



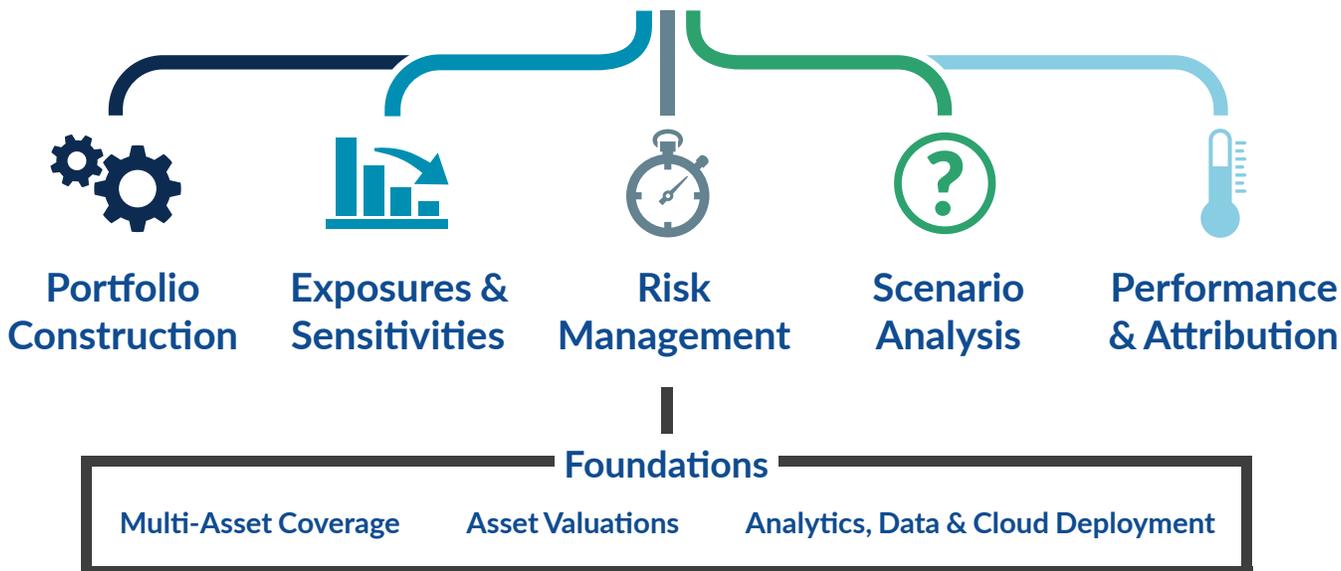
Charles River IMS Portfolio Management and Risk Analytics

**Charles
River**

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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
- Readily identify portfolios and positions requiring attention with exception-based workflows

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, Managed Data, and Cloud-based Deployment

- Global instrument and analytics coverage and managed reference, pricing, index and benchmark data
- Industry standard computational models help ensure accurate valuations
- Frequent upgrades, managed data services and best-of-breed cyber security

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.

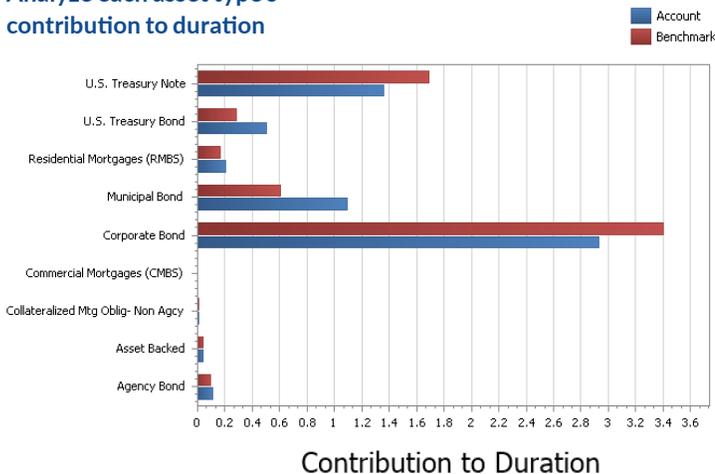
Charles River also supports historical analysis. Portfolio managers can view history in terms of holdings, and/or perform trend analysis. For example, a fixed income manager may wish to see how they were positioned actively against a benchmark in terms of exposure and duration; this analysis can be performed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

Analyze and Understand Exposures and Sensitivities

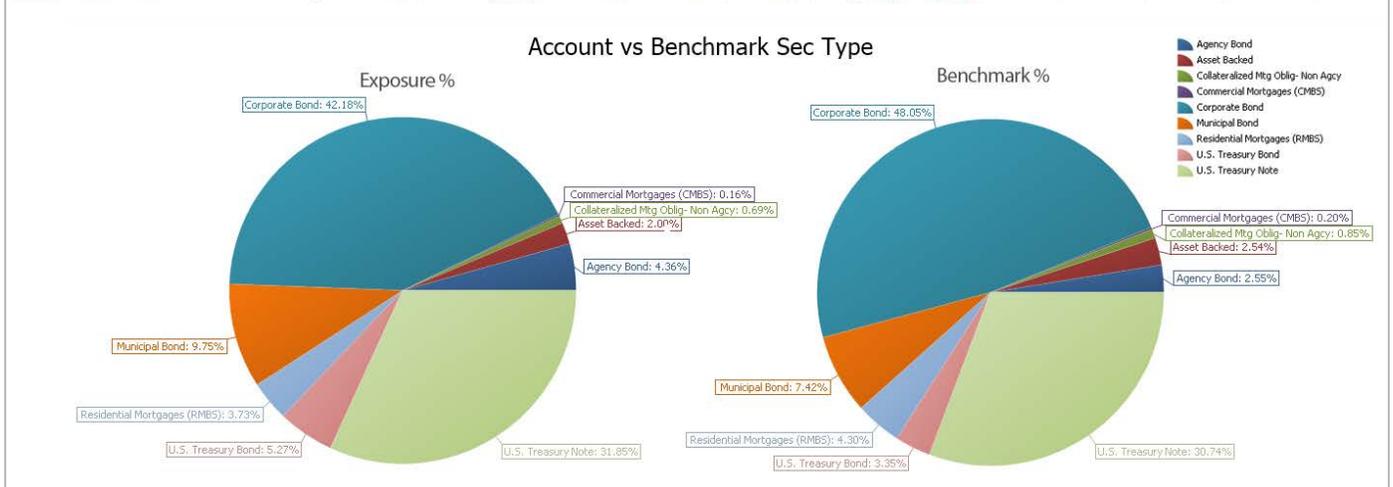
Portfolio managers, compliance officers, and risk managers can calculate, manage, and monitor risk across the entire investment lifecycle. Assessments of portfolio, market, and sector risk are calculated using a single, consistent set of data, eliminating the potential for conflicting or questionable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



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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.

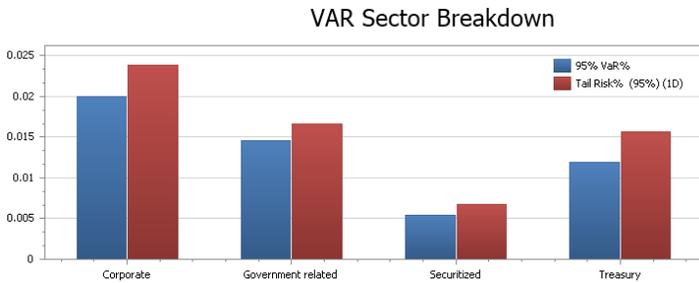
CONDITIONAL VaR, or expected shortfall, quantifies the potential loss once the VaR threshold has been exceeded.

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.

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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.

Cloud Deployment & Data

Cloud-based Deployment & Managed Data

Charles River IMS is deployed via Software as a Service (SaaS). This helps simplify client operations, improve data quality and investment professional productivity, manage risk and lower technology costs.

UP TO DATE CAPABILITIES: Charles River's operations specialists provide software upgrades and other updates in a timely manner, and aims to ensure that new instrument support and other improvements are made available to meet client needs. End users can leverage the latest capabilities, and firms avoid the risks associated with outdated software. Charles River can also introduce incremental enhancements more frequently in response to client, regulatory and market requirements.

MANAGED DATA SERVICES: The Charles River Data Service alleviates many of the complexities and costs of data management by integrating multiple data sources to provide complete, accurate and timely data to the Charles River IMS.

Charles River's Data Management Service is designed to ensure that high quality security master data is made available to the front office before each trading day. In a typical client scenario, foundational security data from the Charles River Data Service or Bloomberg is blended with other data sources and brought directly into the Charles River IMS. The Data Management Service evaluates and resolves all data exceptions related to reference data, pricing, analytics and benchmarks. By performing proactive data validation, Charles River's global data team can identify and rectify issues before they impact front office activities.



PRIVATE CLOUD-BASED DELIVERY: ISO certification of our private cloud environment helps ensure that the Charles River IMS is running on the latest infrastructure, security protocols and operating systems. SaaS deployment provides a more predictable cost structure and better application performance and reliability than firms can maintain internally.

FIX CONNECTIVITY: A certified global FIX network is administered by an internal support team that manages, tests and certifies broker connectivity, helping ensure seamless, reliable electronic trading.

SWIFT CONNECTIVITY: Direct connectivity to SWIFT destinations allows firms to send trade notifications to custodians, receive trade confirmations and settlement status, and obtain position and trade reconciliations.



A State Street Company

Charles River Development, a State Street Company, enables sound and efficient investing across all asset classes. Investment firms in more than 40 countries use Charles River IMS to manage more than US\$25 Trillion in assets in the institutional investment, wealth management and hedge fund industries. Our Software as a Service-based solution (SaaS) is designed to automate and simplify investment management on a single platform – from portfolio management and risk analytics through trading and post-trade settlement, with integrated compliance and managed data throughout. Headquartered in Burlington, Massachusetts, we support clients globally with more than 750 employees in 11 regional offices.

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