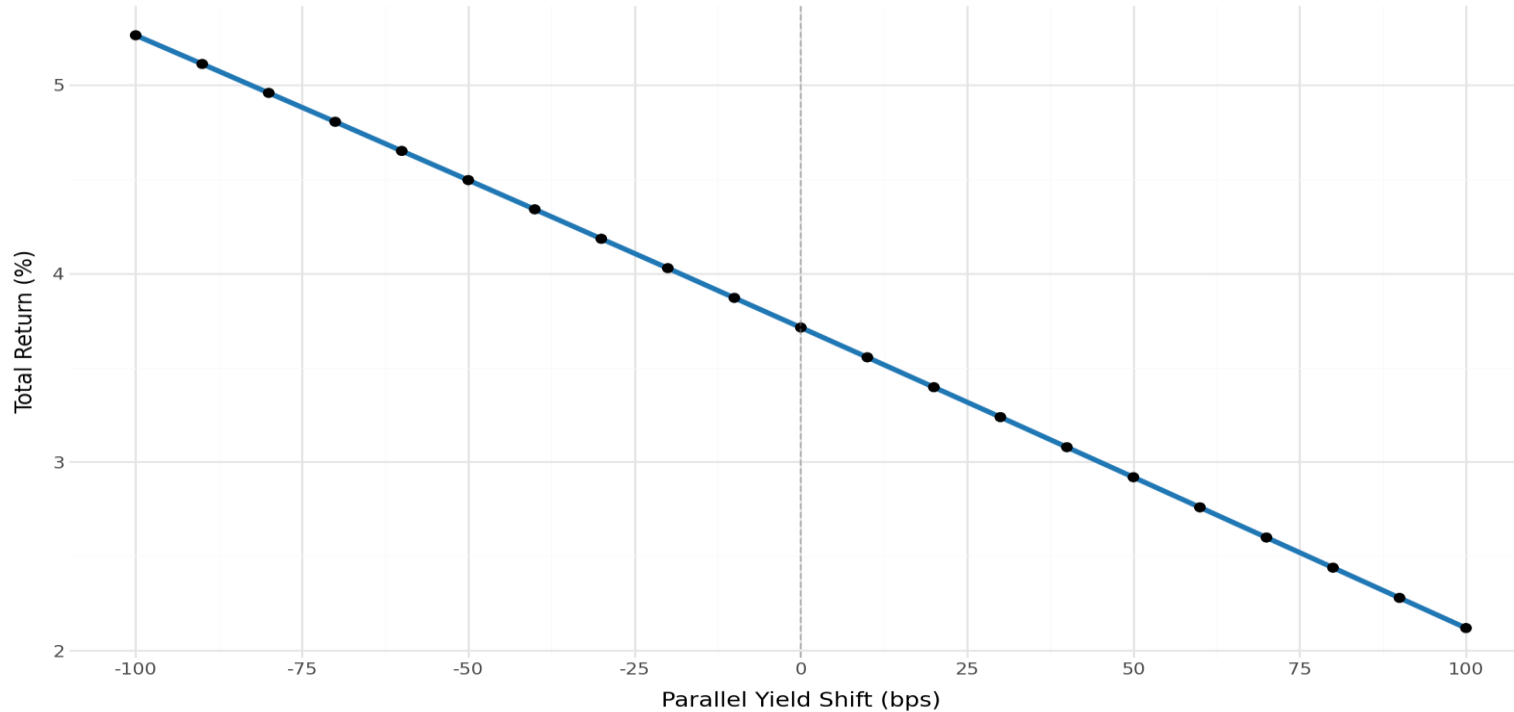
Ticker	CUSIP	Market Price	Model DirtyPrice	Model Clean Price	Model Error	Calibrated Sigma
WM	34061XAH5	98.834	103.015	102.347	3.513	0.008626

2. Calibrated to solve implied OAS and option value

Ticker	Straight Price at Maturity	Straight Price 2028 Put	Market Price	Implied Price	Model Error	Implied OAS (bps)	BBG OAS (bps)	OAS Error	Option Value	Call Value	Mandatory Put Value	Calibrated Sigma
WM	72.451	98.921	98.834	98.834	0.000002	142.7	143.3	-0.606939	-26.38	0.087	-26.47	0.008626

5. Calibrated HW model then enables interest rate sensitivity analysis

1-Year Horizon Performance: WM
 Horizon Date: 2026-12-07 | Yield Shift +/- 100bps



- HW model computes option adjusted duration and convexity using finite differencing methods.
- A parallel curve shift of 10bps was used to compute WM's effective duration of 2.49 and effective convexity of -1.79.
- Enables analysis of the risky bond's performance vs. the risk-free bond. Horizon analysis is conducted by using a constant yield forward curve and a trinomial tree grid to price the bonds.

Change in rates (bps)	-100	-70	-50	-30	-20	-10	0	10	20	30	50	70	100
Bond Total Return	5.26%	4.80%	4.49%	4.18%	4.03%	3.87%	3.71%	3.55%	3.40%	3.24%	2.92%	2.60%	2.12%
RF Total Return	3.75%	3.31%	3.02%	2.73%	2.59%	2.44%	2.30%	2.15%	2.01%	1.86%	1.57%	1.27%	0.82%
Excess Return	1.51%	1.49%	1.47%	1.45%	1.44%	1.43%	1.41%	1.40%	1.39%	1.38%	1.35%	1.33%	1.30%