



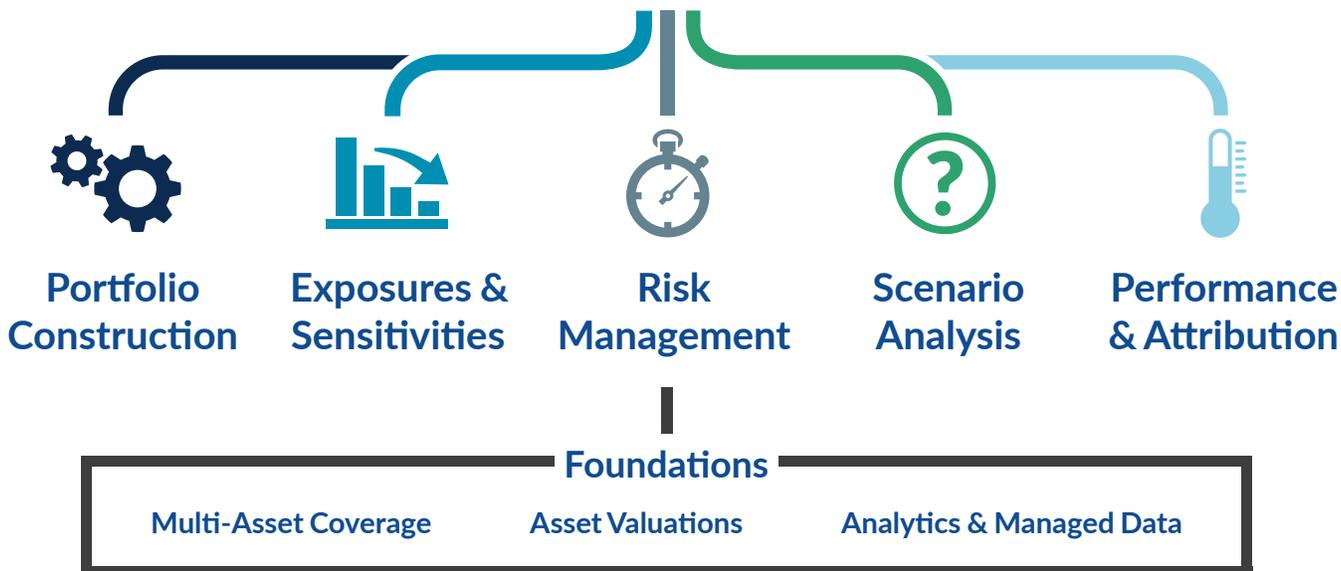
Charles River IMS Portfolio Management and Risk Analytics

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Charles River Portfolio Management and Risk Analytics



Portfolio Construction

Portfolio Construction, Optimization and Analysis

- Analyze accounts containing different currencies and instruments, managed to different mandates
- Construct portfolios to align with investment guidelines and optimize portfolio composition
- Manage Liability Driven Investment mandates and strategies

Exposures & Sensitivities

Analyze and Understand Exposures and Sensitivities

- View portfolio exposures across multiple dimensions and custom classifications
- Propose trades to bring exposure to target levels, and see exposures adjust in real-time
- Analyze sensitivities to rate, credit and inflation risk factors at portfolio and category levels

Risk Management

Model, Measure and Manage Portfolio Risk

- Decompose risk at portfolio and category levels into systemic and idiosyncratic risk
- Manage total portfolio risk using Value at Risk (VaR), conditional VaR and component VaR
- Provide the front and middle office with a single, consistent view of risk

Scenario Analysis

Scenario Analysis, Stress Testing and Trend Analysis

- Model portfolio stress factors: interest rate and FX shifts, credit spread changes, and inflation shocks
- Leverage factor models to predict how factor shifts impact the scenario based on factor covariances
- Apply stress factor shifts and visualize portfolio and benchmark impacts over any time horizon

Performance & Attribution

Performance Measurement and Attribution

- View historical performance across any timeframe to evaluate portfolio construction decisions
- Select attribution methodology based on business needs; apply at global, account or report levels
- Analyze ex-post risk to verify that investment decisions align with risk mandate

Foundations

Analytics, Valuations and Managed Data

- Global instrument and analytics coverage and managed reference, pricing, index and benchmark data
- Industry standard computational models help ensure accurate valuations
- Managed pricing, benchmark, corporate actions and reference data services

A Complete Solution for Portfolio Managers

Charles River Portfolio Management and Risk Analytics combines all of the necessary capabilities, data, analytics and benchmarks needed to effectively manage large multi-asset portfolios. The solution provides asset managers with:

- Portfolio construction and analysis
- Ex-ante risk modeling and ex-post risk measurement
- Scenario and trend analysis
- Performance measurement and attribution
- Pre-packaged workflows and standardized interfaces

The scalable, cloud-based infrastructure helps ensure buy-side firms can handle complex multi-asset portfolios as well as large benchmarks. Native analytics and a high performance modeling engine allow portfolio managers to generate risk forecasts and analyze scenarios in real-time.

Buy-side firms can replace multiple systems with a single solution that supports all investment products and asset classes, and provides the front and middle office with a consistent, enterprise-wide view of risk and performance.

Institutional asset managers can implement their entire investment process on Charles River using a common set of data and analytics, and can incorporate third-party risk models and bespoke data sources to support their strategies and products.

Charles River helps institutional investment managers:

- More readily understand risks with a single, enterprise-wide view of counterparty exposures and risk metrics
- Respond faster to market opportunities and make more informed allocation, targeting and hedging decisions
- Increase portfolio manager and analyst productivity by providing a complete set of capabilities that streamline the investment process
- Eliminate disparate systems by managing all products on a single solution
- Leverage the latest capabilities and risk models with cloud-based deployment



Portfolio Construction

Construct, Analyze and Optimize Multi-Asset Portfolios

Centralized portfolio management capabilities provide views of exposures and holdings, so portfolio managers can:

- See the impact of asset allocation and de-risking decisions
- Construct portfolios that align with investment guidelines
- Understand even the most complex compliance and risk guidelines and readily adjust proposed allocations

Managers can optimize a number of portfolio attributes directly from the portfolio management workspace. Attributes include the desired level of turnover, tracking error ranges, and the desired number of transactions. Portfolios can be tilted toward specific targets for any number of user-defined variables or security groupings. Hard constraints can be applied in absolute terms, relative to a benchmark, or relative to the initial position. Both market neutral and uneven long/short strategies can be optimized as a single problem, eliminating the need to perform separate optimizations. The optimizer can use factors derived from both Charles River's standard models and third-party models.

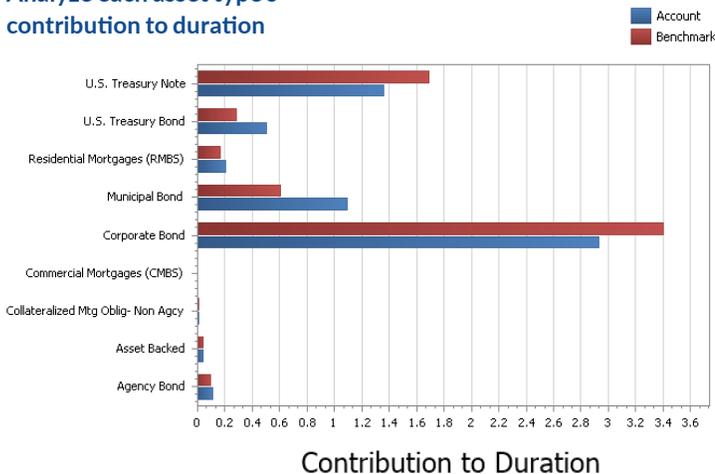
Charles River also supports historical analysis. Portfolio managers can view history in terms of holdings, and/or perform trend analysis. For example, a fixed income manager may wish to see how they were positioned actively against a benchmark in terms of exposure and duration; this analysis can be performed via the historical views and charted for visual effect.

Security Type	Duration	Exp %	Bmk %	Yield to Worst	DV01	Spread Dur	OAS	Rating
Positions Grand Total	6.435	97.06	99.37	2.086	0.077	6.367	78	A
Municipal Bond	11.540	9.44	5.24	3.807	0.167	12.281	143	A+
U.S. Treasury Bond	9.853	5.14	2.85	1.487	0.125	9.551	2	AAA
Corporate Bond	7.145	40.97	43.68	2.723	0.084	6.951	135	BBB+
Residential Mortgages (RMBS)	5.648	3.61	2.92	2.216	0.059	5.557	95	AA+
U.S. Treasury Note	4.384	30.92	38.59	0.993	0.048	4.284	3	AAA
Agency Bond	2.689	4.22	3.64	1.019	0.029	2.581	15	AA+
Asset Backed	2.046	1.94	1.73	1.305	0.020	1.961	42	AA+
Collateralized Mtg Oblig- Non Agcy	1.339	0.67	0.58	2.208	0.013	1.254	154	AAA
Commercial Mortgages (CMBS)	0.844	0.16	0.14	2.059	0.008	0.789	148	AAA

View portfolio characteristics by asset type and exposure versus benchmark by issuer.

Issuer	Exp %	Bmk %	Coupon	Rating
Positions Grand Total	47.02	99.37	2.590	A
Wal-Mart Stores Inc	0.89	1.11	5.315	AA
JPMorgan Chase & Co	0.96	1.10	3.350	A-
AT&T Inc	1.06	1.21	4.089	BBB+
Federal National Mortgage Association	1.12	0.96	1.753	AA+
Citigroup Inc	1.14	1.05	4.224	BBB+
State of Illinois	1.31	0.74	5.253	BBB
Goldman Sachs Group Inc/The	1.32	1.37	5.154	BBB+
State of California	1.55	0.87	7.345	A+
Federal Home Loan Mortgage Corp	1.60	1.40	3.555	AA+
United States Treasury Note/Bond	36.06	41.44	1.994	AAA

Analyze each asset type's contribution to duration



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Liability Driven Investing

Construct and Manage LDI Driven Strategies

Liability-Driven Investment (LDI) strategies help insurers and pensions manage assets based on the cash flows required to fund future liabilities. These strategies may include matching the cash flows of assets with the cash flows of liabilities, or matching the risk sensitivities of both assets and liabilities, so that assets can still fund liabilities if market conditions change. These capabilities help asset managers minimize a portfolio's liquidation risk by ensuring asset sales, interest, and dividend payments correspond with expected payments to beneficiaries.

The Charles River Investment Management Solutions (Charles River IMS) uses a "Liability Instrument" to streamline modeling of cash flows. The following capabilities support LDI workflows:

LIABILITY BENCHMARKS: Users assign a liability benchmark to their respective funds. These benchmarks contain the liabilities that correspond to the fund.

LIABILITY MAPPING: Users can define liabilities to be either nominal or inflation-adjusted. Inflation adjusted liabilities can be modeled based on an imported set of real and/or inflation adjusted cash flows.

FLEXIBLE ANALYTICS: Liability valuations can be produced relative to a set of actuarial cash flows discounted relative to the appropriate curve (e.g., IRS curve) and spread. Users can specify tenor set sensitivities for the asset portfolio and the liabilities. The sets feature:

- Flexible tenor definitions
- Ability to generate interest rate and inflation sensitivities per tenor
- Ability to link interest rate to inflation sets

PORTFOLIO MANAGEMENT: The Charles River Manager Workbench enables users to efficiently manage a portfolio of assets and liabilities. Portfolio managers can display liability securities, calculate and show funding ratios, and generate a range of analytics by tenor, including PV01, DV01 and IE01. This supports standard hedging and targeting workflows, for example, hedging a position and determining funding ratio impact.

SCENARIO ANALYSIS: Charles River Scenario Analysis supports the ability to shift the market factors that are relevant to liabilities (e.g., interest rates, inflation and spreads). User-specified shifts are applied to all relevant curves, liability, and asset attributes in order to obtain a scenario specific set of valuations, analytics and cash flows.

From a fund management perspective this allows a portfolio manager to:

- View funding and hedge ratios subject to various economic environments
- Perform cash ladder analysis relative to their liabilities
- Analyze changes in valuations and sensitivities subject to regime changes

For stress testing, liabilities can be proxied or used in factor scenarios if factor exposures are available.

COMPLIANCE MONITORING: Compliance rules can be based on portfolio level analytics, tenors, and funding ratio.

Exposures & Sensitivities

Analyze and Understand Exposures and Sensitivities

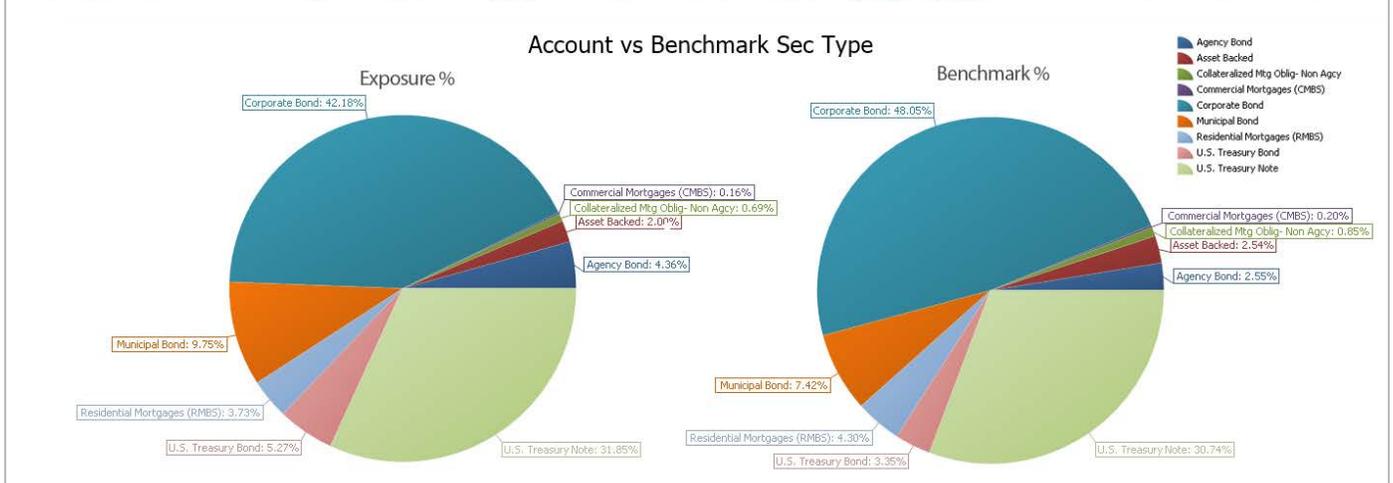
Portfolio managers, compliance officers, and risk managers can calculate, manage, and monitor risk across the entire investment lifecycle. Assessments of portfolio, market, and sector risk are calculated using a single, consistent set of data, eliminating the potential for conflicting or questionable results.

Managers can view portfolio exposures across multiple dimensions and custom classifications, propose trades to bring exposure to target levels, and see exposures adjust in real-time. Trades can then be generated and routed to the appropriate trading desk. The solution lets managers and analysts:

- Analyze sensitivities to rate, credit and inflation risk factors at portfolio and category levels
- Propose changes and analyze results of de-risking decisions pre-trade
- Model and hedge portfolios using the latest market data
- Optionally incorporate bespoke and 3rd party analytics
- Utilize industry-standard derivative valuation models

Aggregate account exposures by key rate duration and compare current exposures to benchmark.

Security Type	Eff Duration	Active	6M KRD	1YR KRD	2YR KRD	3YR KRD	5YR KRD	7YR KRD	10YR KRD	20YR KRD	30YR KRD
▼ Positions Grand Total	6.38	(1.66)	0.01	0.04	0.06	0.13	0.05	(0.39)	(0.34)	(0.57)	(0.44)
> FI Core Corp 2	6.39	(1.51)	0.01	0.04	0.06	0.12	0.05	(0.40)	(0.34)	(0.56)	(0.43)
> FI Core Corp 3	6.39	(1.47)	0.01	0.04	0.06	0.12	0.05	(0.39)	(0.34)	(0.56)	(0.43)
> FI Core Corp 4	6.38	(1.78)	0.01	0.04	0.06	0.12	0.05	(0.39)	(0.34)	(0.57)	(0.43)
▼ FI Core Corp 5	6.36	(1.72)	0.01	0.04	0.06	0.13	0.04	(0.38)	(0.34)	(0.59)	(0.45)
Corporate Bond	7.04	(1.54)	0.01	0.04	0.08	0.21	0.08	(0.43)	(0.60)	(1.00)	(0.59)
U.S. Treasury Note	4.32	(0.48)	0.02	0.05	0.04	0.08	0.05	(0.47)	(0.18)	(0.44)	(0.63)
Residential Mortgages (RMBS)	5.61	(0.03)	0.00	0.00	0.00	0.00	(0.00)	(0.03)	0.000		
Asset Backed	2.04	(0.01)	0.00	0.00	0.00	(0.000)	(0.00)				



Risk Management

Assess Forward Looking Risk

Charles River implements three ex-ante risk measures that help managers assess forward-looking risk and adjust their portfolios accordingly:

VALUE AT RISK (VaR) uses historical simulation to calculate the worst case loss over a given time period that won't be exceeded with a given level of confidence.

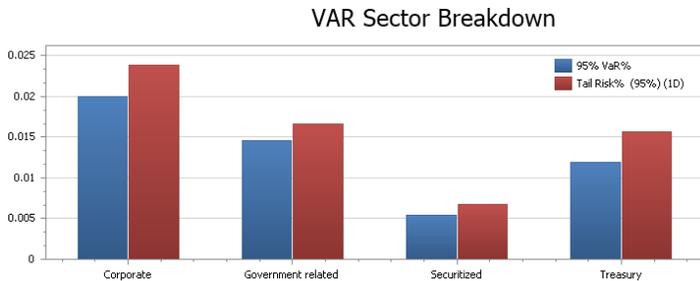
CONDITIONAL VaR, or expected shortfall, quantifies the potential loss once the VaR threshold has been exceeded.

COMPONENT VaR lets portfolio managers quickly visualize how much a particular sector, category or security adds or subtracts to their overall VaR so they can reduce or hedge those exposures.

Adjustments are immediately reflected, helping managers validate their decision and understand portfolio-level impacts. Historical simulation is a robust, non-parametric method for calculating VaR that makes no assumptions about the underlying distribution of risk factors or returns. VaR calculations can incorporate either exponential decay to weight recent data more heavily, or stressed conditions to produce realistic worst-case forecasts. Replacement securities can be utilized to account for missing data.

Charles River also supports risk forecasts based on factor models, including projected volatility, tracking error, and beta. Firms can utilize Charles River's proprietary factor model based on Principal Components Analysis (PCA), or incorporate in-house and third party models.

Component VaR displays how much a particular sector or category impacts overall VaR.



Security	VaR MV%	VaR MV	Tail Risk%	Tail Risk MV	Contrib VaR Acct Amt
Positions					
FI Core Corp 5	0.006	8,453.857	0.007	9,692.619	
> Asset Backed Securities	0.040	1,089.493	0.051	1,382.226	73.321
> Basic Materials	0.021	455.254	0.026	568.231	12.134
> Communications	0.024	1,293.222	0.028	1,507.360	453.002
> Consumer, Cyclical	0.016	878.354	0.020	1,128.857	355.436
> Consumer, Non-cyclical	0.014	1,301.203	0.017	1,574.778	372.286
> Energy	0.014	912.620	0.018	1,162.844	239.155
> Financial	0.012	1,928.075	0.013	2,157.643	669.689
> Government	0.010	6,556.637	0.012	8,177.643	4,794.587
> Industrial	0.015	688.353	0.019	870.584	461.883
> Mortgage Securities	0.021	1,359.490	0.027	1,745.649	145.528
> Technology	0.022	896.842	0.027	1,105.746	549.829
> Utilities	0.012	479.833	0.014	565.676	133.326

VaR simulation engine inputs by asset class.

Instrument Type	VaR Simulation Inputs
Equities	Individual securities' historical returns, including corporate actions
ETFs, Mutual Funds and other basket securities	Either the baskets' historical returns or the look-through returns of the underlying instruments
Fixed Income and Derivatives	Delta-Gamma method: Utilizes sensitivities to risk factors such as yield curves

Understand Risk in a Historical Context

Portfolio managers can monitor changes in historical VaR and ex-post risk metrics over time and analyze the evolution of their portfolio using trend analysis. This provides insight into whether changes to risk levels were anticipated and desired, or whether they were a result of increased risk exposures that should have been managed and reduced. The displays are also actionable, so de-risking activities can be carried out and reflected in real time.

Screenshots are for informative purposes only; no live data being used.

Scenario Analysis

Model Historical and Hypothetical Stress Scenarios

Charles River's Scenario Analysis capabilities are used to model portfolio impacts of one or more stress factors, including interest rate and FX shifts, credit spread changes, inflation shocks, and equity market movements.

STRESS TESTING applies scenarios mandated by regulatory authorities to model potential outcomes and gauge worst-case drawdown.

HYPOTHETICAL SCENARIO ANALYSIS allows managers to construct and apply a plausible scenario based on their portfolio's risk exposures, reflecting the full impact of underlying instruments, including derivatives, and taking into account all portfolio and cash events.

HORIZON ANALYSIS applies shifts and then displays portfolio performance over a horizon term ranging from days to years, based on a reinvestment rate for any cash flows received, including coupon payments, maturities, and callable/puttable bonds that would be called/put within that term.

The following methodologies are applied when evaluating scenarios:

Instrument Type	Methodology
Fixed rate bonds	Interest rate shift is applied to the spot curve and credit shift to OAS.
Floating rate bonds	Interest rate shift is applied to both the index and the discount curve, and credit shift to OAS.
Inflation linked bonds	Interest rate shift is applied to discount curve and credit shift to OAS. Inflation shift is applied to either an inflation swap curve or a constant inflation rate assumption.
Mortgages and other asset-backed instruments	Scenario analysis is performed using the Yield Book calculation engine, via real-time integration.
Interest rate swaps	Each leg of a swap can be shifted independently, including accrual and discount curves. Credit shifts do not apply.
Bond futures	Interest rate shift is applied to the yield curve. Credit shifts do not apply. Daily mark-to-market is ignored for horizon analysis; cheapest-to-deliver bond is assumed to remain unchanged throughout the life of the future.
Interest rate futures	Interest rate shift is applied to the yield curve. Credit shifts do not apply. Daily mark-to-market is ignored for horizon analysis; futures are converted to cash at the futures' expiration date, including any gain/loss on the contract.
Bond and interest rate options	Interest rate shift is applied to the underlying future.
Forward rate agreements	Interest rate shift is applied to the yield curve. Credit shifts do not apply. For horizon analysis rate of return calculations, fair value is centered on 100.
Currency futures and forwards	FX shifts are applied to the FX forward curves.

Details of portfolio impact of stressed scenarios, broken down by sector.

Bloomberg Industry Sectors	Horizon MV	Stressed MV	Horizon RoR	Stressed RoR	Horizon Eff Duration	Stressed Eff Duration
Positions Grand Total	3,575,884,209.510	3,385,155,301.870	2.458	(2.689)	6.212	5.252
IG_Corp Bond Fund A	1,191,883,119.360	1,128,312,228.760	2.458	(2.689)	6.212	5.252
Basic Materials	68,754,078.110	67,764,821.230	0.867	(0.482)	2.318	1.449
Consumer, Cyclical	30,076,067.610	29,584,418.770	2.354	0.743	2.547	1.647
Consumer, Non-cyclical	30,963,269.270	28,688,006.640	10.956	3.360	8.596	7.282
Energy	27,498,450.750	27,179,243.080	13.054	11.860	1.958	1.165
Financial	196,434,145.350	181,574,309.130	4.515	(3.030)	8.536	7.583
Government	769,250,391.330	727,426,421.350	1.184	(4.021)	6.326	5.349
Industrial	42,836,214.480	40,342,570.150	6.167	0.352	6.790	5.914

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Performance & Attribution

Measure Portfolio Performance and Attribution

Portfolio managers can view historical portfolio performance across any timeframe and understand the portfolio construction and asset selection decisions responsible for that performance. Users can change performance or attribution settings on the fly and run different analyses for the same account across asset types, down to the individual security level. Performance results can be converted to any currency and custom benchmarks can be created by importing and blending category- or constituent-level indices.

Managers can:

- Measure performance using either time-weighted or money-weighted methodologies, configurable at the account level
- Calculate multiple return types, including capital, income, base, local, currency, gross and net
- Roll up performance to any level, including multiple nested classifications, total portfolio/benchmark, account groups and composites
- Choose the attribution methodology that best supports their business needs, and configure the methodology at global system, account, or report levels

Attribution methodologies and major capabilities include:

- Daily attribution by asset style, including currency, fixed income roll, duration, convexity and spread effects
- Roll up attributions to multiple classification levels for each security, including domicile (region, country, currency) and sector (industry or sub-sector)
- Automated rule-based workflows for composite construction and maintenance
- Extensive audit trail reduces third-party verification costs
- Equity attribution methods include Brinson-Hood-Beebower, Brinson-Fachler and Karnosky-Singer
- Fixed income attribution methods include van Breukelen and Tim Lord-styled breakdowns (income, roll, duration, convexity, spread allocation and selection, currency)

Risk-adjusted performance measures can be viewed at account and position levels.

Account	1Q	BM 1Q	Tracking Error	Sharpe Ratio	Vol	Security	% Weight	Total Return	CTR
Accounts						Positions			
FI Core Corp 2	(0.508)	(0.280)	0.073	(0.131)	0.069	FI Core Corp 3	100.000	(0.008)	(0.008)
FI Core Corp 3	(0.008)	(0.280)	0.069	(0.022)	0.065	ONCOR ELECTRIC DELIVERY 2.15% 06/01/2019	0.022	12.888	0.003
FI Core Corp 4	0.811	(0.280)	0.068	0.178	0.061	BROOKFIELD ASSET MAN INC 7.375% 03/01/2033	0.028	13.688	0.004
FI Core Corp 5	(0.156)	(0.280)	0.079	(0.052)	0.071	WISCONSIN POWER & LIGHT 7.6% 10/01/2038	0.035	14.522	0.004
						ENTERPRISE PRODUCTS OPER 4.85% 03/15/2044	0.122	15.349	0.016
						NEWMONT MINING CORP 6.25% 10/01/2039	0.105	15.535	0.012

Understand Risk-Adjusted Performance

Performance risk analysis quantifies how much risk was required to achieve historical portfolio returns. This enables portfolio managers to ensure their risk/return ratio aligns with their risk guidelines and Investment Policy Statements and provides visibility into how closely they track their benchmark. Supported risk measures include:

ABSOLUTE AND RELATIVE SUMMARY RISK MEASURES: alpha, beta, Sharpe ratio, Treynor ratio and Sortino ratio

EX-POST RISK MEASURES: beta, information ratio, tracking error, volatility and variance

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Multi-Asset Coverage

Global Multi-Asset Coverage

The Charles River Data Service provides managed reference and pricing data to support broad and deep global coverage across all asset classes. Frequent updates help ensure that new instruments are made available to asset managers on a timely basis.

Fixed Income, Currencies and Commodities (FICC)

- Global Government: Over 100 jurisdictions/sovereigns
- Securitized Products: MBS, ABS, CMBS and CMOs
- Treasury and Swap curve-based analytics, swap curves in 14 currencies
- Corporate: Global Investment Grade, High Yield, and Bank Loans
- Structured Products: Fixed Rate, Floating Rate, Fixed-to-Float, Stepped, PIK, Callable
- Municipals: Comprehensive state coverage
- Inflation Linked: Over 20 countries
- Currencies: Spot and Forwards for 174 base currencies
- Futures for over 3200 commodities

Equities

- Common Stock, Closed-End Funds, ETFs, ADRs, REITs, Convertible Bonds
- Developed and Emerging Markets in 160 countries and 72 currencies

Derivatives

- Exchange Traded - Bond Futures, Interest Rate Futures, Currency Futures, Equity Index Futures, Options on Futures, Equity Options and Equity Index Options
- OTC Rate and Credit - Interest Rate Swaps, Inflation Swaps, Asset Swaps, FRAs, Caps/ Floors, Swaptions, CDS, CDX/iTraxx, TRS- Bond, CDS/CDX Swaptions
- OTC Other - TRS- Equity, Variance/Volatility Swaps, FX Forwards, FX Options, Commodity Swaps

Asset Valuations

Consistent and Accurate Asset Valuations

Charles River provides a highly performant analytics engine; managed reference, benchmark and pricing data; extensive global instrument coverage; and industry standard computational models for accurate, real-time valuations of all instruments.

Firms can store and compare multiple reference, analytics, and pricing suppliers and sources to meet the particular valuation requirements of their investment process and product mix. Charles River maintains always-current mappings for 1000+ data elements to support over 120 types of bonds globally. Continuous validation helps ensure that accrued interest and critical analytics are calculated correctly.

Analytics

Analytics & Valuations

Charles River supports both natively calculated and third-party analytics for bonds, derivatives, mortgages, and asset-backed securities. Natively calculated analytics are compatible with major index analytics across all asset types such that comparisons to benchmarks can be performed accurately. This eliminates the need for external index-provider analytics systems. However, external analytics can be imported, and selectively mixed and validated.

Native analytics calculated using the embedded analytics engine.

Category	Analytic(s)
Trade-level	Price, yield, accrued interest, projected cash flows, factor, spread to benchmark
Sensitivities	Duration, modified duration, convexity, DV01, mortgage-specific sensitivities
Derivative-related	Option greeks, credit DV01, inflation DV01, par swap rate
Advanced	Option adjusted spreads, I-spread, Z-spread, fair value, spread duration, spread convexity, key rate durations

Users also have the capability to recalculate analytics for specific components of their portfolios should underlying market activity dictate. Analytics are calculated using industry standard methodologies, and new methods (e.g., dual-curve stripping) are added when industry best practices change.

Representative technologies utilized to calculate analytics.

Instrument Type	Methodology
Bonds	1-factor Hull-White model Black Karasinski with configurable volatility and mean reversion parameters
Options	Black Scholes or binomial tree for European options Binomial tree for American or Bermudan options Dividend yield or projected discrete dividends
CDS Basket	1-factor Gaussian copula for homogeneous baskets Normal copula for non-homogeneous baskets
CDS Index Tranche	Monte Carlo Fast Fourier Transform Recursion method
Swaptions	Black model with lognormal volatility
Inflation Swaps	Accruing on inflation swap curves, discounting on LIBOR/Swap or OIS
Interest Rate Swaps	Discounted cash flows with different principal exchange conventions Supporting different accrual (forward) and discount curves – e.g., accrual on LIBOR/Swap and discount on OIS
Variance & Volatility Swaps	Discounted cash flows, Heston, and Options Portfolio Replicating methods

MORTGAGE PASS-THROUGH SECURITIES AND TBA'S: Trade-time analytics and mortgage duration and convexity are calculated natively. Charles River provides an internally developed model that uses security characteristics, such as WALA and WAC, and mortgage rate scenarios to estimate future prepayment rates.

ASSET-BACKED SECURITIES: Instrument coverage includes RMBS and CMBS, agency and non-agency CMOs, fixed and adjustable rate mortgages, TBAs and other asset-backed securities. More sophisticated pre-payment models are supported in Charles River via the integrated Yield Book analytics. For example, the Citi Mortgage Prepayment model incorporates over 12 factors, including average credit score, turnover effects, refinancing, and loan-to-value. Supported interest rate models include LIBOR-Market, 2-factor skew and 1-factor single volatility.



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Investment firms, asset owners, wealth managers, hedge funds and insurers in more than 30 countries rely on Charles River's front and middle office investment management platform to manage more than US\$30 Trillion in assets. Together with State Street's middle and back office capabilities, Charles River's software technology forms the foundation of State Street AlphaSM. The Charles River Investment Management Solution (Charles River IMS) is designed to automate and simplify the institutional investment process across asset classes, from portfolio management and risk analytics through trading and post-trade settlement, with integrated compliance and managed data throughout. Charles River's growing partner ecosystem enables clients to seamlessly access external data and analytics, applications and liquidity venues that support the unique demands of their product and asset class mix. Headquartered in Burlington, Massachusetts, we serve clients globally with more than 975 employees in 12 regional offices. (Statistics as of October 2019)

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