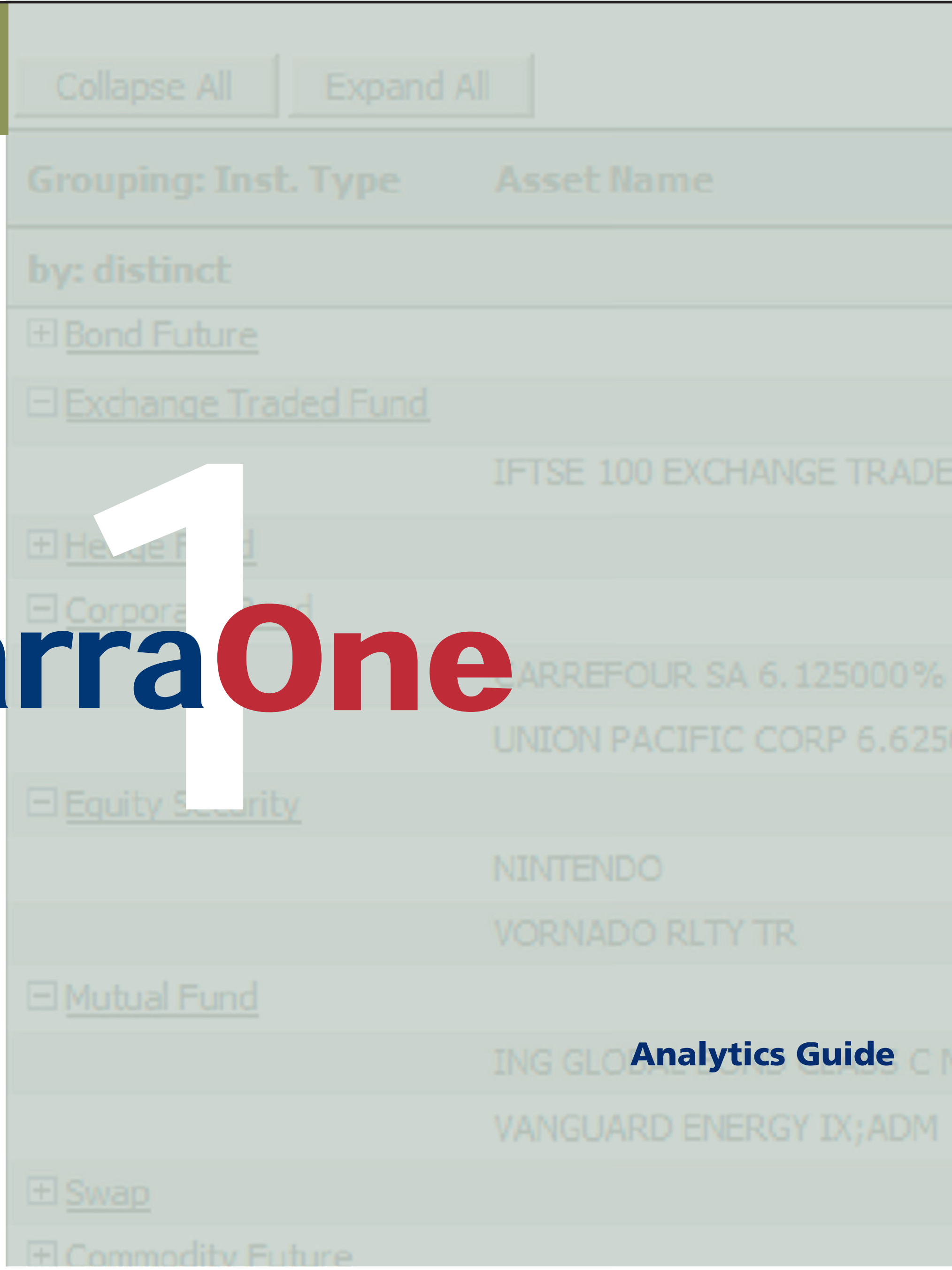
Barra

BarraOne



Analytics Guide

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[1] *As of September 30, 2012, as published by eVestment, Lipper and Bloomberg on January 31, 2013*

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Chapter 1

Introduction

This chapter provides an introduction to the *BarraOne Analytics Guide*.

About BarraOne

BarraOne, MSCI Barra's Web-based risk platform, provides a global, multi-asset class framework for interactive risk analysis, trade scenarios, portfolio optimization, and risk reporting, delivered through a browser interface. BarraOne lets you examine equities, bonds, derivatives, currencies, and hedge fund strategies in one system that captures complex cross-market and cross-asset class relationships, while preserving local market detail.

With BarraOne's flexible interface, you can slice and dice the risk of any portfolio along the dimensions that best reflect your own investment processes. You can aggregate holdings or portfolios to analyze risk and exposures across asset classes, countries, or your entire firm. Powered by the Barra Integrated Model, BarraOne allows you to assess the risk of domestic, global, equity, fixed income, and balanced portfolios in a single, unified risk framework.

About this Guide

This *BarraOne Analytics Guide* describes portfolio-level and asset-level analytics provided by BarraOne.

Here is what the *BarraOne Analytics Guide* contains:

- Chapter 2, "Portfolio Analytics," describes and defines the portfolio analytics available in BarraOne reports.
  - Risk Decomposition Report
  - Positions Report
  - Local Market Risk Breakdown Report
  - Factor Exposure Breakdown Report
  - Allocation-Selection Report
  - Multiple Portfolio Comparison Report
  - Stress Testing Report
  - Cashflow Reports
  - Asset Correlations Report
  - Asset-Liability Management Reporting
- Chapter 3, "Asset Analytics," is dedicated to the technical treatment of specific financial instruments in BarraOne.
  - Interest Rate Instruments
  - Fixed Income Instruments
  - Foreign Exchange Instruments
  - Equity Instruments
  - Commodity Instruments
  - Funds
  - Real Estate
  - Certificates and Trackers
  - StructureTool Assets
  - Unit Exposure Assets
  - Option Risk Measurements
  - Derivative Valuation Methodology

- Chapter 4, "Value at Risk," is dedicated to the treatment of Value at Risk in BarraOne.
  - Valuation Methodology
  - Simulation Methods
  - VaR Statistics
  - VaR Analytic Definitions
  - Sample Reports
  - Historical VaR
  - Monte Carlo Simulation
- Chapter 5, "VaR Backtesting," is dedicated to the treatment of VaR Backtesting in BarraOne.
  - Assumptions and Prerequisites
  - Methodology
  - Asset-Level VaR Backtesting Methods
  - Evaluating the Results
  - Treatment of Data Issues
  - Sample Reports
- Chapter 6, "Miscellaneous Analytics," covers the following topics:
  - Multiple Model Support
  - BIM301XL
  - Macro Factor Models
  - BIM with Global Equity Factors
  - Factor Correlations Report
  - Month-End Reporting

Other Resources

You can find additional information about BarraOne in the following locations:

BarraOne's comprehensive, context-sensitive online help, available within the application itself, provides complete instructions for using BarraOne.

The BarraOne home page on MSCI client support website (https://support.msci.com/community/barraone) is a central location for information about BarraOne, including asset coverage, Barra-supplied index portfolios, automation tools, templates for importing your own data files, model details, and more, all aimed at helping you get the most from BarraOne.

Chapter 2

Portfolio Analytics

The portfolio analytics described in this chapter are those used in reports based on the Barra Integrated Model (BIM). Refer to the MSCI Client Support site for complete information on BIM. Value-at-Risk and other reports that are not based on BIM are described elsewhere in this book.

Reporting Overview

Risk is a multi-faceted problem, and a better understanding can be achieved by decomposing risk, by analyzing exposure, and by analyzing the marginal risk contributions of assets, factors, and segments of the portfolio. Risk management is not necessarily about selecting one particular methodology and sticking to it forever. Often an application of alternative but complementary methodologies will provide a more detailed understanding of the risk of the positions.

Multiple Views of Risk

BarraOne offers multiple views of risk, including fundamental factor views, stress testing profit and loss, and VaR (*i.e.,* Parametric, Historical, and Monte Carlo Value-at-Risk).

BarraOne enables users to evaluate various forward-looking scenarios and outcomes for total plan assets. This information can serve as the basis for dialogue with respective asset class groups, senior investment officers, external managers and Board Members. By evaluating the various scenario outputs, the Risk Team and Investment Officers can identify and confirm both intended and unintended bets. Moreover, BarraOne output can serve as the basis for risk budget adjustments or to evaluate global tactical asset allocation changes on a "what-if" basis.

Flexible Risk Reporting

BarraOne's risk reporting is scalable and flexible and can be tailored to each client's portfolios. For example, Barra factor exposures can be viewed in isolation at multiple levels, including asset class, portfolio, or security. Acknowledging that not all users of BarraOne will think of risk measurements in Barra terms, clients can also create up to two levels of custom grouping schemes (such as market cap or duration) to analyze exposures and risks on a systematic or ad-hoc basis. As a result, users are not limited to standard Barra risk decomposition or factor exposure reports.

For instance, BarraOne reports include Total and Active Total (total tracking error) Risk that can be decomposed into Barra- and user-defined buckets:

- Barra-defined buckets include style, industry (sector or concentration), term structure (interest rate), swap and spread, currency, asset-specific sources, *etc.* Marginal Contribution (MC) to Risk is also available for each of these buckets.
- User-defined buckets are created by the client and can be measurements such as market cap, valuation ratios, duration buckets, custom sectors/industries, regions, *etc.*

Portfolio Analytics Reports

The risk reports covered in this chapter include the following:

- The Risk Decomposition Report is an aggregated view of risk. It provides the ability to decompose portfolio, benchmark, and active total risk in *ex ante* annualized standard deviation terms based upon the grouping of the factors in the factor covariance matrix of the Barra Integrated Model (BIM). Custom factor groupings are also supported, and the user can see the covariances between factor groups.
- The Positions Report is an asset-level, or position, view of risk (and also provides a grouped positions view — up to two levels — within the asset-level view) and asset attributes.
- The Local Market Risk Breakdown Report is a view of portfolio risk by local market broken down into its sources (market timing, common factor, and asset selection risk). The report excludes any currency risk from the analysis.
- The Factor Exposure Breakdown Report is a factor-level view of risk. It enables you to determine which factor exposures are driving your risk. Factor exposure is a term used to quantify the magnitude of an asset's (or portfolio's) sensitivity to Barra Integrated Model (BIM) factors.
- The Allocation-Selection Report is an asset allocation view of risk. It presents the active total risk of a fund in terms of two common investment decisions: a top-down allocation decision and a bottom-up security selection decision. BarraOne provides two methods of analyzing the allocation-selection decision: variance and x-sigma-rho.
- The Multiple Portfolio Comparison Report provides relative risk values and *ex ante* correlation matrices that identify portfolios with similar risk characteristics and measure whether they serve to concentrate or diversify other strategies in the analysis.
- The Stress Testing Report shows how your portfolios are affected by various market scenarios, or simulated factor shocks. This functionality enables users to shock their portfolios and find the resulting profit and loss due to user-defined or pre-defined events. BarraOne currently has 57 pre-defined historical scenarios. Users can define their own shocks based on up to five shock types, including equity, interest rate, foreign exchange, credit spreads, or commodity. Additionally, shocks can be defined as uncorrelated or correlated, of which the latter allows users to understand the impact on portfolio profit and loss using correlations in the Barra Integrated Model.

Value-at-Risk

To fully account for inherent asymmetries, BarraOne provides simulation techniques to estimate the future potential return distribution. This simulation is carried out by sampling scenarios of potential market conditions and revaluing the current holdings under these alternative conditions. The scenarios are typically constructed using historical simulations or by using Monte Carlo techniques. These techniques are discussed in detail in Chapter 4.

Historical Value-at-Risk (HVaR)

This functionality enables users to select the risk measures, data range, return horizon, and confidence level, which in combination will form the basis of an historical simulation. There are three steps involved when applying a historical simulation:

- Select a sample of actual daily risk factor or price changes over a given period, such as 250 trading days.
- Apply those daily changes to the current value of the risk factors or prices, and revalue the current portfolio as many times as the number of days in the historical sample.
- Construct a histogram of portfolio values, and identify the VaR that isolates the 5th percentile of the distribution in the left tail, assuming VaR is set at the 95% confidence level. This confidence level is user-defined and can be changed.

Monte Carlo Value-at-Risk (MCVaR)

This functionality enables users to model the possible future prices and values of an asset or portfolio using random factor returns. There are several steps in this process:

- The possible future states are randomly chosen using statistical knowledge of the present.
- The value of an instrument is then calculated for each of the possible future states.
- The probable future value is then estimated by averaging the instrument's value in all future states. The number of iterations is defined by the user.
- The resulting set of price changes are ordered thereby allowing for VaR to be computed for the user-defined confidence interval.

Value-at-Risk Backtesting (VaR Backtesting)

This functionality enables users to check the realized returns of assets and portfolios against the VaR forecast models. Realized losses are checked against simulated VaR values for exceptions (defined as realized losses greater than simulated VaR figure).

Risk Decomposition Report

Overview

The Risk Decomposition report provides the ability to decompose portfolio, benchmark, and active total risk in *ex ante* annualized standard deviation terms (or in terms of a value equivalent to one annual standard deviation), based upon the grouping of the factors in the factor covariance matrix of the Barra Integrated Model (BIM). The report gives you an overview of the risk of your portfolio, and it breaks risk into its major sources so you can identify and isolate each source's contribution. It also lets you drill down to other reports for more detail.

Risk Source	Portfolio Risk	Active Risk	% Portfolio Risk	% Active Risk
Local Market Risk	11.00	5.96	100.00%	100.00%
Common Factor Risk	10.38	4.73	88.99%	62.98%
Industry	10.69	3.24	94.39%	29.50%
Risk Indices	1.40	1.13	1.62%	3.58%
Term Structure	2.46	0.36	5.01%	0.36%
Spread	1.05	1.18	0.91%	3.95%
Emerging Market	0.00	0.04	0.00%	0.00%
Factor Interaction	N/A	N/A	-12.94%	25.58%
Selection Risk	3.65	3.63	11.01%	37.02%
Total Risk	**11.00**	**5.96**	**100.00%**	**100.00%**

Figure 1: Sample Risk Decomposition Report

The report shows a breakdown of portfolio, benchmark, and active numbers for:

- risk, expressed as annualized, *ex ante* standard deviation of return (in percent) calculated from BIM
- percent contribution to risk
- variance (the square of standard deviation)
- parametric value-at-risk (estimated maximum potential loss, expressed in the base currency; not shown for benchmark)

Flexible Risk Decomposition

BarraOne also supports custom risk decomposition along user-defined factor hierarchy trees. Users can create expandable, drill-down factor breakdowns within a single screen and decompose risk along multiple dimensions, such as asset class-by-country or region-by-asset class. Multiple factor decomposition views can be created in the context of user-specific investment decision lines.

Flexible risk decomposition provides the ability to create an aggregated risk decomposition view across all factor types, and to perform risk analyses that would otherwise require combining the standard Risk Decomposition and Factor Exposure Breakdown reports.

Sources of Risk

As an overview of portfolio risk, the Risk Decomposition Report focuses on the upper levels of BarraOne's overall risk decomposition framework:

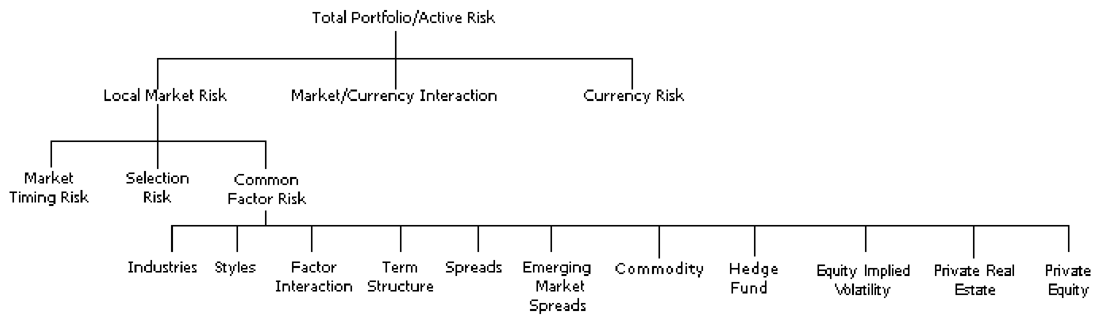


Figure 2: Risk Decomposition Framework

At the top level, the report divides total risk into three main sources:

- Local Market Risk, or risk arising from exposure to a particular local market.
- Currency Risk, or risk arising from implicit and explicit investment in a foreign currency. This risk takes into account the exchange rates and short-term interest rates of the foreign country and the country from whose base currency perspective you are viewing the portfolio.
- Currency/Market Interaction, or the correlation between Local Market and Currency bets—the degree to which they behave in similar or dissimilar ways.
  - A positive number means the two reinforce each other and thus add to the total risk of the portfolio.
  - A negative number means they tend to "move in opposite directions" and thus have a diversifying effect on the portfolio, reducing its total risk.

  Currency/Market Interaction can therefore be viewed as a measure of diversification, with negative values indicating a diversifying and positive values a concentrating effect.

  ▷ **Note:** Since Currency/Market Interaction is a measure of the covariance between investment areas, rather than an investment area itself, it does not have a risk value and therefore appears as N/A in the Risk and VaR columns. You can see it in the Variance and %Risk columns of the report.

Common Market Risk is further broken down into:

- Market Timing Risk, or the part of risk due to exposure of the portfolio to the market portfolio. Exposure is measured by active beta (the market beta of the portfolio minus the market beta of the benchmark portfolio). If no market is selected, then Market Timing Risk is set to zero (0).

> **Note:** To account for the separation of currency risk, the beta calculation omits currency exposures (*i.e.,* all currency factor exposures are set to 0 for both the covariance and variance calculations). Compare to "Beta" on page 93, which does include currency exposures.

- Selection Risk, or the risk arising from the specific asset choices made in individual countries. BarraOne models asset-level risk for each local market. Selection Risk is a measure of the non-factor component of a security's total risk. For a broad and diversified benchmark portfolio, asset selection risk is expected to be a very small component of overall total risk. For a single security, asset selection risk can be a large portion of the overall risk.
- Common Factor Risk captures the systematic sources of return. For each local market and asset class, the Barra Integrated Model (BIM) contains a specific set of factors. For example, the risk of a corporate bond is captured by term structure, spread and currency factors.

  Factor Interaction, under Common Factor Risk, is derived from the correlation among these factor bets. It is calculated as the difference between the Common Factor variance and the sum of variances of the components of Common Factor risk (this sum is the Common Factor variance, assuming zero correlation among components). All else being equal, a higher level of correlation among Common Factor components implies a larger Factor Interaction term.

  > **Note:** Since Factor Interaction is a measure of the covariance between investment areas rather than an investment area itself, it does not have a risk value, and therefore appears as N/A in the Risk and VaR columns. You can see it in the Variance and %Risk columns of the report.

Portfolio Risk and Active Risk

Risk is expressed as the annualized standard deviation of return. Given a portfolio with an expected return of X% and a total portfolio risk of Y%, the 1-year portfolio return has approximately a two-thirds chance of falling within the range X% +/– Y% (assuming that returns are normally distributed). Portfolio Risk is the *ex ante* volatility derived from BIM and is based on asset weights.

$$\sqrt{\boldsymbol{w}'\left(\boldsymbol{XFX}'+\boldsymbol{D}\right)\boldsymbol{w}}$$

where:

$\boldsymbol{w}$ = vector of asset effective weights

$\boldsymbol{X}$ = matrix of asset exposures

$\boldsymbol{F}$ = factor covariance matrix

$\boldsymbol{D}$ = specific covariance matrix
(including linked specific risk)

If you are tracking a benchmark, a total active risk of 2, for example, means that the portfolio has a two-thirds chance of falling within 2% of the benchmark (assuming that returns are normally distributed). Total active risk is a measure of the difference between the portfolio and its benchmark. Input to the calculation of total active risk are the active weights of the securities. Derived from BIM, total active risk is an *ex ante* measure of active returns.

$$\sqrt{\boldsymbol{w}'\left(\boldsymbol{XFX}'+\boldsymbol{D}\right)\boldsymbol{w}}$$

where:

$\boldsymbol{w}$ = vector of asset effective active weights

$\boldsymbol{X}$ = matrix of asset exposures

$\boldsymbol{F}$ = factor covariance matrix

$\boldsymbol{D}$ = specific covariance matrix
(including linked specific risk)

Percent Portfolio Risk and Percent Active Total Risk (% Portfolio Risk and % Active Risk)

Instead of expressing risk in standard deviation terms, the Risk Decomposition Report enables the user to decompose risk by percent of either portfolio or active risk. For example, 50% Selection Risk in the % Active Risk column means that 50% of the total active risk can be attributed to asset selection risk. Percentages are calculated using variance:

$$\%\sigma_{selection}=\frac{\sigma^2_{selection}}{\sigma^2_{active}}$$

Adding Up Risk Sources

One disadvantage of using standard deviation as a measure of risk is that it is not additive. To add up the sources of risk in the report, look at the Variance column.

By looking at portfolio variance, you can also clearly see the effect of Market/Currency Interaction and Factor Interaction when adding up the risk sources. For example, if Market/Currency Interaction is a negative value, it reduces the sum of total risk. If positive, it increases total risk.

Residual Exposure Reporting

Optional columns in BarraOne provide flexible, additive risk reporting that offers clients a way to drill down into sources of risk based on the residual exposures of the managed and active portfolio. Columns in the Risk Decomposition Report facilitate a risk attribution summary report based on residual effective weights and exposures.

> **Note:** When residual exposures are computed with a market that is different from the benchmark, then there are three sources of selection risk: 1) assets in the portfolio, 2) assets in the benchmark that are not in the portfolio, and 3) assets in the market that are not in the portfolio. Although BarraOne has an option to display the benchmark assets not held, it does not provide an option to display the market assets not held. As such, in the case of different market and benchmark portfolios, we advise clients to use the residual return methodology (see "Marginal Contribution to Residual Risk Reporting" on page 22) to correctly decompose local market risk into its market timing risk and residual risk components.

The following section describes the columns for BarraOne to generate residual-exposure-based reports. Each report attributes the risk of the managed and active portfolio.

Example Portfolios

The examples are based on the following managed and benchmark portfolios:

Asset ID	Asset Name	Holdings	Weight (%)	Bmk Weight (%)	Active Weight (%)
FINAAL4	NOKIA OYJ	100.00	10.44%	19.60%	-9.16%
FRAAGO1	SOC GENERALE	10.00	4.39%	0.00%	4.39%
JPNCDC1	SONY	100.00	26.67%	50.07%	-23.39%
JPNCIW1	TOYOTA MOTOR	100.00	27.23%	0.00%	27.23%
UKIALX1	LLOYDS BANKING GROUP	1,000.00	5.93%	0.00%	5.93%
UKIBBB1	ROYAL BK SCOT GRP	1,000.00	4.33%	8.13%	-3.80%
USAFK41	FORD MTR CO DEL	100.00	9.18%	0.00%	9.18%

The analysis date is March 10, 2010, and the numeraire is USD. For purposes of illustration, the market portfolio is set equal to the benchmark portfolio; all equations are valid for an arbitrary market portfolio.

Residual Exposure and Residual Weight Formulas

The following formulas are required for use in the column definitions:

Portfolio Local Beta (Mkt)

$$\beta_{loc}^{P} = \frac{X_{loc}^{P} F X_{loc}^{M'} + w_{\mathrm{eff}}^{P} \Delta w_{eff}^{M'}}{\sigma_{LM}^{2}}$$

where:

X_{loc}^{P} = the vector of portfolio exposures to non-currency factors with exposure 0 to all currency factors

$X_{loc}^{M'}$ = the vector of market portfolio exposures to non-currency factors with exposure 0 to all currency factors

w_{eff}^{P} = the portfolio effective weight vector

$w_{eff}^{M'}$ = the effective weight vector of the market portfolio

σ_{LM} = the local market risk of the market portfolio

Portfolio Residual Effective Weight Vector

$$w_{eff}^{P,R} = w_{eff}^{P} - \beta_{loc}^{P} w_{eff}^{M}$$

where:

w_{eff}^{P} = the portfolio effective weight vector

β_{loc}^{P} = the portfolio local beta (defined earlier)

w_{eff}^{M} = the market portfolio effective weight vector

Note : The residual effective weight vector has nonzero values for market portfolio assets not held.

Portfolio Residual Factor Exposure Vector

$$X^{P,R} = X^{P} - \beta_{loc}^{P} X_{loc}^{M}$$

where:

X^{P} = the portfolio exposure vector for all factors

β_{loc}^{P} = the portfolio local beta (defined earlier)

X_{loc}^{M} = the market exposure vector to all non-currency factors having exposure 0 to all currency factors

Benchmark Local Beta

$$\beta_{loc}^{B} = \frac{X_{loc}^{B} F X_{loc}^{M'} + w_{\text{eff}}^{B} \Delta w_{eff}^{M'}}{\sigma_{LM}^{2}}$$

where:

X_{loc}^{B} = the vector of benchmark exposures to non-currency factors with exposure 0 to all currency factors

$X_{loc}^{M'}$ = the vector of market portfolio exposures to non-currency factors with exposure 0 to all currency factors

w_{eff}^{B} = the effective weight vector of the market portfolio

σ_{LM} = the local market risk of the market portfolio

Benchmark Residual Effective Weight Vector

$$w_{eff}^{B,R} = w_{eff}^{B} - \beta_{loc}^{B} w_{eff}^{M}$$

where:

w_{eff}^{B} = the benchmark effective weight vector

β_{loc}^{B} = the benchmark local beta (defined earlier)

w_{eff}^{M} = the market benchmark effective weight vector

Note : The residual effective weight vector has nonzero values for market portfolio assets not held.

Benchmark Residual Factor Exposure Vector

$$X^{B,R} = X^{B} - \beta_{loc}^{B} X_{loc}^{M}$$

where:

X^{B} = the benchmark exposure vector to all factors

β_{loc}^{B} = the benchmark local beta (defined earlier)

X_{loc}^{M} = the market exposure vector to all non-currency factors having exposure 0 to all currency factors

Active Local Beta (Mkt)

$$\beta_{loc}^{A} = \frac{X_{loc}^{A} F X_{loc}^{M'} + w_{\text{eff}}^{A} \Delta w_{eff}^{M'}}{\sigma_{LM}^{2}}$$

where:

X_{loc}^{A} = the vector of active exposures to non-currency factors with exposure 0 to all currency factos

$X_{loc}^{M'}$ = the vector of market portfolio exposures to non-currency factors with exposure 0 to all currency factors

w_{eff}^{A} = the active effective weight vector

$w_{eff}^{M'}$ = the effective weight vector of the market portfolio

σ_{LM} = the local market risk of the market portfolio

Active Residual Effective Weight Vector

$$w_{eff}^{A,R} = w_{eff}^{A} - \beta_{loc}^{A} w_{eff}^{M}$$

where:

w_{eff}^{A} = the active effective weight vector

β_{loc}^{A} = the active local beta (defined earlier)

w_{eff}^{M} = the market portfolio effective weight vector

Note : The residual effective weight vector has nonzero values for market portfolio assets not held.

Active Residual Factor Exposure Vector

$$X^{A,R} = X^{A} - \beta_{loc}^{A} X_{loc}^{M}$$

where:

X^{A} = the active exposure vector to all factors

β_{loc}^{A} = the active local beta (defined earlier)

X_{loc}^{M} = the market exposure vector to all non-currency factors having exposure 0 to all currency factors

Residual Exposure Risk Decomposition Report

The Risk Decomposition Report decomposes the total portfolio risk or active risk into contributions from systematic sources such as currencies, market timing, and factor groups (industry, style, etc.), plus a contribution from selection risk.

Risk Source	Portfolio Risk	Portfolio Correlation	Portfolio Risk Contribution	Active Risk	Active Portfolio Correlation	Active Portfolio Risk Contribution
Total Risk	**29.42%**	**1.00**	**29.42%**	**10.31%**	**1.00**	**10.31%**
Local Market Risk	30.14%	0.98	29.45%	10.33%	1.00	10.31%
Mkt Timing Risk	28.39%	0.92	26.21%	2.00%	0.21	0.42%
Common Factor Risk	5.65%	0.56	3.15%	5.65%	0.45	2.57%
Industry	4.44%	0.42	1.87%	4.44%	0.40	1.78%
Style	2.92%	0.44	1.28%	2.92%	0.27	0.78%
Selection Risk	8.41%	0.01	0.10%	8.41%	0.87	7.33%
Currency Risk	6.41%	-0.01	-0.04%	0.57%	-0.01	0.00%

The risk contributions are additive: in the example below (allowing for rounding errors), the Portfolio Risk Contribution of Total Risk (29.42%) is the sum of the Portfolio Risk Contributions from Local Market Risk (29.45%) and Currency Risk (–0.04%); the Portfolio Risk Contribution from Local Market Risk (29.45%) is the sum of the Portfolio Risk Contributions from Market Timing Risk (26.21%), Common Factor Risk (3.15%), and Selection Risk (0.10%).

The risk contribution of each risk source is further decomposed into two components: 1) the volatility of the source contribution to portfolio return, and 2) the correlation of the source contribution with the portfolio. Multiplying the Portfolio Risk by the Portfolio Correlation of a source gives the Portfolio Risk Contribution. For instance, the Portfolio Risk Contribution of Style risk (1.28%) is found by multiplying the Portfolio Risk of Style risk (2.92%) and the Portfolio Correlation of Style risk (0.44). Note that while some sources of returns may be volatile on a standalone basis, their risks are diversified away when they are negligibly correlated with the total portfolio risk.

Drilldown into the risk contribution of a Common Factor group is provided by the Factor Exposure Breakdown Report. Drilldown into the Portfolio Risk Contribution of Selection Risk is provided by the Positions Report.

Drilldowns into the risk contribution of Currency Risk, Local Market Risk, Market Timing Risk, and Residual Risk at the security level is provided by the Positions Report.

These are the columns used for a residual exposure version of the Risk Decomposition Report:

Portfolio Risk Contribution for Mkt Timing Risk

$$\text{Portfolio Risk Contribution} = \beta_{loc}^{P}\left(\frac{X_{loc}^{M} F X^{P'} + w_{\text{eff}}^{M} \Delta w_{eff}^{P'}}{\sigma^{P}}\right)$$

where:

β_{loc}^{P} = the portfolio local beta (defined earlier)

X_{loc}^{M} = the market exposure vector to all non-currency factors having 0 exposure to all currency factors

$X^{P'}$ = the portfolio factor exposure vector

w_{eff}^{M} = the market effective weight vector

$w_{eff}^{P'}$ = the portfolio effective weight vector

σ^{P} = the portfolio total risk

Portfolio Risk Contribution for a Factor Group

$$\text{Portfolio Risk Contribution} = \frac{X_{G}^{P,R} F X^{P'}}{\sigma^{P}}$$

where:

$X_{G}^{P,R}$ = the portfolio residual exposure vector (defined earlier) to factors in group G having exposure 0 to all factors not in group G

$X^{P'}$ = the portfolio factor exposure vector

σ^{P} = the portfolio total risk

Portfolio Risk Contribution for Selection Risk

$$\text{Portfolio Risk Contribution} = \frac{w_{eff}^{P,R} \Delta w_{eff}^{P}}{\sigma^{P}}$$

where:

$w_{eff}^{P,R}$ = the portfolio residual effective weight vector (defined earlier)

w_{eff}^{P} = the portfolio effective weight vector

σ^{P} = the portfolio total risk

Active Portfolio Risk Contribution for Mkt Timing Risk

$$\text{Active Portfolio Risk Contribution} = \beta_{loc}^{A}\left(\frac{X_{loc}^{M} F X^{A'} + w_{\text{eff}}^{M} \Delta w_{eff}^{A'}}{\sigma^{A}}\right)$$

where:

β_{loc}^{A} = the active local beta (defined earlier)

X_{loc}^{M} = the market exposure vector to all non-currency factors have exposure 0 to all currency factors

$X^{A'}$ = the active factor exposure vector

w_{eff}^{M} = the market effective weight vector

$w_{eff}^{A'}$ = the active effective weight vector

σ^{A} = the active total risk

Active Portfolio Risk Contribution for a Factor Group

$$\text{Active Portfolio Risk Contribution} = \frac{X_{G}^{A,R} F X^{A'}}{\sigma^{A}}$$

where:

$X_{G}^{A,R}$ = the active residual exposure vector (defined earlier) to factors in group G having exposure 0 to all factors not in group G

$X^{A'}$ = the active factor exposure vector

σ^{A} = the active total risk

Active Portfolio Risk Contribution for Selection Risk

$$\text{Active Portfolio Risk Contribution} = \frac{w_{eff}^{A,R} \Delta w_{eff}^{A}}{\sigma^{A}}$$

where:

$w_{eff}^{A,R}$ = the active residual effective weight vector (defined earlier)

$w_{eff}^{A'}$ = the active effective weight vector

σ^{A} = the active total risk

All correlations can be backed out as:

$$\text{Correlation} = \frac{\text{(Risk Contribution)}}{\text{(Risk)}}$$

Marginal Contribution to Residual Risk Reporting

In the standard Risk Decomposition Report, the Local Market Risk contribution is decomposed into a Market Timing Risk contribution and a residual risk contribution. The residual risk contribution is reported as a Common Factor Risk contribution and a Selection Risk contribution based on residual factor exposures and residual asset weights.

Marginal Contribution to Residual Risk Reporting is an alternative methodology for attributing the residual risk contribution, and it provides a different view of the balance of the residual risk contribution attributable to Common Factor Risk and Selection Risk sources. In this methodology, residual risk is attributed on the basis of residual returns (*i.e.,* the portion of returns uncorrelated with benchmark returns), rather than that on the basis of residual exposures.

Optional columns are also available in the Positions Report and the Factor Exposure Breakdown Report in BarraOne to facilitate reporting using this approach, which is applicable when the user would like to drill into the both the Market Timing Risk Contribution and Residual Risk Contribution on the basis of the market timing return and the residual return components of each source of risk.

Sample Risk Decomposition Report

When the market portfolio is set to CASH, note that both methodologies provide the same view of risk, because then beta is zero, market timing is zero, and residual risk is equal to active risk, as illustrated in the following Risk Decomposition Report:

Risk Source	Portfolio Risk	Portfolio Correlation	Portfolio Risk Contribution	Active Risk	Active Portfolio Correlation	Active Portfolio Risk Contribution
Total Risk	**29.42%**	**1.00**	**29.42%**	**10.31%**	**1.00**	**10.31%**
Local Market Risk	30.14%	0.98	29.45%	10.33%	1.00	10.31%
Mkt Timing Risk	0.00%	0.00	0.00%	0.00%	0.00	0.00%
Common Factor Risk	28.56%	0.92	26.29%	5.05%	0.48	2.44%
Industry	22.96%	0.90	20.69%	4.19%	0.40	1.67%
Style	7.29%	0.77	5.61%	2.89%	0.27	0.77%
Selection Risk	9.64%	0.33	3.16%	9.00%	0.87	7.87%
Currency Risk	6.41%	-0.01	-0.04%	0.57%	-0.01	0.00%

Example Portfolios

The discussion of Marginal Contribution to Residual Risk Reporting in the Positions Report section and the Factor Exposure Breakdown Report section of this chapter will refer to the examples in this report. The examples are based on the following managed and benchmark portfolios:

Asset ID	Asset Name	Holdings	Weight (%)	Bmk Weight (%)	Active Weight (%)
FINAAL4	NOKIA OYJ	100.00	10.44%	19.60%	-9.16%
FRAAGO1	SOC GENERALE	10.00	4.39%	0.00%	4.39%
JPNCDC1	SONY	100.00	26.67%	50.07%	-23.39%
JPNCIW1	TOYOTA MOTOR	100.00	27.23%	0.00%	27.23%
UKIALX1	LLOYDS BANKING GROUP	1,000.00	5.93%	0.00%	5.93%
UKIBBB1	ROYAL BK SCOT GRP	1,000.00	4.33%	8.13%	-3.80%
USAFK41	FORD MTR CO DEL	100.00	9.18%	0.00%	9.18%

The analysis date is March 10, 2010, and the numeraire is USD. For the purposes of illustration, all local betas are computed with respect to a market portfolio equal to the benchmark portfolio; all equations are valid for an arbitrary market portfolio.

Risk Decomposition Report (Residual Return Based) — Managed Portfolio

This is an x-sigma-rho version of the BarraOne Risk Decomposition Report for a managed portfolio.

Risk Source	Portfolio Risk	Portfolio Correlation	Portfolio Risk Contribution	Portfolio Local Beta (Mkt)	Portfolio Mkt Timing Risk	Portfolio Mkt Timing Corr	Portfolio Mkt Timing Risk Contribution	Portfolio Residual Risk	Portfolio Residual Correlation	Portfolio Residual Risk Contribution
Total Risk	**29.42%**	**1.00**	**29.42%**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**
Local Market Risk	30.14%	0.98	29.45%	0.93	28.39%	0.92	26.21%	10.13%	0.32	3.25%
Common Factor Risk	28.56%	0.92	26.29%	0.83	25.21%	0.92	23.28%	13.41%	0.22	3.02%
Industry	22.96%	0.90	20.69%	0.66	19.96%	0.92	18.43%	11.35%	0.20	2.26%
Style	7.29%	0.77	5.61%	0.17	5.25%	0.92	4.85%	5.05%	0.15	0.76%
Selection Risk	9.64%	0.33	3.16%	0.10	3.17%	0.92	2.93%	9.10%	0.03	0.23%
Currency Risk	6.41%	-0.01	-0.04%	n/a	n/a	n/a	n/a	n/a	n/a	n/a

The Portfolio Risk, Portfolio Correlation, and Portfolio Risk Contribution columns are identical to those in “Residual Exposure Risk Decomposition Report” on page 19 with a Market Portfolio setting of CASH. The other columns in this report are defined as follows.

Portfolio Local Beta (Mkt)

Portfolio Local Beta (Mkt) for a non-currency Common Factor Risk group G (e.g., Industry, Style, Common Factor Risk) is given by:

$$\beta_G^P = \frac{X_G^P F X^{M'}}{\sigma_{LM}^2}$$

where:

X_G^P = the vector of managed portfolio factor exposures to group G that has exposure 0 to all factors not in group G

$X^{M'}$ = the vector of market portfolio exposures to non-currency factors with exposure 0 to all currency factors

σ_{LM} = the local market risk of the market portfolio

Portfolio Local Beta (Mkt) for the Selection Risk Group is given by:

$$\beta_{SR}^P = \frac{w_{\text{eff}}^P \Delta w_{\text{eff}}^{M'}}{\sigma_{LM}^2}$$

where:

w_{eff}^P = the managed portfolio effective weight vector

$w_{\text{eff}}^{M'}$ = the effective weight vector of the market portfolio

σ_{LM} = the local market risk of the market portfolio

Portfolio Local Beta (Mkt) for the Local Market Risk Group is given by:

$$\beta_{loc}^P = \frac{X_{loc}^P F X_{loc}^{M'} + w_{\text{eff}}^P \Delta w_{\text{eff}}^{M'}}{\sigma_{LM}^2}$$

where:

X_{loc}^P = the vector of managed portfolio exposures to non-currency factors with exposure 0 to all currency factors

$X_{loc}^{M'}$ = the vector of market portfolio exposures to non-currency factors with exposure 0 to all currency factors

w_{eff}^P = the portfolio effective weight vector

$w_{\text{eff}}^{M'}$ = the effective weight vector of the market portfolio

σ_{LM} = the local market risk of the market portfolio

Portfolio Mkt Timing Risk

$$\text{Portfolio Mkt Timing Risk} = \left|\beta_{loc}^{P}\right| \times \sigma_{LM}$$

where:

$| \, |$ denotes absolute value

β_{loc}^{P} = the Portfolio Local Beta (Mkt)

σ_{LM} = the local market risk of the market portfolio

Portfolio Mkt Timing Risk Contribution

$$\text{Portfolio Mkt Timing Risk Contribution} = \beta_{loc}^{P} \times LMCTR^{M}$$

where:

β_{loc}^{P} = the Portfolio Local Beta (Mkt)

The auxiliary quantity $LMCTR^{M}$ is given by:

$$LMCTR^{M} = \frac{X^{M} F X^{P'} + w^{M} \Delta w^{P'}}{\sigma_{P}}$$

where:

X^{M} = the vector of market portfolio exposures to non-currency factors

$X^{P'}$ = the vector of managed portfolio exposures to all factors, including currency

w^{M} = the effective weight vector of the market portfolio

$w^{P'}$ = the effective weight vector of the managed portfolio

σ_{P} = the total risk of the managed portfolio

Portfolio Mkt Timing Correlation

$$\text{Portfolio Mkt Timing Correlation} = \frac{\begin{pmatrix} \textit{Portfolio} \\ \textit{Mkt Timing} \\ \textit{Risk Contribution} \end{pmatrix}}{\begin{pmatrix} \textit{Portfolio} \\ \textit{Mkt Timing} \\ \textit{Risk} \end{pmatrix}}$$

Portfolio Residual Risk

$$\text{Portfolio Residual Risk} = \sqrt{(\sigma_P)^2 - \begin{pmatrix} \textit{Portfolio} \\ \textit{Mkt Timing} \\ \textit{Risk} \end{pmatrix}^2}$$

where:

$\sigma_P = \text{Portfolio Risk}$

Portfolio Residual Risk Contribution

$$\text{Portfolio Residual Risk Contribution} = \begin{pmatrix} \textit{Portfolio} \\ \textit{Risk} \\ \textit{Contribution} \end{pmatrix} - \begin{pmatrix} \textit{Portfolio} \\ \textit{Mkt Timing} \\ \textit{Risk Contribution} \end{pmatrix}$$

Portfolio Residual Correlation

$$\text{Portfolio Residual Correlation} = \frac{\begin{pmatrix} \textit{Portfolio Residual} \\ \textit{Risk Contribution} \end{pmatrix}}{\begin{pmatrix} \textit{Portfolio} \\ \textit{Residual} \\ \textit{Risk} \end{pmatrix}}$$

Risk Decomposition Report (Residual Return Based) — Active Portfolio

This is an x-sigma-rho version of the BarraOne Risk Decomposition Report for an active portfolio.

Risk Source	Active Risk	Active Correlation	Active Portfolio Risk Contribution	Active Local Beta (Mkt)	Active Mkt Timing Risk	Active Mkt Timing Corr	Active Mkt Timing Risk Contribution	Active Residual Risk	Active Residual Correlation	Active Residual Risk Contribution
Total Risk	**10.31%**	**1.00**	**10.31%**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**
Local Market Risk	10.33%	1.00	10.31%	-0.07	2.00%	0.21	0.42%	10.13%	0.98	9.89%
Common Factor Risk	5.05%	0.48	2.44%	0.03	0.79%	-0.21	-0.16%	4.99%	0.52	2.61%
Industry	4.19%	0.40	1.67%	0.00	0.10%	-0.21	-0.02%	4.19%	0.40	1.69%
Style	2.89%	0.27	0.77%	0.02	0.69%	-0.21	-0.14%	2.80%	0.33	0.92%
Selection Risk	9.00%	0.87	7.87%	-0.09	2.78%	0.21	0.58%	13.16%	0.55	7.28%
Currency Risk	0.57%	-0.01	0.00%	n/a	n/a	n/a	n/a	n/a	n/a	n/a

This report is generated in the same manner as that of the Managed Portfolio in the previous section. The Active Risk, Active Correlation, and Active Portfolio Risk Contribution columns are identical to those in "Residual Exposure Risk Decomposition Report" on page 19 with a Market Portfolio setting of CASH. The other columns in this report are defined as follows.

Active Local Beta (Mkt)

Active Local Beta (Mkt) for a non-currency Common Factor Risk group G (e.g., Industry, Style, Common Factor Risk) is given by:

$$\beta_G^A = \frac{X_G^A F X^{M'}}{\sigma_{LM}^2}$$

where:

X_G^A = the vector of active portfolio factor exposures to group G that has exposure 0 to all factors not in group G

$X^{M'}$ = the vector of market portfolio exposures to non-currency factors with exposure 0 to all currency factors

σ_{LM} = the local market risk of the market portfolio

Active Local Beta (Mkt) for the Selection Risk Group is given by:

$$\beta_{SR}^A = \frac{w_{\text{eff}}^A \Delta w_{eff}^{M'}}{\sigma_{LM}^2}$$

where:

w_{eff}^A = the active portfolio effective weight vector

$w_{eff}^{M'}$ = the effective weight vector of the market portfolio

σ_{LM} = the local market risk of the market portfolio

Active Local Beta (Mkt) for the Local Market Risk Group is given by:

$$\beta_{loc}^A = \frac{X_{loc}^A F X_{loc}^{M'} + w_{\text{eff}}^A \Delta w_{eff}^{M'}}{\sigma_{LM}^2}$$

where:

X_{loc}^A = the vector of active portfolio exposures to non-currency factors with exposure 0 to all currency factors

$X_{loc}^{M'}$ = the vector of market portfolio exposures to non-currency factors with exposure 0 to all currency factors

w_{eff}^A = the active effective weight vector

$w_{eff}^{M'}$ = the effective weight vector of the market portfolio

σ_{LM} = the local market risk of the market portfolio

Active Mkt Timing Risk

$$\text{Active Mkt Timing Risk} = \left|\beta_{loc}^{A}\right| \times \sigma_{LM}$$

where:

| | denotes absolute value

β_{loc}^{A} = the Active Local Beta (Mkt)

σ_{LM} = the local market risk of the market portfolio

Active Mkt Timing Risk Contribution

$$\text{Active Mkt Timing Risk Contribution} = \left(\beta_{loc}^{A}\right) \times \left(LMCAR^{M}\right)$$

where:

β_{loc}^{A} = the Active Local Beta (Mkt)

The auxiliary quantity $LMCAR^{M}$ is given by:

$$LMCAR^{M} = \frac{X^{M} F X^{A'} + w^{M} \Delta w^{A'}}{\sigma_{A}}$$

where:

X^{M} = the vector of market portfolio exposures to non-currency factors

$X^{A'}$ = the vector of all active portfolio factor exposures, including currency factors

w^{M} = the effective weight vector of the market portfolio

$w^{A'}$ = the effective weight vector of the active portfolio

σ_{A} = the total risk of the active portfolio

Active Mkt Timing Correlation

$$\text{Active Mkt Timing Correlation} = \frac{\begin{pmatrix} Active \\ Mkt\,Timing \\ Risk\,Contribution \end{pmatrix}}{\begin{pmatrix} Active \\ Mkt\,Timing \\ Risk \end{pmatrix}}$$

Active Residual Risk

$$\text{Active Residual Risk} = \sqrt{(\sigma_A)^2 - \begin{pmatrix} \textit{Active} \\ \textit{Mkt Timing} \\ \textit{Risk} \end{pmatrix}^2}$$

where:

σ_A = Active Risk

Active Residual Risk Contribution

$$\text{Active Residual Risk Contribution} = \begin{pmatrix} \textit{Active} \\ \textit{Risk} \\ \textit{Contribution} \end{pmatrix} - \begin{pmatrix} \textit{Active} \\ \textit{Mkt Timing} \\ \textit{Risk Contribution} \end{pmatrix}$$

Active Residual Correlation

$$\text{Active Residual Correlation} = \frac{\begin{pmatrix} \textit{Active Residual} \\ \textit{Risk Contribution} \end{pmatrix}}{\begin{pmatrix} \textit{Active} \\ \textit{Residual} \\ \textit{Risk} \end{pmatrix}}$$

Positions Report

Overview

The Positions Report in BarraOne's Analysis tab is an asset-level view of risk and valuation attributes. For further analysis, positions can be grouped (up to two levels) for comparison to similar groups within the benchmark portfolio. Zooming enables you to view a group of assets in a portfolio as if it were a complete portfolio containing only the positions in that group.

The following sample report decomposes risk by country. The report identifies where the portfolio is over- and underweight versus the balanced benchmark. In addition, the report identifies the percentage each country contributes to Active Total Risk (%CR to Active Total Risk) and Total Risk (%CR to Total Risk). Here, the 4.02% active weight in the United States is contributing 66.85% of Active Total Risk.

Country	Mkt Value	Weight (%)	Active Weight (%)	%CR to Active Total Risk	MC to Active Total Risk	%CR to Total Risk	MC to Total Risk
United States	10,760,109,637.96	70.51%	4.02%	66.85%	-0.0363	56.366%	0.0540
Japan	447,529,162.61	2.93%	-2.04%	9.40%	-0.0813	3.309%	0.0763
Canada	172,081,352.56	1.13%	-0.80%	5.29%	-0.0666	1.106%	0.0663
United Kingdom	633,670,079.16	4.15%	-0.71%	4.99%	-0.0823	5.418%	0.0882
France	172,229,727.33	1.13%	-0.78%	3.64%	-0.0977	1.774%	0.1062
Australia	76,813,099.67	0.50%	-0.56%	2.54%	-0.0843	0.728%	0.0978
Sweden	11,603,294.61	0.08%	-0.39%	2.49%	-0.1161	0.085%	0.0758
Italy	57,187,533.46	0.37%	-0.38%	1.72%	-0.0753	0.412%	0.0743
Hong Kong	30,773,383.78	0.20%	-0.12%	1.64%	-0.0968	0.179%	0.0599
Taiwan	170,057,350.32	1.11%	-0.30%	1.52%	-0.1069	2.425%	0.1471
Finland	13,236,416.87	0.09%	-0.20%	1.05%	-0.1080	0.203%	0.1582
Germany	208,664,213.31	1.37%	-0.17%	0.89%	-0.0945	2.093%	0.1034

Figure 3: Sample Positions Report — By Country

Grouping

Aggregate Values

When you group your positions, BarraOne displays aggregate values for each group. These are the aggregated values for all positions that make up the group. Each column, or asset attribute, has its own aggregation scheme that governs how its values are aggregated.

This attribute type	Typically uses this aggregation scheme
Risk Model Data	Risk
Valuation Data	Average, or market-weighted average
Descriptive Data	Count
Miscellaneous	Custom

For detailed information about specific aggregation schemes, refer to each specific attribute later in this chapter.

Multi-Level Grouping

Multi-level grouping for risk reporting in the Positions Report enables clients to view risk contributions using two levels of user-defined grouping schemes. This reporting flexibility provides clients with the ability to zoom into multiple groups simultaneously.

Multi-level grouping provides users with aggregating capability that enables them to view risk along their specific investment framework. For example, a pension plan might like to view the risk along the asset allocation framework, which involves first grouping along asset classes and then subsequently grouping by managers. Other users might want to drill down in an allocation selection framework to the asset level.

All risk attributes that can be grouped can be used in a multi-level grouping scheme. In global mode, contributions are reported in terms of the portfolio. In local mode, contributions are reported in terms of the group.

⊳ **Note:** When Positions Report grouping is discussed and when grouping examples are used in the chapter, we assume that global mode is being used.

Global Mode

Use global mode if you would like to identify the contribution of the risk of each asset to the overall risk of the plan. In other words, you want to view the contribution of each asset to the overall Portfolio- or Tree-level risk.

This drilldown applies to all of the risk attributes, marginal contributions, weight aggregated attributes, and weight attributes:

- Weight Attributes

  In global mode, the weights are global weights. The sum of the weights of each asset sums to the weight of the level 2 Group; the level 2 groups' weight sums to portfolio weight.

- Risk Attributes (*e.g.,* total risk, active total risk)

  The risk of the each group is aggregated as if it were a part of the overall portfolio and not as if it were an individual portfolio.

  In global mode, risk is computed for a zoomed portfolio with the total benchmark.

- Weight-aggregated Attributes (*e.g.,* beta)

  In global mode, these are aggregated with global weights.

- Marginal Contributions

  In global mode, global beta is used to compute aggregated marginal contributions.

Local Mode

In local mode, all asset-level attributes are computed relative to the group in which the asset resides. All group-level attributes on the second level, however, are computed based on the relationship between the second-level group and the first-level group. All group-level attributes on the first level are computed based on the relationship between the group and the current portfolio. Note that for cases in which the grouped report is shown for a portfolio that represents the zoomed state of a session portfolio, the "current" portfolio is the zoomed one.

Notes:

- The weights of the assets within a group are computed relative to this group and sum to 100%; however, 100% is not displayed for the second-level group, itself. Rather, the group-level weight is the weight of the second-level group in the first-level group.
- The %CR to Total Risk for assets within a group are computed relative to this group and sum to 100%; however. 100% is not displayed for the second-level group, itself. Rather, the second-level group's contribution to the total risk of the first-level group is displayed. This number is equal to the sum of the contributions of assets within the second-level group to the total risk of the first-level group.
- Benchmark assets are also grouped according to the grouping criteria. For example, if the grouping is Local by Instrument ID and Country, and if the benchmark = MMIM, then only the group Equity/USA will have benchmark assets. The rest of the groups will have no benchmark.

Zooming

When you zoom in on a group (a subportfolio), BarraOne displays the group of assets as if it were a complete portfolio containing only the positions in that group.

Position Weights

Because a subportfolio includes only the group of assets you zoomed in on and excludes all other assets in the parent portfolio, the asset weights you see in the subportfolio are different from the unzoomed view:

- In the unzoomed (parent) view, an asset's weight is its percentage value in the entire portfolio.
- In the zoomed view, its weight is its percentage value in the zoomed subportfolio (a subset of the entire portfolio and thus a different universe of assets).

To keep track of the weights in both perspectives when viewing a subportfolio, you can add Weight and Global Weight columns to the Positions Report:

- Weight shows asset weights in the zoomed subportfolio; values will sum to 100% (representing 100% of the subportfolio value).
- Global Weight shows asset weights relative to the entire portfolio; values will sum to the weight the group occupies in the overall (parent) portfolio.

Benchmark and Market Comparisons

When you zoom in on a subportfolio, BarraOne also zooms in on the same component of the benchmark portfolio to calculate the subportfolio's risk numbers. This means, for example, that if you zoom in on the equity group in your portfolio, that subportfolio's total tracking error and benchmark beta are measured against only the equity portion of the benchmark. By comparing "apples to apples" in this way, you can perform a complete and focused analysis of the subportfolio's active total risk.

Note: If you group your positions by Member Fund or Native Portfolio, when you zoom in on a subportfolio BarraOne loads a *cash* benchmark. This is because the "Member Fund" and "Native Portfolio" attributes cannot be tracked against a benchmark.

Unlike the benchmark comparison, however, your subportfolio's market beta is measured against the complete, unzoomed market portfolio, rather than a subset of its assets.

Consider the following tree structure, which has been expanded to show the assets in each portfolio (each of which has a position of 1). The grouping scheme can either be Member Fund or Native Portfolio:

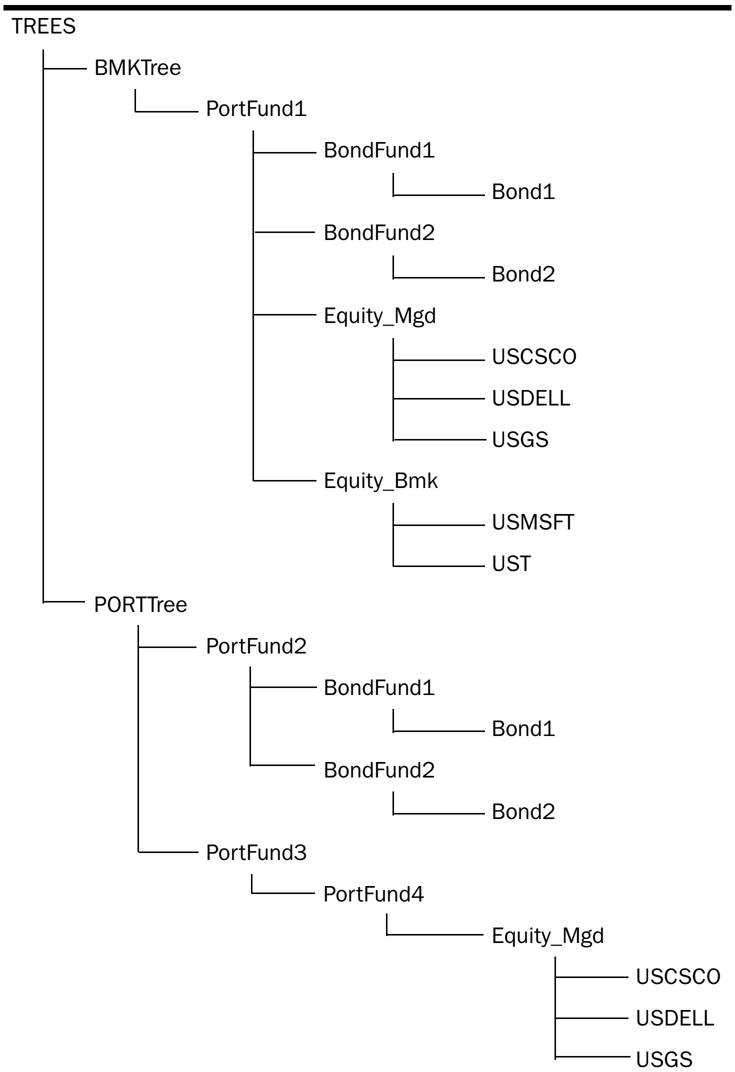


Figure 4: Tree Structure Example

If we make BMKTree the benchmark of PORTTree, then in the Positions report, we will see that for USCSCO, an asset shared by both the portfolio and its benchmark, the weights in the Global Weight column are identical to the weights in the Portfolio Weight column, because Global Weights are only relevant in a zoomed view.

However, if we zoom in to the Equity_Mgd portfolio, the portfolio weights change as shown below:

Weights	Global	Portfolio
Active	-2.34	12.43
Portfolio	1.39	12.43
Benchmark	3.73	0.00

Note that the weights in the Global Weight column remain unchanged, because this column shows the asset weights relative to the entire portfolio; values will sum to the weight the group occupies in the overall (parent) portfolio. The weights in the Portfolio Weight column will change. That is because when we zoom in to the portfolio, we are comparing the assets in the zoomed portfolio compared to a cash portfolio as a benchmark. Thus, the active weight of the asset in the portfolio and the weight of the asset in the portfolio will be identical, and the benchmark weight of the asset will become zero (0).

Currency Hedging

Currency hedging is the process of offsetting currency risk. BarraOne enables you to hedge the currency exposures of your portfolio and benchmark automatically. You can:

- Hedge the benchmark, the portfolio, or both
- Hedge to the numeraire or to another currency you choose
- Hedge all, or just a percentage, of the currency exposures

When hedging is turned on, BarraOne dynamically adds cash positions to the benchmark or portfolio to eliminate currency exposures, while simultaneously adding an offsetting cash position in the numeraire (or other currency you have chosen) to keep the portfolio value constant.

The following table represents a Positions Report in which the first three assets are currency hedging positions.

Table 1: Sample Positions Report

Asset ID	Asset Name	Holdings	Price	Mkt Value	Weight(%)
10		54,661,818.73	1,931.007	55,129,578.73	100.00%
%EUR	EUR Currency Exposure Unit	-237,700.00	128.677	-30,586,555.06	-55.48%
%JPY	JPY Currency Exposure Unit	55,129,578.73	1.000	55,129,578.73	100.00%
%USD	USD Currency Exposure Unit	-253,060.00	96.985	-24,543,023.67	-44.52%
BELAQH1	ANHEUSER	2,000.00	2,995.604	5,991,207.42	10.87%
FRAAAO2	BOUYGUES	2,000.00	4,144.047	8,288,094.28	15.03%
GERAAX1	BASF	3,000.00	3,424.099	10,272,295.71	18.63%
GERAHD2	LUFTHANSA VNA	5,000.00	1,206.992	6,034,957.64	10.95%
USAGMU1	HEWLETT PACKARD CO	3,000.00	3,535.103	10,605,309.56	19.24%
USAKT21	PFIZER INC	5,000.00	1,302.509	6,512,542.64	11.81%
USAMTI1	AT&T INC	3,000.00	2,475.057	7,425,171.47	13.47%

BarraOne adds currency unit exposure assets to the benchmark or portfolio to hedge out currency exposures. These assets have a market value of one currency unit (in the currency they represent). BarraOne treats the hedging assets like other cash assets, and includes them when computing portfolio reports.

The table below represents the same currency hedged portfolio in a Risk Decomposition Report. You can see that there is no currency risk for the portfolio (null rows are hidden in this report).

Table 2: Sample Risk Decomposition Report

Risk Source	Portfolio Risk	Active Risk	% Portfolio Risk	% Active Risk
Local Market Risk	29.22	17.51	100.00%	100.00%
Common Factor Risk	27.13	13.85	86.20%	62.58%
Industry	26.06	13.59	79.54%	60.25%
Style	2.77	1.98	0.90%	1.28%
Term Structure	0.00	2.16	0.00%	1.53%
Spread	0.00	1.98	0.00%	1.28%
Emerging Market	0.00	0.04	0.00%	0.00%
Factor Interaction	N/A	N/A	5.77%	-1.75%
Selection Risk	10.85	10.71	13.80%	37.42%
Total Risk	29.22	17.51	100.00%	100.00%

Currency hedges are applied at the top level of the portfolio. If you group the positions and then zoom into a group subportfolio, BarraOne does not reapply hedging to that subportfolio.

In addition to hedging the portfolio and benchmark, you can define currency hedging settings for composite assets. BarraOne applies your hedging settings to the composite's constituents, hedging out the currency exposures inside the composite.

If you add a hedged composite to a hedged portfolio, BarraOne applies both position-level hedging (for the composite) and portfolio-level hedging.

▷ **Note:** Currency hedging is not applied to "nested" composites (composites within a composite). If a composite contains another composite inside it, BarraOne hedges only the top-level composite.

If you have the Look Through Composites setting turned on when viewing the Positions Report, BarraOne shows the composite's underlying constituents, including all currency unit exposure assets added for hedging.

Application Notes

If a portfolio has currency hedging in its strategy, the hedging is applied as the portfolio is opened or when the hedging is invoked in the strategy. All currency hedging assets (%USD, etc.) that have previously existed in the portfolio are deleted prior to applying the hedging.

If a portfolio does not have currency hedging strategy settings, it is opened as is; all currency hedging assets are kept as they are.

When a portfolio is saved, all currency hedging assets currently present are saved with it.

- When saving portfolio under the Portfolio Admin tab, both strategy settings and holdings are saved together.
- In the Analysis tab, the user may save strategy settings only and holdings only.

Tree Aggregation

BarraOne has two methods (selectable only when the user creates the tree) for tree aggregation:

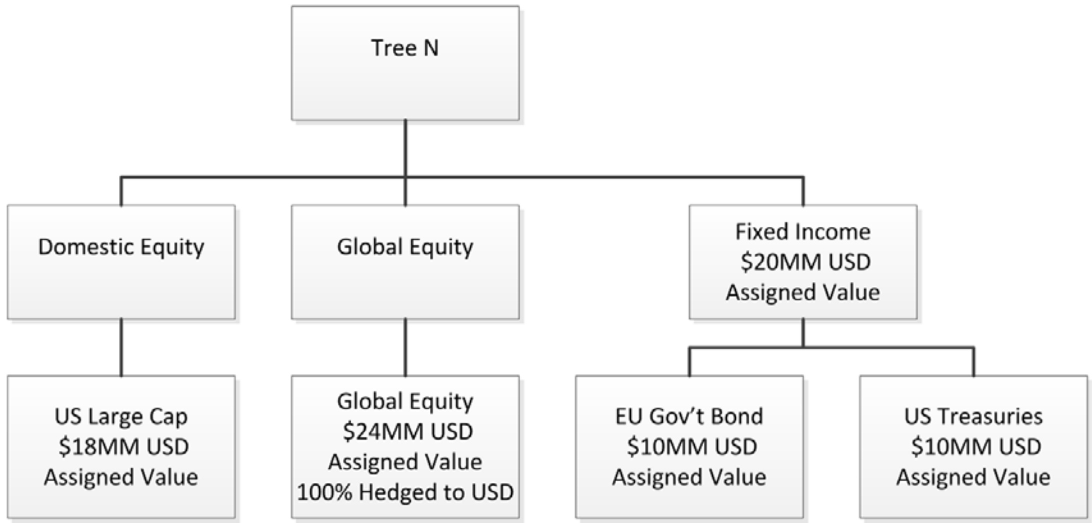
- Top-Down
- Bottom-Up

In Top-Down Aggregation, BarraOne does consider the assigned value of a portfolio when computing the value/weight of that portfolio within a tree. This means that a complex, multi-level tree does not consider the assigned value of each portfolio in the calculation of each portfolio's weight in the top or intermediate level tree nodes. Portfolios are evaluated based only in the context of their immediate parent within the tree and considered only on the basis of the assigned weights of the nodes immediately below the tree node on which the report is based.

In Bottom-Up Aggregation, the assigned value of portfolios is considered at all points within the tree when the value and weight of each tree node is computed. In other words, the user can define a tree for which its value and the weights of its constituents are evaluated starting from the bottom of the tree. As such, the value of each constituent portfolio can be used in the calculation of each portfolio's weight within the tree structure.

Example

Consider the following example tree in BarraOne:



This tree uses currency hedging on the Global Equity portfolio and has assigned values set at various nodes within the tree. This tree is not configured with any assigned weights.

Top-Down Tree Aggregation

The following report illustrates the existing methodology of top-down tree aggregation.

Grouping: Member Fund+Native Portfolio	Asset ID	Holdings	Eff Weight (%)	Mkt Value	%CR to Total Risk	Currency Risk	Total Risk
by: distinct+distinct	1742	18,447,701.61	100.00000000%	59,679,142.65	100.000%	4.40	11.22
Domestic Equity	500	291,399.10	20.85469804%	12,445,904.99	29.855%	0.00	19.64
US Large Cap	500	291,399.10	20.85469804%	12,445,904.99	29.855%	0.00	19.64
Fixed Income	439	5,166.27	43.20064388%	25,781,773.89	20.139%	8.85	10.27
EU Government Bond	230	94.38	33.87978448%	20,219,164.91	20.666%	11.28	12.65
US Treasuries	209	5,071.89	9.32085940%	5,562,608.98	-0.527%	0.00	4.42
Global Equity	803	18,151,136.25	35.94465808%	21,451,463.77	50.006%	1.61	17.78
Global Developed Equity	803	18,151,136.25	35.94465808%	21,451,463.77	50.006%	1.61	17.78

Notice that the market values for tree nodes and portfolios with assigned values do not reflect those assigned values. Note also that the currency hedging is not reflected in the analysis.

If no weights are assigned to the tree, then the weights of the portfolios in the tree are derived from the market value of the portfolios. The assigned value of the portfolios is not included in the analysis. There is the option of assigning a base value to the tree, but this base value must be updated every day. More important, the assigned value at the tree level is distributed in proportion to the market value of the nodes. The weights are distributed in proportion to the market values. Moreover, if you assign weights at the nodes of the tree, then the weights are held constant, and they must be updated based on the NAV of the portfolio.

Bottom-Up Tree Aggregation

The following report illustrates the methodology of bottom-up tree aggregation.

Grouping: Member Fund+Native Portfolio	Asset ID	Holdings	Eff Weight (%)	Mkt Value	%CR to Total Risk	Currency Risk	Total Risk
by: distinct+distinct	1746	24,035,076.93	100.00000000%	62,000,000.00	100.000%	3.68	10.49
Domestic Equity	501	5,845,494.11	29.03225806%	18,000,000.00	31.135%	0.00	13.58
US Large Cap	501	5,845,494.11	29.03225806%	18,000,000.00	31.135%	0.00	13.58
Fixed Income	441	-5,776,607.62	32.25806452%	20,000,000.00	19.455%	11.41	13.25
EU Government Bond	231	-10,219,070.54	16.12903226%	10,000,000.00	20.040%	22.81	25.57
US Treasuries	210	4,442,462.91	16.12903226%	10,000,000.00	-0.585%	0.00	2.46
Global Equity	804	23,966,190.45	38.70967742%	24,000,000.00	49.410%	0.00	15.61
Global Developed Equity	804	23,966,190.45	38.70967742%	24,000,000.00	49.410%	0.00	15.61

Notice that the market values of each tree node and portfolio reflect their individual settings. Note also that the currency hedging is calculated and reflected in the analysis. The base value of the tree is computed as the sum of the base values of the underlying portfolios.

Bottom-Up Aggregation Business Rules

1. When a tree uses Bottom-Up aggregation, the value of each node in the tree is always determined based on that node's base value setting. All base value types are supported (Net, Assigned, Long, Long + Short). For example, if a tree node has a base value assigned as 100MM USD, this is the starting point used for that Node's value in the subsequent calculations.

2. In a simple tree that has Top Node A and two portfolios B and C beneath it, where B has a net base value of 200MM USD and C has an Assigned base value of 400MM USD, Top Node A is computed as having a total value of 600MM USD, which is made up of 33.3% of Node B and 66.7% of Node C.

3. Only the Base Value Type selected for the lowest leaf portfolios has an effect on the top nodes; the Base Value settings for intermediate nodes are ignored by the top node and affect only its own level.

4. Each node in the tree is computed based on its own settings. For a situation in which a parent node is not using assigned weights but its children do use assigned weights, the parent is computed using market value weighting, and the children use the assigned weights.

5. Portfolios within a tree that have an assigned base value are represented such that the risk of the portfolio in the tree matches the risk of the same portfolio with the same assigned value by itself.

6. The Aggregation Setting for a tree is applied to the entire tree. An individual portfolio can have any base value setting, but the aggregation mode applies to the entire tree.

Currency Hedging

When calculating a tree in Bottom-Up aggregation mode, currency hedging is also calculated in a bottom-up fashion. Currency hedging is first calculated at each leaf node based on that node's currency hedge settings. Moving up the tree, the currency hedging for each node is then calculated based on that node's currency hedge settings, and all of its immediate children are treated as currency-hedged composites for the purposes of calculating the hedge. The aggregate does not have any additional currency hedging adjustments.

In Top-Down aggregation, the only currency hedges considered in an analysis are those specified for the tree node being evaluated, and hedging on children of that tree node is not considered. Note that any currency hedging assets already saved in the leaf portfolios are kept, however.

Benchmarks

When evaluating an assigned benchmark that is a tree, the tree aggregation method set on the benchmark tree (not the managed portfolio) determines which mode is used for computing benchmark absolute and portfolio relative risk statistics.

Position Data: Weight

This section describes selected Position Data columns involving Weight that are available in a Positions Report.The weights discussed in this section include the following:

- Weight (%)
- Benchmark Weight (Bmk Weight (%))
- Active Weight (%)
- Global Weight (%)
- Global Benchmark Weight (Global Bmk Weight (%))
- Global Active Weight (%)
- Effective Weight (Eff Weight (%))
- Effective Benchmark Weight (Eff Bmk Weight (%))
- Effective Active Weight (Eff Active Weight (%))
- Effective Global Weight (Eff Global Weight (%))
- Effective Global Benchmark Weight (Eff Global Bmk Weight (%))
- Effective Global Active Weight (Eff Global Active Weight (%))

Note that all weights described in this section assume a base value of "net." Refer below for a discussion of how different base value settings affect weight calculations.

Base Value

Base value is the figure BarraOne uses as the portfolio value for risk aggregation/proportion calculations. Thus, all risk and other percentages are expressed as a percentage of a “base value.” Ordinarily, the base value is net portfolio value, and asset weights, for example, are shown as a percentage of that net value.

In some situations, however, net value is not the appropriate figure on which to base percentage calculations, such as a long/short portfolio where the long side equals the short side and the net value is therefore zero.

BarraOne enables you to choose the type of base value you want to use for your analyses. Your choices are:

- Net Value (long minus short)
- Long Value
- Long + Short Value (long plus the absolute value of the short side)
- Assigned Value (a figure you specify)

Base value affects several measures in BarraOne, including:

- portfolio-level risk measures
- marginal contributions
- asset weights

Impact of Base Value Type and Assigned Base Value on Weights

Suppose we have a portfolio containing two assets. The first, IBM, has 1000 shares long. The second, Microsoft, has 500 shares short. The prices of IBM and Microsoft are $55 and $102 5/8 respectively. The Assigned Base Value is $100000.

Portfolio				Weights for Different Base Value Types (%)			
LOCALID	**Shares**	**Price**	**Value**	**Long**	**Net**	**Assigned**	**Long + Short**
USIBM	1,000	55.00	55,000.00	100.00	1,491.53	55.00	51.73
USMSFT	–500	102.63	–51,312.50	–93.90	–1,391.53	–51.31	–48.27

Long Value	55,000.00
Net Value	3,687.50
Assigned Value	100,000.00
Long + Short Value	106,312.50

Weight (%)

Definition

The ratio of a position's market value to the portfolio's market value. In BarraOne, it is the percentage of a position (asset or group) relative to the current view of the portfolio.

Portfolio Aggregation

As the Positions Report below illustrates, Weight is the sum of the Market Value of each asset divided by the Market Value of the portfolio for the respective members of the portfolio:

Positions Report (Portfolio)			**Calculations**
Asset ID	Mkt Value	Weight(%)	Mkt Value of asset ÷ Mkt Value of portfolio
5	100.18	**100.0000%**	
USCSCO	15.81	15.7816%	15.7816%
USDELL	10.54	10.5211%	10.5211%
USGS	73.83	73.6973%	73.6973%
USMFST	0.00%	0.0000%	0.0000%
UST	0.00%	0.0000%	0.0000%
			Sum **100.0000%**

Group Aggregation

Aggregation at the group level is the sum of the weight of each asset in the portfolio for the respective members of the group. This is illustrated below for the Information Technology sector group:

Positions Report (Portfolio)				**Calculations**
Grouping: GICS Sector	Asset ID	Mkt Value	Weight(%)	Mkt Value of asset ÷ Mkt Value of portfolio
by: distinct	5	100.18	100.0000%	
. . .	. . .			
Information Technology	3	26.35	**26.3027%**	
	USCSCO	15.81	15.7816%	15.7816%
	USDELL	10.54	10.5211%	10.5211%
	USMSFT	0.00	0.0000%	0.0000%
. . .	. . .			
			Sum	**26.3027%**

Note: At the group level, the weight of the assets in the group will not sum to 100%, because you are viewing the weight of a group relative to the entire portfolio.

Zoomed Aggregation

If we zoom in on the group, we can see that the Weight changes because it is calculated as though the zoomed portfolio were a separate portfolio, altogether. That is, if we were to take the zoomed portfolio and make it its own, separate portfolio, then we would see the same results as displayed in the zoomed portfolio:

Positions Report (Portfolio)				**Calculations**
Asset ID	Mkt Value	Weight(%)	GICS Sector	Mkt Value of asset ÷ Mkt Value of group in portfolio
3	26.35	**100.0000%**		
USCSCO	15.81	60.0000%	Information Technology	60.0000%
USDELL	10.54	40.0000%	Information Technology	40.0000%
USMSFT	0.00	0.0000%	Information Technology	0.0000%
			Sum	**100.0000%**

Note: In contrast to the behavior at the group level, the weight of the assets in a zoomed portfolio are scaled to sum to 100%.

Benchmark Weight (Bmk Weight (%))

Definition

The weight of a position (asset or group) in the assigned benchmark portfolio. This enables comparison of the weight of a position in the portfolio against the weight of the same security in the benchmark. The user must have permission from the benchmark data vendor in order to view this weight characteristic.

Portfolio Aggregation

As the Positions Report below illustrates, the Benchmark Weight is the sum of the Market Value of each asset divided by the Market Value of the benchmark portfolio for the respective members of the benchmark portfolio:

Positions Report (Benchmark)			**Calculations**	
Asset ID	Mkt Value	Weight(%)		Mkt Value of asset ÷ Mkt Value of benchmark portfolio
5	144.54	**100.0000%**		
USCSCO	15.81	10.9381%		10.9381%
USDELL	10.54	7.2921%		7.2921%
USGS	73.83	51.0793%		51.0793%
USMFST	19.24	13.3112%		13.3112%
UST	25.12	17.3793%		17.3793%
			Sum	**100.0000%**

Group Aggregation

Aggregation at the group level is the sum of the weight of each asset in the benchmark portfolio for the respective members of the group. This is illustrated below for the Information Technology sector group:

Positions Report (Benchmark)				**Calculations**	
Grouping: GICS Sector	Asset ID	Mkt Value	Weight(%)		Mkt Value of asset ÷ Mkt Value of benchmark portfolio
by: distinct	5	144.54	100.0000%		
. . .	. . .				
Information Technology	3	45.59	**31.5414%**		
	USCSCO	15.81	10.9381%		10.9381%
	USDELL	10.54	7.2921%		7.2921%
	USMSFT	19.24	13.3112%		13.3112%
. . .	. . .				
				Sum	**31.5414%**

Note: At the group level, the weight of the assets in the group will not sum to 100%, because you are viewing the weight of a group relative to the entire benchmark portfolio.

Zoomed Aggregation

If we zoom in on the group, we can see that the Weight changes because it is calculated as though the zoomed portfolio were a separate portfolio, altogether. That is, if we were to take the zoomed portfolio and make it its own, separate portfolio, then we would see the same results as displayed in the zoomed portfolio:

Positions Report (Benchmark)				**Calculations**
Asset ID	Mkt Value	Weight(%)	GICS Sector	Mkt Value of asset ÷ Mkt Value of group in bmk portfolio
3	45.59	**100.0000%**		
USCSCO	15.81	34.6787%	Information Technology	34.6787%
USDELL	10.54	23.1191%	Information Technology	23.1191%
USMSFT	19.24	42.2022%	Information Technology	42.2022%
				Sum **100.0000%**

▷ **Note:** In contrast to the behavior at the group level, the weight of the assets in a zoomed benchmark portfolio are scaled to sum to 100%.

Active Weight (%)

Definition

Generally, the difference between the weight of an asset in the managed portfolio and the weight of the asset in the benchmark portfolio. A positive active weight indicates an overweighted position compared to the benchmark, while a negative active weight indicates an underweighted position. When grouping and zooming in BarraOne, active weight is the difference between the weight of a position relative to the current view of your portfolio and the weight of that same security in the benchmark portfolio when viewed in the same perspective.

Portfolio Aggregation

As the Positions Report below illustrates, the Active Weight for a portfolio is the sum of the Active Weight of each member of the portfolio:

Positions Report (Portfolio)					Calculations
Asset ID	Mkt Value	Weight(%)	Bmk Weight(%)	Active Weight(%)	Weight of asset — Bmk Weight of asset
5	100.18	100.0000%	100.0000%	**0.0000%**	
USCSCO	15.81	15.7816%	10.9382%	4.8434%	4.8434%
USDELL	10.54	10.5211%	7.2921%	3.2290%	3.2290%
USGS	73.83	73.6973%	51.0793%	22.6181%	22.6181%
USMSFT	0.00	0.0000%	13.3112%	-13.3112%	-13.3112%
UST	0.00	0.0000%	17.3793%	-17.3793%	-17.3793%
					Sum **0.0000%**

Group Aggregation

Aggregation at the group level is the sum of the weight of each asset in the portfolio minus the weight of each asset in the benchmark for the respective members of the group. This is illustrated below for the Information Technology sector group:

Positions Report (Portfolio)					Calculations
Grouping: GICS Sector	Asset ID	Weight(%)	Bmk Weight(%)	Active Weight(%)	Weight of asset — Bmk Weight of asset
by: distinct	5	100.0000%	100.0000%	0.0000%	
. . .	. . .				
Information Technology	3	26.3023%	31.5414%	**-5.2388%**	
	USCSCO	15.7816%	10.9381%	4.8434%	4.8434%
	USDELL	10.5211%	7.2921%	3.2290%	3.2290%
	USMSFT	0.0000%	13.3112%	-13.3112%	-13.3112%
. . .	. . .				
					Sum **-5.2388%**

Note: At the group level, the active weight of the assets in the group will not sum to 0%, because you are viewing the active weight of a group relative to the entire benchmark.

Zoomed Aggregation

If we zoom in on the group, we can see that the Active Weight changes because it is calculated as though the zoomed portfolio were a separate portfolio, altogether. That is, if we were to take the zoomed portfolio and make it its own, separate portfolio, then we would see the same results as displayed in the zoomed portfolio:

Positions Report (Portfolio)					**Calculations**
Asset ID	Weight(%)	Bmk Weight(%)	Active Weight(%)	GICS Sector	Weight of asset in group — Bmk Weight of asset in group
3	100.0000%	100.0000%	**0.0000%**		
USCSCO	60.0000%	34.6790%	25.3213%	Information Technology	25.3213%
USDELL	40.0000%	23.1191%	16.8809%	Information Technology	16.8809%
USMSFT	0.0000%	42.2022%	-42.2022%	Information Technology	-42.2022%
					Sum **0.0000%**

⊳ **Note:** In contrast to the behavior at the group level, the active weight of the assets in a zoomed portfolio are scaled to sum to 0%, because you are viewing the active weight of a group relative to that *same group* in the benchmark.

Global Weight (%)

Definition

The percentage of a position (asset or group) relative to the overall portfolio.

Portfolio Aggregation

As the Positions Report below illustrates, Global Weight in the portfolio is identical to Weight (the sum of the Market Value of each asset divided by the Market Value of the portfolio for the respective members of the portfolio):

Positions Report (Portfolio)			**Calculations**	
Asset ID	Mkt Value	Global Weight(%)	Mkt Value of asset ÷ Mkt Value of portfolio	
5	100.18	**100.0000%**		
USCSCO	15.81	15.7816%		15.7816%
USDELL	10.54	10.5211%		10.5211%
USGS	73.83	73.6973%		73.6973%
USMFST	0.00%	0.0000%		0.0000%
UST	0.00%	0.0000%		0.0000%
			Sum	**100.0000%**

Group Aggregation

Aggregation at the group level is the same as Weight (the sum of the global weight of each asset in the portfolio for the respective members of the group). This is illustrated below for the Information Technology sector group:

Positions Report (Portfolio)				Calculations
Grouping: GICS Sector	Asset ID	Mkt Value	Global Weight(%)	Mkt Value of asset ÷ Mkt Value of portfolio
by: distinct	5	100.18	100.0000%	
. . .	. . .			
Information Technology	3	26.35	**26.3027%**	
	USCSCO	15.81	15.7816%	15.7816%
	USDELL	10.54	10.5211%	10.5211%
	USMSFT	0.00	0.0000%	0.0000%
. . .	. . .			
				Sum **26.3027%**

Note: At the group level, the global weight of each asset in the group will not sum to 100%, because you are viewing the global weight of a group relative to the entire portfolio.

Zoomed Aggregation

If we zoom in on the group, we can see that the Global Weight does not change, because it is calculated against the entire portfolio, rather than against only the group:

Positions Report (Portfolio)				**Calculations**
Asset ID	Mkt Value	Global Weight(%)	GICS Sector	Mkt Value of asset ÷ Mkt Value of portfolio
3	26.35	**26.3027%**		
USCSCO	15.81	15.7816%	Information Technology	15.7816%
USDELL	10.54	10.5211%	Information Technology	10.5211%
USMSFT	0.00	0.0000%	Information Technology	0.0000%
				Sum **26.3027%**

▷ **Note:** At the zoomed level, the global weight of each asset in the group will not sum to 100%, because you are viewing the global weight of a group relative to the entire portfolio.

Global Benchmark Weight (Global Bmk Weight (%))

Definition

The percentage of a position (asset or group) relative to the overall benchmark portfolio.

Portfolio Aggregation

As the Positions Report below illustrates, Global Benchmark Weight in the portfolio is identical to Benchmark Weight (the sum of the Market Value of each asset divided by the Market Value of the benchmark portfolio for the respective members of the portfolio):

Positions Report (Benchmark)			**Calculations**
Asset ID	Mkt Value	Global Weight(%)	Mkt Value of asset ÷ Mkt Value of benchmark portfolio
5	144.54	**100.0000%**	
USCSCO	15.81	10.9381%	10.9381%
USDELL	10.54	7.2921%	7.2921%
USGS	73.83	51.0793%	51.0792%
USMFST	19.24	13.3112%	13.3112%
UST	25.12	17.3793%	17.3793%
			Sum **100.0000%**

Group Aggregation

Aggregation at the group level is the same as Benchmark Weight (the sum of the weight of each asset in the portfolio for the respective members of the group). This is illustrated below for the Information Technology sector group:

Positions Report (Benchmark)				Calculations	
Grouping: GICS Sector	Asset ID	Mkt Value	Global Weight(%)	Mkt Value of asset ÷ Mkt Value of benchmark portfolio	
by: distinct	5	144.54	100.0000%		
. . .	. . .				
Information Technology	3	45.59	**31.5414%**		
	USCSCO	15.81	10.9381%		10.9381%
	USDELL	10.54	7.2921%		7.2921%
	USMSFT	19.24	13.3112%		13.3112%
. . .	. . .				
				Sum	**31.5414%**

▷ **Note:** At the group level, the benchmark weight of each asset in the group will not sum to 100%, because you are viewing the benchmark weight of a group relative to the entire benchmark portfolio.

Zoomed Aggregation

If we zoom in on the group, we can see that the Global Benchmark Weight does not change, because it is calculated against the entire portfolio, rather than against only the group:

Positions Report (Benchmark)				**Calculations**
Asset ID	Mkt Value	Global Weight(%)	GICS Sector	Mkt Value of asset ÷ Mkt Value of benchmark portfolio
3	45.59	**31.5414%**		
USCSCO	15.81	10.9381%	Information Technology	10.9381%
USDELL	10.54	7.2921%	Information Technology	7.2921%
USMSFT	19.24	13.3112%	Information Technology	13.3112%
			Sum	**31.5414%**

Note: At the zoomed level, the global benchmark weight of each asset in the group will not sum to 100%, because you are viewing the global benchmark weight of a group relative to the entire benchmark portfolio.

Global Active Weight (%)

Definition

The difference between the weight of a position in the overall portfolio and the weight of that same security in the benchmark portfolio.

Portfolio Aggregation

As the Positions Report below illustrates, Global Active Weight in the portfolio is identical to Active Weight (the sum of the Active Weight of each respective member of the portfolio):

Positions Report (Portfolio)					**Calculations**
Asset ID	Mkt Value	Weight(%)	Bmk Weight(%)	Global Active Weight(%)	Weight of asset — Bmk Weight of asset
5	100.18	100.0000%	100.0000%	**0.0000%**	
USCSCO	15.81	15.7816%	10.9381%	4.8434%	4.8434%
USDELL	10.54	10.5211%	7.2921%	3.2290%	3.2290%
USGS	73.83	73.6973%	51.0793%	22.6181%	22.6181%
USMSFT	0.00	0.0000%	13.3112%	-13.3112%	-13.3112%
UST	0.00	0.0000%	17.3793%	-17.3793%	-17.3793%
				Sum	**0.0000%**

Group Aggregation

Aggregation at the group level is the same as Active Weight (the sum of the global weight of each asset in the portfolio minus the weight of the asset in the benchmark for the respective members of the group). This is illustrated below for the Information Technology sector group:

Positions Report (Portfolio)					**Calculations**
Grouping: GICS Sector	Asset ID	Weight(%)	Bmk Weight(%)	Global Active Weight(%)	Weight of asset — Bmk Weight of asset
by: distinct	5	100.0000%	100.0000%	0.0000%	
. . .	. . .				
Information Technology	3	26.3027%	31.5414%	**-5.2388%**	
	USCSCO	15.7816%	10.9381%	4.8434%	4.8434%
	USDELL	10.5211%	7.2921%	3.2290%	3.2290%
	USMSFT	0.0000%	13.3112%	-13.3112%	-13.3112%
. . .	. . .				
					Sum **-5.2388%**

▷ **Note:** At the group level, the active weight of the assets in the group will not sum to 0%, because you are viewing the active weight of a group relative to the entire benchmark.

Zoomed Aggregation

If we zoom in on the group, we can see that the Global Active Weight does not change, because it is calculated against the entire portfolio, rather than against only the group:

Positions Report (Portfolio)					**Calculations**
Asset ID	Weight(%)	Bmk Weight(%)	Global Active Weight(%)	GICS Sector	Weight of asset in portfolio — Bmk Weight of asset
3	26.3027%	31.5414%	**-5.2388%**		
USCSCO	15.7816%	10.9381%	4.8434%	Information Technology	4.8434%
USDELL	10.5211%	7.2921%	3.2290%	Information Technology	3.2290%
USMSFT	0.0000%	13.3112%	-13.3112%	Information Technology	-13.3112%
					Sum **-5.2388%**

▷ **Note:** At the zoomed level, the global active weights of the assets in the group will not sum to 0%, because you are viewing the global active weight of a group relative to the entire portfolio.

Effective Weight (Eff Weight (%))

Definition

The implicit position held in an asset with no monetary investment. Effective weights are used for risk calculations and may differ from the weight represented by the amount of money actually invested in the security. In BarraOne, futures contracts have a weight of zero and an effective weight equal to *price x contract size x holdings ÷ portfolio market value*. (For bond futures and eurodollar futures, *price* is *clean price* ÷ 100). See also *weight*.

For example, if you hold an equity futures contract with holding equal to 1, a contract size of 10, and a price of 3,796.34, its effective market value will be 1 x 10 x 3,796.34 = 37,963.43. If the market value of the portfolio is 100,001.31, then the effective weight of the equity future is 37,963.43 ÷ 100,001.31 = 37.9629%.

Portfolio Aggregation

As the Positions Report below illustrates, the effective weight is the sum of the effective market value of each asset divided by the market value of the portfolio for the respective members of the portfolio:

Positions Report (Portfolio)			**Calculations**
Asset ID	Mkt Value/Eff Mkt Value	Eff Weight(%)	Eff Mkt Value of asset ÷ Mkt Value of portfolio
5	144.54	**100.0000%**	
USCSCO	15.81	10.9381%	10.9381%
USDELL	10.54	7.2921%	7.2921%
USGS	73.83	51.0793%	51.0793%
USMFST	19.24	13.3112%	13.3112%
UST	25.12	17.3793%	17.3793%
			Sum **100.0000%**

Group Aggregation

Aggregation at the group level is the sum of the effective market value of each asset in the portfolio divided by the market value for the respective members of the group. This is illustrated below for the Information Technology sector group:

Positions Report (Portfolio)				**Calculations**
Grouping: GICS Sector	Asset ID	Mkt Value/ Eff Mkt Value	Eff Weight(%)	Eff Mkt Value of asset ÷ Mkt Value of portfolio
by: distinct	5	144.54	100.0000%	
. . .	. . .			
Information Technology	3	45.59	**31.5414%**	
	USCSCO	15.81	10.9381%	10.9381%
	USDELL	10.54	7.2921%	7.2921%
	USMSFT	19.24	13.3112%	13.3112%
. . .	. . .			
				Sum **31.5414%**

Note: At the group level, the effective weight of each asset in the group will not sum to 100%, because you are viewing the effective weight of a group relative to the entire portfolio.

Zoomed Aggregation

If we zoom in on the group, we can see that the Effective Weight changes, because it is calculated as though the zoomed portfolio were a separate portfolio, altogether. That is, if we were to take the zoomed portfolio and make it its own, separate portfolio, then we would see the same results as displayed in the zoomed portfolio:

Positions Report (Portfolio)				**Calculations**
Asset ID	Mkt Value / Eff Mkt Value	Eff Weight(%)	GICS Sector	Eff Mkt Value of asset ÷ Mkt Value of group in portfolio
3	45.59	**100.0000%**		
USCSCO	15.81	34.6787%	Information Technology	34.6787%
USDELL	10.54	23.1191%	Information Technology	23.1191%
USMSFT	19.24	42.2022%	Information Technology	42.2022%
				Sum **100.0000%**

⊳ **Note:** In contrast to the behavior at the group level, the effective weight of the assets in a zoomed portfolio are scaled to sum to 100%.

Effective Benchmark Weight (Eff Bmk Weight (%))

Definition

The implicit position the benchmark holds in an asset with no monetary investment, or the percentage of the position (asset or group). Effective weights are used for risk calculations and may differ from the weight represented by the amount of money actually invested in the security. In BarraOne, futures contracts have a weight of zero and an effective weight equal to *price x contract size x holdings ÷ portfolio market value*. (For bond futures and eurodollar futures, *price* is *clean price* ÷ 100). See also *benchmark weight* and *effective weight*.

Aggregation

Sum

Effective Active Weight (Eff Active Weight (%))

Definition

The implicit active position held in an asset with no monetary investment, or the percentage of the position (asset or group) relative to the overall benchmark portfolio. Effective weights are used for risk calculations and may differ from the weight represented by the money actually invested in the security. In BarraOne, futures contracts have a weight of zero and an effective weight equal to *price x contract size x holdings ÷ portfolio market value*. (For bond futures and eurodollar futures, *price* is *clean price* ÷ 100). See also *active weight* and *effective weight*.

Aggregation

Sum

▷ **Note:** Effective Active Weight will not sum to zero at the portfolio level unless the Benchmark Asset Not Held attribute is selected for the Positions Report.

Effective Global Weight (Eff Global Weight (%))

Definition

The implicit position the held in an asset with no monetary investment. Effective weights are used for risk calculations and may differ from the weight represented by the amount of money actually invested in the security. In BarraOne, futures contracts have a weight of zero and an effective weight equal to *price x contract size x holdings ÷ portfolio market value*. (For bond futures and eurodollar futures, *price* is *clean price* ÷ 100). See also *global weight* and *effective weight*.

Aggregation

Sum

Effective Global Benchmark Weight (Eff Global Bmk Weight (%))

Definition

The implicit position the benchmark holds in an asset with no monetary investment, or the percentage of the position (asset or group). Effective weights are used for risk calculations and may differ from the weight represented by the amount of money actually invested in the security. In BarraOne, futures contracts have a weight of zero and an effective weight equal to *price x contract size x holdings ÷ portfolio market value*. (For bond futures and eurodollar futures, *price* is *clean price* ÷ 100). See also *global benchmark weight* and *effective weight*.

Aggregation

Sum

Effective Global Active Weight (Eff Global Active Weight (%))

Definition

The implicit active position held in an asset with no monetary investment, or the percentage of the position (asset or group) relative to the overall benchmark portfolio. Effective weights are used for risk calculations and may differ from the weight represented by the amount of money actually invested in the security. In BarraOne, futures contracts have a weight of zero and an effective weight equal to *price x contract size x holdings ÷ portfolio market value*. (For bond futures and eurodollar futures, *price* is *clean price* ÷ 100). See also *global active weight* and *effective weight*.

Aggregation

Sum

Position Data: Miscellaneous

This section describes selected Position Data columns not related to weight that are available in a Positions Report.

- Benchmark Asset Not Held
- Market Value (Mkt Value)
- Member Fund
- Native Portfolio
- Par
- Par Value

Benchmark Asset Not Held

Definition

Assets in the benchmark that are not explicitly held in the managed portfolio. The example below indicates that USMSFT and UST exist in the benchmark portfolio but not in the managed portfolio.

Positions Report (Portfolio)					
Asset ID	Mkt Value	Benchmark Asset Not Held	Weight(%)	Bmk Weight(%)	Active Weight(%)
5	100.18	5	100.0000%	100.0000%	0.0000%
USCSCO	15.81	Held	15.7816%	10.9382%	4.8435%
USDELL	10.54	Held	10.5211%	7.2921%	3.2290%
USGS	73.83	Held	73.6974%	51.0793%	22.6181%
USMSFT	0.00	Not Held	0.0000%	13.3112%	-13.3112%
UST	0.00	Not Held	0.0000%	17.3793%	-17.3793%

Aggregation

Count

Note: Effective Active Weight will not sum to zero at the portfolio level unless the Benchmark Asset Not Held attribute is selected for the Positions Report. This will affect all BarraOne calculations that use Effective Active Weight.

Market Value (Mkt Value)

Definition

The formula used by BarraOne for calculating market value is dependent upon the asset type. The tables below show the figures used in each calculation, and where effective market value differs from market value, the figures used in that calculation are displayed, as well.

Table 10: Interest Rate Instruments

Instrument	Market Value	Eff. Market Value	Price Source
EuroDollar Future **Note:** Rate Term is used here to get an approximation. To get the exact market value, use ACT/360.	Zero	(1 – (1 – Price / 100) ∗ Rate Term) ∗ Contract Size ∗ Holdings	Barra-Calculated
Eurodollar Future Option **Note:** Rate Term is the Rate Term of the underlying future.	Price / 100 ∗ Rate Term ∗ Contract Size ∗ Contract Size of Underlying Future	N/A	Barra-Calculated
Swap (Vanilla and Basis) Currency Swap Zero Coupon Swap Overnight Index Swap Inflation Swap Cap/Floor Total Return Swap (Equity and Fixed Income) Swaption FRA (Forward Rate Agreement)	Price ∗ Contract Size ∗ Holdings	N/A	Barra-Calculated

Table 11: Fixed Income Instruments

Instrument	Market Value	Eff. Market Value	Price Source
Duration Proxy	(Price / 100 + Accrued Interest(%)) ∗ Contract Size ∗ Holdings	N/A	User Import
Agency Bond Agency Zero Corporate Bond Eurobond Government Note/Bond Treasury Convertible Bond Floating Rate Note Variable Rate Note Inflation-Protected Bond MBS Danish MBS TBA MBS Securitized Products	(Price / 100 + Accrued Interest(%)) ∗ Contract Size ∗ Holdings	N/A	Barra-Calculated Barra-Supplied
Cashflow Bond Commercial Deposit Optionable (Callable and Putable) Bonds Municipal Bond Municipal Floating Rate Note	(Price / 100 + Accrued Interest(%)) ∗ Contract Size ∗ Holdings	N/A	Barra-Calculated
Adjustable Rate Mortgage (ARM)	(Price / 100 + Accrued Interest(%)) ∗ Contract Size ∗ Holdings	N/A	Barra-Supplied User Import
Term Deposit	Price / 100 * Contract Size * Holdings	N/A	Barra-Calculated Barra-Supplied
Bond Forward	Discounted (fair forward price – contract forward price)	N/A	Barra-Calculated User Import
Treasury Future	Zero	Price ∗ Contract Size ∗ Holdings / 100	Barra-Calculated Barra-Supplied
Bond Option	Price / 100 * Contract Size * Holdings * Contract Size of Underlier	N/A	Barra-Calculated

Table 11: Fixed Income Instruments (Continued)

Instrument	Market Value	Eff. Market Value	Price Source
Treasury Future Option	Price / 100 ∗ Contract Size ∗ Contract Size of Underlying Futures ∗ Holdings	N/A	Barra-Calculated
Repo	Price / 100 ∗ Contract Size ∗ Holdings	N/A	Barra-Calculated
Cash Flow Asset	Price ∗ Holdings	N/A	Barra-Calculated
Inflation-Linked Liability	Price ∗ Holdings	N/A	Barra-Calculated User Import
Syndicated Loan	(Price / 100 + Accrued Interest(%)) ∗ Contract Size ∗ Holdings	N/A	Barra Calculated User Import
Credit Default Swap Credit Default Swap Basket	(1 – Fitted Price / 100 + Accrued Interest) ∗ Contract Size ∗ Holdings	N/A	Barra-Calculated
Credit Linked Note	(Fitted Price / 100 + Accrued Interest) ∗ Contract Size ∗ Holdings	N/A	Barra-Calculated
CDS Option	(Expressed as a percentage of the notional adjusted for any exchange rate) = Option Price * Holding * Contract size of underlier / 100	N/A	Barra-Calculated User Import
CDS Tranche Nth-to-Default	(Fitted Price / 100 + Accrued Interest) ∗ Contract Size ∗ Holdings	N/A	Barra-Calculated

Table 12: Foreign Exchange Instruments

Instrument	Market Value	Eff. Market Value	Price Source
Currency	Price ∗ Holdings	N/A	Barra-Supplied (FX rate vs. numeraire)
FX Forward	Price ∗ Contract Size ∗ Holdings	N/A	Barra-Calculated
FX Future	Zero	Price ∗ Contract Size ∗ Holdings	Barra-Calculated
FX Option FX Future Option	Price ∗ Holdings	N/A	Barra-Calculated

Table 13: Equity Instruments

Instrument	Market Value	Eff. Market Value	Price Source
Private Equity	Price * Holdings	N/A	User Import
Equity Rule-Based Proxy	Price ∗ Holdings	N/A	User Import
Equity Option Equity Claim	Price ∗ Contract Size ∗ Holdings	N/A	Barra-Calculated
Contract for Difference (CFD)	Zero	Price ∗ Contract Size ∗ Holdings	Barra-Calculated
Equity Security	Price ∗ Holdings	N/A	Barra-Supplied User Import
Equity Index Exchange-traded Fund Equity Basket	Price ∗ Contract Size ∗ Holdings	N/A	Barra-Supplied User Import
Equity Forward	Discounted (fair forward price – contract forward price)	N/A	Barra-Calculated User Import
Equity Future	Zero	Price ∗ Contract Size ∗ Holdings	User Import
Equity Index Future	Zero	Price ∗ Contract Size ∗ Holdings	Barra-Supplied User Import
Equity Index Future Option	Price ∗ Contract Size ∗ Holdings ∗ Contract Size of Underlying EIF	N/A	Barra-Calculated
Volatility Swap Variance Swap Forward Volatility Agreement Volatility Option	Holdings * Contract Size * Price	N/A	Barra-Calculated User Import
Variance Future	Zero	Holdings * Contract Size * Price	User Import

Table 14: Miscellaneous Instruments

Instrument	Market Value	Eff. Market Value	Price Source
Certificate/Tracker	Price ∗ Contract Size ∗ Holdings	N/A	Barra-Calculated
Commodity	Price ∗ Contract Size ∗ Holdings	N/A	Default (1)
Commodity Future Commodity Index Future	Zero	Price ∗ Contract Size ∗ Holdings	User Import
Commodity Future Option	Price ∗ Contract Size ∗ Holdings ∗ Contract Size of Underlying Futures	N/A	Barra-Calculated

Table 14: Miscellaneous Instruments (Continued)

Composite Index	Price * Contract Size * Holdings	N/A	Default (100) User Import
Custom Exposure Asset	Price * Holdings	N/A	User Import
Hedge Fund	Price * Contract Size * Holdings	N/A	Default (1)
Mutual Fund/Unit Trust Property/Real Estate Unit Exposure Asset	Price * Contract Size * Holdings	N/A	Barra-Supplied
Private Real Estate	Price * Contract Size * Holdings	N/A	Barra-Supplied User Import
StructureTool Asset	Price * Holdings	N/A	User Import

Aggregation

Sum

Member Fund

Definition

The name of the first branch of the parent tree node of the portfolio to which an asset belongs. This feature is intended to display membership information about an asset for grouping purposes in an aggregate portfolio analysis.

In the example illustrated in Table 4 on page 34, any asset belonging to the portfolio Equity_Mgd will have a Member Fund of PortFund3 (not PortFund4).

To illustrate the concepts of Member Fund, the assets in the portfolios BondFund1, BondFund2, and Equity_Mgd are represented in the PORTTree Positions Report, grouped by Member Fund, reproduced below:

Positions Report (Portfolio)					
Grouping: Member Fund	Asset ID	Benchmark Asset Not Held	Holdings	Member Fund	Native Portfolio
by: distinct	7	7	5.00	7	7
PortFund1	2	2	0.00	2	2
	USMSFT	Not Held	0.00	PortFund1	Equity_Bmk
	UST	Not Held	0.00	PortFund1	Equity_Bmk
PortFund2	2	2	2.00	2	2
	Bond1	Held	1.00	PortFund2	BondFund1
	Bond2	Held	1.00	PortFund2	BondFund2
PortFund3	3	3	3.00	3	3
	USCSCO	Held	1.00	PortFund3	Equity_Mgd
	USDELL	Held	1.00	PortFund3	Equity_Mgd
	USGS	Held	1.00	PortFund3	Equity_Mgd

Note that USMSFT and UST in this example are members of a benchmark portfolio that does not reside within the PORTTree portfolio tree.

▷ **Note:** If you group your positions by Member Fund or Native Portfolio, when you zoom in on a subportfolio, BarraOne loads a *cash* benchmark. This is because the "member fund" and "native portfolio" attributes cannot be tracked against a benchmark. However, your subportfolio's market beta is measured against the complete, unzoomed market portfolio, rather than a subset of its assets. Refer to "Benchmark and Market Comparisons" on page 33 for details.

See also "Native Portfolio."

Aggregation

Count

Native Portfolio

Definition

The name of the portfolio where an asset actually resides. This feature is intended to display membership information about an asset for grouping purposes in an aggregate portfolio analysis. Refer to the example illustrated in Table 4 on page 34.

The assets in the portfolios BondFund1, BondFind2, and Equity_Mgd are represented in the PORTTree Positions Report, grouped by Native Portfolio, reproduced below:

Positions Report (Portfolio)					
Grouping: Native Portfolio	Asset ID	Benchmark Asset Not Held	Holdings	Member Fund	Native Portfolio
by: distinct	5	5	5.00	5	5
Equity_Mgd	3	3	3.00	3	3
	USCSCO	Held	1.00	PortFund3	Equity_Mgd
	USGS	Held	1.00	PortFund3	Equity_Mgd
	USDELL	Held	1.00	PortFund3	Equity_Mgd
BondFund1	1	1	1.00	1	1
	Bond1	Held	1.00	PortFund2	BondFund1
BondFudn2	1	1	1.00	1	1
	Bond1	Held	1.00	PortFund2	BondFund1

See also "Member Fund" on page 64.

Note: If you group your positions by Member Fund or Native Portfolio, when you zoom in on a subportfolio, BarraOne loads a *cash* benchmark. This is because the "member fund" and "native portfolio" attributes cannot be tracked against a benchmark. However, your subportfolio's market beta is measured against the complete, unzoomed market portfolio, rather than a subset of its assets. Refer to "Benchmark and Market Comparisons" on page 33 for details.

Aggregation

Count

Par

Definition

The value of the security as it appears on the certificate of the instrument. This is the amount of principal due the bondholder at maturity, and it is the amount on which interest payments are calculated. It is the same as face value or face amount, *i.e.,* the holding unit to the imported position. When Par is set to 1000, an imported position of size 1 becomes 1000 in terms of the currency.

Aggregation

Count

Par Value

Definition

Par multiplied by Holdings.

Aggregation

Sum

Risk Model: Risk Types

This section describes selected risk type columns available in a Positions Report under Risk Model: Portfolio Risk:

- Total Risk
- Selection Risk
- Common Factor Risk
- Local Market Risk
- Currency Risk
- Industry Risk
- Style Risk
- Term Structure Risk
- Spread Risk
- Emerging Market Risk
- Hedge Fund Risk
- Liquidation Risk
- Market Timing Risk (Mkt Timing Risk)

Total Risk

The total (gross) risk to an asset, which is the standard deviation of the asset's total return distribution, expressed in percent. We forecast total risk using Barra's multiple factor model (BIM). The total risk for an asset depends on the asset's exposures to the risk factors, the factor variance/covariance matrix, and the forecast selection risk of the asset.

For fixed income assets, total risk is the combination of selection risk and systematic risk, or shift, twist, butterfly, spread, currency, and selection risk.

$$\underbrace{\sqrt{XFX^T}}_{\text{common factor risk}} + \underbrace{\sqrt{hDh^T}}_{\text{specific risk}} \text{ (includes currency)}$$

Selection Risk

Risk that is specific to an asset and is uncorrelated (or negligibly correlated) with the risks of other assets. That is, asset selection risk is the portion of an asset's or portfolio's risk that is unexplained by the risk model. Also called specific, unique, idiosyncratic, or independent risk.

$$\sqrt{hDh^T}$$

where:

D = asset-by-asset specific variance-covariance matrix

h = matrix of holdings

$= h_{\mathrm{P}} - \beta h_{\mathrm{M}}$

Common Factor Risk

A common factor is a characteristic shared by a group of securities that influences the returns of those securities. Securities with similar characteristics exhibit similar return behavior, which may be distinct from the rest of the market. In Barra multiple-factor risk models, the common factors determine correlations between asset returns. Examples of common factors are industries, styles, term structure, and spreads.

Common factor risk is the part of total risk due to exposure to common factors.

$$\sqrt{XFX^T}$$

where:

X = has no currency exposures

- if no market is selected, then:

X = exposures of portfolio

- if market is selected, then:

X = exposures of portfolio $-\ \beta$ of portfolio to market $\cdot$ exposures of market

$= X_{\mathrm{P}} - \beta X_{\mathrm{M}}$

Local Market Risk

The part of risk due to exposure to local market factors such as styles, industries, term structure movements, and changes in spreads. Local market risk arises from decisions made with local markets.

$$\sqrt{XFX^T}$$

where:

X = local market exposures of portfolio

Currency Risk

The predicted risk (in one-year standard deviation) arising from implicit and explicit holdings in assets that are denominated in currencies other than the numeraire currency. This risk takes into account the exchange rates and short-term interest rates of the foreign country and the numeraire currency.

$$\sqrt{XFX^T}$$

where:

X = currency exposures of portfolio

Industry Risk

The part of risk due to exposure to industry factors (applicable only to equities).

$$\sqrt{XFX^T}$$

where:

X = industry exposures of portfolio

Style Risk

Definition

The part of risk due to exposure to style factors, a risk factor that characterizes an equity's fundamental or market-based characteristics such as Size, Value, Momentum, and Volatility.

$$\sqrt{XFX^T}$$

where:

X = style exposures of portfolio

Term Structure Risk

The part of risk due to exposure to term structure movements.

$$\sqrt{XFX^T}$$

where:

X = Shift, Twist, and Butterfly exposures of portfolio

Spread Risk

The risk due to exposure to spread movements, a risk factor that captures typical movements in term structure spreads. Spread factors in Barra's risk model include non-government spread (also known as spread) and emerging market spread.

$$\sqrt{XFX^T}$$

where:

X = spread exposures of portfolio

Emerging Market Risk

The part of risk due to exposure to emerging market spreads, or the spread associated with bonds issued in an external currency by an emerging market sovereign or by a company domiciled in an emerging market country. In the Barra risk model, emerging market spread is measured relative to the swap spread.

$$\sqrt{XFX^T}$$

where:

X = emerging market exposures of the portfolio

Note: Emerging Market (EM) factors apply to bonds for which the issuer is domiciled in an Emerging Market* and the currency of denomination is any external currency. In particular, note that if an issuer in an Emerging Market country issues a bond in another emerging market, then the EM factor applies. For example, if a Korean company or the Korean government issues a bond with principal and coupon denominated in the Brazilian real, then the bond is exposed to the Brazilian (real-denominated) Shift, Twist, Butterfly, and Swap factors, as well as the EM factor for Korea.

* See https://support.msci.com/docs/DOC-3077 for markets covered by EM factors.

Hedge Fund Risk

The part of risk due to exposure to hedge fund factors.

$$\sqrt{XFX^T}$$

where:

X = hedge fund exposures of portfolio

Liquidation Risk

Definition

The change in portfolio risk from having a single asset or group of assets traded out for cash. For example, if an asset's (or a group's) liquidation risk is 1.78 percent, it means portfolio risk would be reduced by that amount if you traded the asset for cash.

Aggregation

For portfolios, it is the total risk of the portfolio. For groups, it is the change in portfolio risk caused by trading the group for cash.

Market Timing Risk (Mkt Timing Risk)

The part of risk due to exposure of the portfolio to the market portfolio (although it is market timing *variance*, technically speaking). Exposure is measured by active beta (the market beta of the portfolio minus the market beta of the benchmark portfolio). The value of this term will be zero if a market is not specified.

$$\beta^2\sigma^2$$

> **Note:** To account for the separation of currency risk, the beta calculation omits currency exposures (*i.e.,* all currency factor exposures are set to 0 for both the covariance and variance calculations). Compare to "Beta" on page 93, which does include currency exposures.

Risk Model: Contribution to Risk

This section describes selected marginal contribution to risk and percent contribution to risk columns available in a Positions Report under Risk Model: Portfolio Risk.

Following a general discussion of marginal contribution, the following marginal contribution terms are defined in greater detail:

- Marginal Contribution to Total Risk (MC to Total Risk)
- Marginal Contribution to Common Factor Risk (MC to Common Factor Risk)
- Marginal Contribution to Industry Risk (MC to Industry Risk)
- Marginal Contribution to Selection Risk (MC to Selection Risk)
- Marginal Contribution to Active Total Risk (MC to Active Total Risk)
- Marginal Contribution to Total Tracking Error (MC to Total Tracking Error)
- Marginal Contribution to Active Market Timing Risk (MC to Active Market Timing Risk)

Then, following a brief discussion of percent contribution in general, a more detailed look at the following percent contribution terms is presented:

- Percent Contribution to Total Risk (%CR to Total Risk)
- Percent Contribution to Active Total Risk (%CR to Active Total Risk)
- Percent Contribution to Total Tracking Error (%CR to Total Tracking Error)

Marginal Contribution to Risk (MC to Risk)

Marginal contribution to risk is an asset's contribution, on the margin, to a particular risk characteristic of a portfolio. It measures the change in that characteristic caused by a one percent change in that asset's or group's percent holding (while shorting an equal amount of cash to keep all other asset weights constant).

Group Aggregation

Here is a formal treatment of how BarraOne aggregates marginal contributions at the portfolio and group level, with a specific illustration for marginal contribution to total risk:

Let:

I^g = index set of assets from a group g

w_i = asset i portfolio weight

$W_g = \sum_{i \in I^g} w_i$ = weight of the group g

$\Delta \overline{w_i}$ = incremental change in weight of asset

Then:

$$\Delta W_g = \sum_{i \in I^g} \left(w_i + \Delta \overline{w_i} \right) - \sum_{i \in I^g} w_i = \sum_{i \in I^g} \Delta \overline{w_i} = \text{change in group } g \text{ weight}$$

we can ensure that:

$$\sum_{i \in I^g} \Delta \overline{w_i} \equiv \Delta W_g = \delta \ (i.e.,\ \delta = 1\%)$$

by normalizing some initial weight increments as:

$$\Delta \overline{w_i} = \frac{\Delta w_i}{\sum_{i \in I^g} \Delta w_i} \delta$$

Then, for MCTR:

$$MCTR_g \approx \frac{\partial \sigma^P}{\partial W_g} \cdot \Delta W_g = \sum_{i \in I^g} \frac{\partial \sigma^P}{\partial w_i} \Delta \overline{w_i} \cdot \delta = \sum_{i \in I^g} MCTR_i \cdot \Delta \overline{w_i}$$

Marginal contribution at the group level is the change in portfolio risk if we increase all asset weights in the group proportionally to their absolute weights:

$$\Delta w_i \sim \left| w_i \right|$$

so that:

$$\Delta\overline{w_i} = \frac{|w_i|}{\sum_{i \in I^g} |w_i|}\delta$$

This definition is consistent with bottom-up intuition, namely, we aggregate asset-level marginal contributions to the group level. One useful feature of this approach is that if the marginal contributions of all assets are positive, then the group marginal contribution will also be positive.

Marginal Contribution to Total Tracking Error and Marginal Contribution to Active Total Risk (MCTE and MCAR)

BarraOne distinguishes between two similar concepts, and the following discussion is intended to clarify the relationship between marginal contribution to total tracking error (MC to Total Tracking Error, or MCTE) and marginal contribution to active total risk (MC to Active Total Risk, or MCAR). Both concepts are used as a measure of the rate of change in portfolio active total risk due to a one percent increase in the position of an asset held in the portfolio, while holding the value of the entire portfolio constant.

MCAR assumes that the increase in the position is financed by borrowing cash (decreasing the cash in the portfolio), *i.e.,* it represents the effect of a change in active asset weight. MCTE assumes that the increase in the position is financed by selling (shorting) an equivalent position in the benchmark, *i.e.,* it represents the effect of a change in total asset weight.

Asset-level MCAR and MCTE differ by the benchmark contribution to active total risk (a constant, which is not displayed in BarraOne):

$$MCAR_i - MCTE_i = CAR_B$$

where:

$$CAR_B = w_B^T MCAR = \sum_{j=1}^{m} w_j MCAR_j$$

and j represents an asset in the benchmark, and m is the number of assets in the benchmark.

MCTE, MCAR, and Futures

Futures positions are marked-to-market every day. All profits and losses are accumulated in a separate margin account, which is managed separately from the portfolio under consideration. Thus (and also due to other arguments that complicate the issue of managing portfolio risk), Barra assigns zero market value to futures contracts, resulting in a weight of zero for futures contracts. However, futures contracts do have effective weight in BarraOne. Thus, the formulas in this section hold for futures if the weight term is replaced with effective weight.

Marginal Contribution to Total Risk (MC to Total Risk)

Definition

Marginal contribution to total risk indicates the approximate change in predicted total risk that would result from an increase or decrease in the asset's weight by one percent of portfolio value and a respective decrease or increase in cash by one percent (to keep the portfolio value constant). It is the partial derivative of a portfolio's total risk with respect to asset *i*'s current weight in the portfolio.

$$MCTR_i = \frac{\partial \sigma^P}{\partial w_i^P} \equiv \frac{1}{\sigma^P} \boldsymbol{\delta}_i^T \cdot \Sigma \cdot \boldsymbol{w}^{\boldsymbol{P}}$$

where:

$\boldsymbol{\delta_i}$ = a vector with all components equal to 0,

except the i^{th} component, which is equal to 1.

Decomposing into common factor and specific components:

$$MCTR_i = \frac{1}{\sigma^P}\left(\boldsymbol{x}_i^T F \boldsymbol{x}^P + \boldsymbol{\delta}_i^T \boldsymbol{D} \boldsymbol{w}^{\boldsymbol{P}} \right)$$

where:

$\boldsymbol{x}_i = X^T \cdot \boldsymbol{\delta_i}$ (a vector of asset i factor exposures)

$\boldsymbol{x}^P = X^T \cdot \boldsymbol{w}^{\boldsymbol{P}}$ (a vector of portfolio P factor exposures).

Here we add linked selection risk and express the formula in a slightly different way:

$$\text{MC Total Risk} = \frac{1}{\sigma_{total,mgd}}\left(\underbrace{X_i^T F X_{mgd}}_{\text{cov}(i,mgd)} + \underbrace{w_{i,mgd}\sigma_{i,sp}^2}_{\text{sp cov}(i,i/mgd)} + \underbrace{\sum_{j=N_i+1}^{N_p} h_j \sigma_{ij,sp}}_{\text{sp cov}(i,j)} \right)$$

$$= \frac{\text{cov}(i,mgd)}{\sigma_{total,mgd}}$$

The following are required to calculate this figure:

- asset *i*'s "pure" common factor exposures (X_i)
- the managed portfolio's common factor exposures (X_{mgd})
- the variance-covariance matrix (F)
- the managed portfolio's total risk ($\sigma_{total,\ mgd}$)
- asset *i*'s selection variance ($\sigma^2_{i,sp}$)
- asset *i*'s weight in the managed portfolio ($w_{i,mgd}$)
- asset *i*'s linked selection risk

Portfolio Aggregation

As the Positions Report below illustrates, the Marginal Contribution to Total Risk for a portfolio is the sum of the products of the Effective Weight and Marginal Contribution to Total Risk for the respective members of the portfolio:

Positions Report			**Calculations**
Asset ID	Eff Weight(%)	MC to Total Risk	Eff Weight(%) x MC to Total Risk
3	100.0000%	**0.3669**	
USCSCO	33.3333%	0.3246	0.1082
USDELL	33.3333%	0.4880	0.1627
USMSFT	33.3333%	0.2880	0.0960
			Sum of Products **0.3669**

Group Aggregation

Aggregation at the group level is the sum of the products of the absolute value of Effective Weight and Marginal Contribution to Total Risk for the respective members of the group, divided by the sum of the absolute value of Effective Weight of the members of the group.

$$MCTR_g = \begin{cases} \sum_{i \in I^g} MCTR_i \cdot \frac{\left|w_i^P\right|}{\sum_{i \in I^g} \left|w_i^P\right|} & \text{if } \sum_{i \in I^g} \left|w_i^P\right| \neq 0 \\ 0 & \text{otherwise} \end{cases}$$

This is illustrated below for the Materials sector group of a portfolio:

Positions Report				Calculations	
Grouping: GICS Sector	Asset ID	Eff Weight(%)	MC to Total Risk	|Eff Weight(%)| x MC to Total Risk	|Eff Weight (%)|
by: distinct	80	100.0000%	0.2505		
. . .	. . .				
Materials	4	2.1542%	**0.3212**		
	USA45V1	0.0000%	0.2916	0.0000	0.0000
	USAE9C1	0.7404%	0.3498	0.2590	0.7404
	USAEBJ1	1.1728%	0.2892	0.3392	1.1728
	USAHE41	0.2410%	0.3886	0.0937	0.2410
. . .	. . .				
				Sum of Products 0.6919	
				Sum of |Eff Weight(%)|	2.1542
				Sum of Products ÷ Sum of |Eff Weight(%)|	**0.3212**

▷ **Note:** At the group level, the effective weight of the assets in the group will not sum to 100%, because you are viewing the risk of a group relative to the entire portfolio.

Zoomed Aggregation

If we zoom in on the group, we can see that the Marginal Contribution to Total Risk changes because Total Risk is calculated as though the zoomed portfolio were a separate portfolio, altogether. That is, if we were to take the zoomed portfolio and make it its own, separate portfolio, then we would see the same results as displayed in the zoomed portfolio:

Positions Report				**Calculations**
Asset ID	Eff Weight(%)	MC to Total Risk	GICS Sector	Eff Weight(%) in group x MC to Total Risk of group
4	100.0000%	**0.4437**		
USA45V1	0.0000%	0.2821	Materials	0.0000
USAE9C1	34.3689%	0.5136	Materials	0.1765
USAEBJ1	54.4440%	0.3921	Materials	0.2135
USAHE41	11.1872%	0.4797	Materials	0.0537
				Sum of Products **0.4437**

Note: In contrast to the behavior at the group level, the effective weight of the assets in a zoomed portfolio are scaled to sum to 100%, because you are viewing the risk of a group relative to the *group*.

Marginal Contribution to Common Factor Risk (MC to Common Factor Risk)

Definition

This figure tells the user exactly how much common factor risk (*i.e.,* the risk "explained" by the model) would increase or decrease if there were a 1% change in asset *i*'s portfolio weight (offset by an equal 1% change in cash).

$$\left(X_i^T F X_{mgd}\right)\left(\frac{1}{\sigma_{CF,mgd}}\right)$$

where:

X_i = asset *i*'s common factor exposures

X_{mgd} = the managed portfolio's common factor exposures

F = the variance-covariance matrix

$\sigma_{CF,mgd}$ = the common factor risk of the managed portfolio

Aggregation

Custom: Effective Weighted Sum at portfolio and zoomed level; Effective Weighted Average at group level (refer to "Marginal Contribution to Total Risk (MC to Total Risk)" on page 74 for an example)

Marginal Contribution to Industry Risk (MC to Industry Risk)

Definition

This figure tells the user how much the total industry risk of the portfolio would increase or decrease with a one-percent increase in asset *i* while offsetting an equal amount in cash. Essentially, it is the partial derivative of industry risk with respect to asset weights. This figure is constructed by taking the covariance of a factor portfolio and the managed portfolio, and dividing this value by industry risk. It is similar in concept to a beta/sensitivity measure.

Calculating this figure requires the following:

- The managed portfolio's industry exposures
- Asset *i*'s industry factor exposures
- The variance-covariance matrix
- The total risk of the managed portfolio

Aggregation

Custom: Effective Weighted Sum at portfolio and zoomed level; Effective Weighted Average at group level (refer to "Marginal Contribution to Total Risk (MC to Total Risk)" on page 74 for an example)

Marginal Contribution to Selection Risk (MC to Selection Risk)

Definition

This measures the sensitivity of selection risk (also known as specific risk) to a marginal change in an asset's holding in the portfolio. Its calculation requires the portfolio's selection risk, the individual asset's selection variance, and the weight of the asset in the portfolio.

$$\text{MC to Selection Risk} = \left(\frac{1}{\sigma_{mgd,sp}}\right)\left(\sigma_{i,sp}^{2}\right)\left(w_i\right)$$

Aggregation

Custom: Effective Weighted Sum at portfolio and zoomed level; Effective Weighted Average at group level (refer to "Marginal Contribution to Total Risk (MC to Total Risk)" on page 74 for an example).

Marginal Contribution to Active Total Risk (MC to Active Total Risk)

Definition

This figure measures the effect of a small (1%) increase in exposure to a position, group, or common factor on the active total risk, or total tracking error, of a portfolio. This type of sensitivity analysis allows one to see which assets or common factors would have the largest impact on the active total risk of the portfolio, on the margin. For example, an asset's Marginal Contribution to Active Total Risk is approximately the increase in predicted active total risk (the amount that would be added to total tracking error) that would result if you increased the asset's weight by one percent of portfolio value and decreased cash by one percent to keep the portfolio value constant. For an industry, the Marginal Contribution to Active Total Risk is the active total risk change due to a 1% increase in the industry weight. A style factor's Marginal Contribution to Active Total Risk represents the change in active total risk that would result from an increase in the portfolio's exposure to the style by 0.01 standard deviations.

Asset *i*'s marginal contribution to active total risk is:

$$MCAR_i = \frac{\partial \sigma^A}{\partial w_i^A} \equiv \frac{1}{\sigma^A} \boldsymbol{\delta}_i^T \cdot \Sigma \cdot \boldsymbol{w}^A$$

Decomposing into common factor and selection components:

$$MCAR_i = \frac{1}{\sigma^A}\left(\boldsymbol{x}_i^T F \boldsymbol{x}^A + \boldsymbol{\delta}_i^T \boldsymbol{D} \boldsymbol{w}^A\right)$$

where:

$$\boldsymbol{x}^A = X^T \cdot \boldsymbol{w}^A = \text{ vector of active factor exposures}$$

See also: "Risk Decomposition Report" on page 11.

Portfolio Aggregation

As the Positions Report below illustrates, the Marginal Contribution to Active Total Risk for a portfolio is the sum of the products of Effective Active Weight and Marginal Contribution to Active Total Risk for the respective members of the portfolio:

Positions Report			**Calculations**
Asset ID	Eff Active Weight(%)	MC to Active Total Risk	Eff Active Weight(%) x MC to Active Total Risk
3	0.0000%	**0.0536**	
USCSCO	-1.3453%	0.0328	-0.0004
USDELL	10.2142%	0.4582	0.0468
USMSFT	-8.8689%	-0.0812	0.0072
			Sum of Products **0.0536**

Note: Effective Active Weight will not sum to zero at the portfolio level unless the Benchmark Asset Not Held attribute is selected for the Positions Report.

Group Aggregation

Aggregation at the group level is the sum of the products of the absolute value of Effective Active Weight and Marginal Contribution to Active Total Risk for the respective members of the group, divided by the sum of the absolute value of Effective Active Weight of the members of the group.

$$MCAR_g = \begin{cases} \sum_{i \in I^g} MCAR_i \cdot \dfrac{\left|w_i^A\right|}{\sum_{i \in I^g} \left|w_i^A\right|} & \text{if} \sum_{i \in I^g} \left|w_i^A\right| \neq 0 \\ 0 & \text{otherwise} \end{cases}$$

This is illustrated below for the Materials sector group:

Positions Report				Calculations	
Grouping: GICS Sector	Asset ID	Eff Active Weight(%)	MC to Active Total Risk	|Eff Active Weight(%)| x MC to Active Total Risk	|Eff Active Weight(%)|
by: distinct	80	0.0000%	0.0674		
. . .	. . .				
Materials	4	1.2627%	**-0.0371**		
	USA45V1	-0.8915%	-0.0359	-0.0320	0.8915
	USAE9C1	0.7404%	-0.0556	-0.0412	0.7404
	USAEBJ1	1.1728%	-0.0145	-0.0170	1.1728
	USAHE41	0.2410%	-0.0946	-0.0228	0.2410
. . .	. . .				
				Sum of Products -0.1130	
				Sum of |Eff Weight(%)|	3.0456
				Sum of Products ÷ Sum of |Eff Weight(%)|	**-0.0371**

▷ **Note:** At the group level, the effective active weight of the assets in the group will not sum to 0%, because you are viewing the active total risk of a group relative to the entire benchmark.

Zoomed Aggregation

If we zoom in on the group, we can see that the Marginal Contribution to Active Total Risk changes because the Active Total Risk is calculated as though the zoomed portfolio were a separate portfolio, altogether. That is, if we were to take the zoomed portfolio and make it its own, separate portfolio, then we would see the same results as displayed in the zoomed portfolio:

Positions Report				Calculations
Asset ID	Eff Active Weight(%)	MC to Active Total Risk	GICS Sector	Eff Active Weight(%) in group x MC to Active Total Risk of group
4	0.0000%	**0.4168**		
USA45V1	-100.0000%	-0.2449	Materials	0.2449
USAE9C1	34.3689%	0.2154	Materials	0.0740
USAEBJ1	54.4440%	0.1463	Materials	0.0797
USAHE41	11.1872%	0.1631	Materials	0.0182
				Sum of Products **0.4168**

- **Note:** In contrast to the behavior at the group level, the effective active weight of the assets in a zoomed portfolio are scaled to sum to 0%, because you are viewing the active total risk of a group relative to that *group* in the benchmark.

Marginal Contribution to Total Tracking Error (MC to Total Tracking Error)

Definition

This value represents the change in the active total risk of an asset's portfolio or group that would result from a one percent increase in the asset's effective position plus an equal short position in the benchmark. To calculate MCTE, the parent must have a benchmark assigned. The MCTE vector is the first partial derivative of active total risk with respect to the position effective weight vector.

$$\frac{\partial \sigma^A}{\partial w_i^P}$$

See also: "Risk Decomposition Report" on page 11.

Portfolio Aggregation

As the Positions Report below illustrates, the Marginal Contribution to Total Tracking Error for a portfolio is the sum of the products of Effective Active Weight and Marginal Contribution to Total Tracking Error for the respective members of the portfolio:

Positions Report			**Calculations**
Asset ID	Eff Active Weight(%)	MC to Total Tracking Error	Eff Active Weight(%) x MC to Total Tracking Error
3	0.0000%	**0.0536**	
USCSCO	-1.3453%	-0.0503	0.0007
USDELL	10.2142%	0.3752	0.0383
USMSFT	-8.8689%	-0.1642	0.0146
			Sum of Products **0.0536**

Note: Effective Active Weight will not sum to zero at the portfolio level unless the Benchmark Asset Not Held attribute is selected for the Positions Report.

Group Aggregation

Aggregation at the group level is the sum of the products of the absolute value of Effective Active Weight and Marginal Contribution to Total Tracking Error for the respective members of the group, divided by the sum of the absolute value of Effective Active Weight of the members of the group, as shown below for the Materials sector group:

Positions Report				**Calculations**	
Grouping: GICS Sector	Asset ID	Eff Active Weight(%)	MC to Total Tracking Error	|Eff Active Weight(%)| x MC to Total Tracking Error	|Eff Active Weight(%)|
by: distinct	80	0.0000%	0.0674		
. . .	. . .				
Materials	4	1.2627%	**-0.0327**		
	USA45V1	-0.8915%	-0.0316	-0.0282	0.8915
	USAE9C1	0.7404%	-0.0512	-0.0379	0.7404
	USAEBJ1	1.1728%	-0.0101	-0.0118	1.1728
	USAHE41	0.2410%	-0.0903	-0.0218	0.2410
. . .	. . .				
				Sum of Products -0.0997	
				Sum of |Eff Weight(%)|	3.0456
				Sum of Products ÷ Sum of |Eff Weight(%)|	**-0.0327**

▷ **Note:** At the group level, the effective active weight of the assets in the group will not sum to 0%, because you are viewing the total tracking error of a group relative to the entire benchmark.

Zoomed Aggregation

If we zoom in on the group, we can see that the Marginal Contribution to Total Tracking Error changes because the Active Total Risk is calculated as though the zoomed portfolio were a separate portfolio, altogether. That is, if we were to take the zoomed portfolio and make it its own, separate portfolio, then we would see the same results as displayed in the zoomed portfolio:

Positions Report				**Calculations**
Asset ID	Eff Active Weight(%)	MC to Total Tracking Error	GICS Sector	Eff Active Weight(%) in group x MC to Total Tracking Error of group
4	0.0000%	**0.4168**		
USA45V1	-100.0000%	0.000	Materials	0.0
USAE9C1	34.3688%	0.4603	Materials	0.1582
USAEBJ1	54.4440%	0.3912	Materials	0.2130
USAHE41	11.1872%	0.4080	Materials	0.0456
				Sum of Products **0.4168**

Note: In contrast to the behavior at the group level, the effective active weight of the assets in a zoomed portfolio are scaled to sum to 0%, because you are viewing the total tracking error of a group relative to that *group* in the benchmark.

Marginal Contribution to Active Market Timing Risk (MC to Active Market Timing Risk)

Definition

This figure tells the user how much the active market timing risk of the portfolio would increase or decrease with a one-percent increase in asset *i* while offsetting an equal amount in cash. It is defined at the asset level as the market timing risk (in decimals) of asset *i*.

$$|\beta_i| \bullet \sigma_M = \text{Mkt\_Timing\_Risk}_i \ \text{(decimals)}$$

Note: The beta and market risk used in this calculation omit currency exposure (*i.e.,* all currency factor exposures are set to 0 for both the covariance and variance calculations). Also note that while beta can be negative, risk cannot, so we take the absolute value of beta.

Portfolio Aggregation

Essentially, it is the partial derivative of active market timing risk (decimals) with respect to asset effective weights.

$$\sum_i \left(\text{MC\_Active\_Mkt\_Timing\_Risk}_i \bullet w_{i,\text{effective active}} \right)$$

Percent Contribution to Risk (%CR)

Percent contribution to the specified risk (total risk, spread risk, *etc.*) is the percent of risk that an individual asset or risk source contributes. For example, a %CR to Spread Risk of 10% indicates that 10% of the portfolio's spread risk is arising from the portfolio's position in that particular asset.

Percent Contribution to Total Risk (%CR to Total Risk)

Definition

The percent of total risk that an individual asset or risk source contributes. For example, a %CR to Total Risk of 10% indicates that 10% of the portfolio's total risk is arising from the portfolio's position in that particular asset.

$$\frac{\text{MC to Total Risk} \times \text{Effective Weight}}{\text{Total Risk}}$$

Portfolio Aggregation

As the Positions Report below illustrates, the %CR to Total Risk for a portfolio is the sum of the %CR to Total Risk for the respective members of the portfolio:

Positions Report	
Asset ID	%CR to Total Risk
3	**100.000%**
USCSCO	29.495%
USDELL	44.341%
USMSFT	26.164%
Sum	**100.000**

Group Aggregation

Aggregation at the group level is the sum of %CR to Total Risk for the respective members of the group. This is illustrated below for the Materials sector group of a portfolio:

Positions Report		
Grouping: GICS Sector	Asset ID	%CR to Total Risk
by: distinct	80	100.000%
. . .	. . .	
Materials	4	**2.762%**
	USA45V1	0.000%
	USAE9C1	1.034%
	USAEBJ1	1.354%
	USAHE41	0.374%
. . .	. . .	
	Sum	**2.762%**

⊳ **Note:** At the group level, the %CR of the assets in the group will not sum to 100%, because you are viewing the risk of a group relative to the entire portfolio.

Zoomed Aggregation

If we zoom in on the group, we can see that the %CR to Total Risk changes because Total Risk is calculated as though the zoomed portfolio were a separate portfolio, altogether. That is, if we were to take the zoomed portfolio and make it its own, separate portfolio, then we would see the same results as displayed in the zoomed portfolio:

Positions Report		
Asset ID	%CR to Total Risk	GICS Sector
4	**100.000%**	
USA45V1	0.000%	Materials
USAE9C1	39.785%	Materials
USAEBJ1	48.118%	Materials
USAHE41	12.097%	Materials
Sum	**100.000%**	

⊳ **Note:** In contrast to the behavior at the group level, the %CR of the assets in a zoomed portfolio are scaled to sum to 100%, because you are viewing the risk of a group relative to the *group*.

Percent Contribution to Active Total Risk (%CR to Active Total Risk)

Definition

Percent contribution to active total risk (or tracking error). The percent of active total risk that an individual asset or risk source contributes. For example, a %CR to Active Total Risk of 10% indicates that 10% of the portfolio's active total risk is arising from the active position in that particular asset.

$$\frac{\text{MC to Active Total Risk} \times \text{Effective Active Weight}}{\text{Active Total Risk}}$$

If all risk sources defined by the benchmark are present in the portfolio, then %CR to Active Total Risk will total to 100%.

Aggregation

Sum

Percent Contribution to Total Tracking Error (%CR to Total Tracking Error)

Definition

The percent of total tracking error that an individual asset or risk source contributes. For example, a %CR to Total Tracking Error of 10% indicates that 10% of the portfolio's total tracking error is arising from the active position in that particular asset.

$$\frac{\text{MC to Total Tracking Error} \times \text{Effective Active Weight}}{\text{Active Total Risk}}$$

Portfolio Aggregation

As the Positions Report below illustrates, the %CR to Total Tracking Error for a portfolio is the sum of the %CR to Total Tracking Error for the respective members of the portfolio:

Positions Report	
Asset ID	%CR to Total Tracking Error
3	**100.000%**
USCSCO	1.263%
USDELL	71.546%
USMSFT	27.191%
Sum	**100.000**

Group Aggregation

Aggregation at the group level is the sum of %CR to Total Tracking Error for the respective members of the group. This is illustrated below for the Materials sector group of a portfolio:

Positions Report		
Grouping: GICS Sector	Asset ID	%CR to Total Tracking Error
by: distinct	80	100.000%
. . .	. . .	
Materials	4	**-0.643%**
	USA45V1	0.418%
	USAE9C1	-0.562%
	USAEBJ1	-0.175%
	USAHE41	-0.323%
. . .	. . .	
	Sum	**-0.643%**

▷ **Note:** At the group level, the %CR of the assets in the group will not sum to 100%, because you are viewing the risk of a group relative to the entire portfolio.

Zoomed Aggregation

If we zoom in on the group, we can see that the %CR to Total Tracking Error changes because Total Risk is calculated as though the zoomed portfolio were a separate portfolio, altogether. That is, if we were to take the zoomed portfolio and make it its own, separate portfolio, then we would see the same results as displayed in the zoomed portfolio:

Positions Report		
Asset ID	%CR to Total Tracking Error	GICS Sector
4	**100.000%**	
USA45V1	0.000%	Materials
USAE9C1	37.951%	Materials
USAEBJ1	51.098%	Materials
USAHE41	10.951%	Materials
Sum	**100.000%**	

▷ **Note:** In contrast to the behavior at the group level, the %CR of the assets in a zoomed portfolio are scaled to sum to 100%, because you are viewing the risk of a group relative to the *group*.

Risk Model: Active Risk

This section describes selected Risk Model columns related to Active Risk that are available in a Positions Report.

Whenever the term "active" is used to modify an attribute (*e.g.,* "Active Duration to Worst"), it refers to the portion of the portfolio that differs from its benchmark, and is therefore attributable to assets held and assets not held (benchmark assets) in the portfolio. For example, if a portfolio's return is 5%, and the benchmark's return is 3%, then the portfolio's active return is 2%. A portfolio's active total risk is the risk that associated with the volatility of active returns. Active weight is the portfolio's weight in an asset minus the benchmark's weight in the same asset. Active exposure is the portfolio's exposure to a factor minus the benchmark's exposure to that same factor.

The columns described in this section include the following:

- Active Beta
- Active Diversification
- Active Implied Alpha
- Active Total Risk
- Active Value-at-Risk (%)

Active Beta

The market beta of the portfolio minus the market beta of the benchmark portfolio.

At the asset level, active beta = *Beta (Mkt)* of the asset – *Beta (Mkt)* of the benchmark. For assets with 0 market value, active beta = *Beta (Mkt)* of the asset.

At the portfolio or group level, active beta = *Beta (Mkt)* of the portfolio or group – *Beta (Mkt)* of the benchmark.

See also: "Beta (Market) (Beta (Mkt))" on page 95.

Active Diversification

In BarraOne, the Active Diversification attribute shows the diversifying effect of covariance on active portfolio risk. For example, an active diversification figure of 60% means that you are diversifying away 60% of active portfolio risk. A higher number thus indicates greater diversification arising from covariance. This can also be thought of as the impact of the covariance calculation in standard deviation space, where 0 = no diversification and 100 = the maximum possible diversification.

$$1-\frac{\sigma_P^A}{\sum_i \left| w_{i_{eff}}^A \sigma_i^A \right|}$$

where:

σ_P^A = portfolio active total risk

$w_{i_{eff}}^A$ = asset i effective active weight

σ_i^A = asset i active total risk

Active Implied Alpha

Expected excess returns implied by the portfolio active holdings, assuming the active portfolio lies on the efficient frontier. Active implied alpha is computed using MCAR at the asset level and active risk at the portfolio level.

$$IA_i = 2\lambda\sigma_a MCAR_i$$

where:

IA_i = active implied alpha

λ = risk aversion parameter

σ_a = active risk

$MCAR_i$ = marginal contribution of asset i to active risk

BarraOne uses a default risk aversion parameter of 0.0075, which is based upon total returns and total risks from the relationship:

$$\lambda = \frac{E[r_P]}{2\sigma_P^2}$$

assuming a long-run beta of 1, and that for a typical benchmark portfolio $E[r_P]$=6; σ_P=20.

▷ **Note:** The risk aversion parameter should be set by the user in accordance with whether the analysis is in total space or active space.

See also: "Implied Alpha" on page 96.

Active Total Risk

The expected standard deviation of the differential return between the portfolio and the benchmark. Active total risk arises from active management, and it is the result of active weights (deviations from the benchmark at the asset level) and therefore active exposures; for passively managed portfolios, it is referred to as "total tracking error."

See also: "Total Risk" on page 67.

Active Value-at-Risk (%)

The parametric active value-at-risk.

Risk Model: Active Risk: Factor Group Drilldown

Factor group drilldown in the Positions Report is facilitated by Active Contribution, Active Correlation, and Active MCTE columns for the Commodity, Emerging Market, Hedge Fund, Industry, Private Real Estate, Spread, Style, Term Structure, and VIX factor groups.

The Factor Group G Active Risk is given by:

$$\text{Factor Group } G \text{ Active Risk} = \sqrt{\left(X_G^n - X_{BG}\right) F (X_G^n - X_{BG})'}$$

where:

X_G^n = the vector of security factor exposures to group G that has exposure zero to all factors not in group G

X_{BG} = the vector of benchmark factor exposures to group G that has exposure zero to all factors not in group G

The Factor Group G Active Correlation is given by:

$$\text{Factor Group } G \text{ Active Correlation} = \frac{\begin{pmatrix} Factor \\ Group\,G \\ MCTE \end{pmatrix}}{\begin{pmatrix} Factor \\ Group\,G \\ Active\ Risk \end{pmatrix}}$$

The Factor Group G MCTE is given by:

$$\text{Factor Group } G \text{ MCTE} = \frac{(X_G^n - X_{BG})FX_A'}{\sigma_A}$$

where:

X_A = the vector of active portfolio factor exposures

σ_A = the total risk of the active portfolio

The Factor Group G Active Risk Contribution is given by:

$$\text{Factor Group } G \text{ Active Risk Contribution} = \begin{pmatrix} \textit{Eff Active} \\ \textit{Weight } (\%) \end{pmatrix} \times \begin{pmatrix} \textit{Factor} \\ \textit{Group } G \\ \textit{MCTE} \end{pmatrix}$$

Risk Model: Portfolio Risk

This section describes miscellaneous selected columns available in a Positions Report under Risk Model: Portfolio Risk. These include the following:

- Below Target Probability
- Below Target Probability Ex-Position
- Beta
- Beta (Benchmark) (Beta (Bmk))
- Beta (Market) (Beta (Mkt))
- Diversification
- Implied Alpha
- Liquidation Value-at-Risk
- Value-at-Risk
- Bmk Value-at-Risk (%)

Below Target Probability

The percent chance that a portfolio, asset, or group of assets will lose a specified percent of its value over a specified time horizon. The user-specified percent of value is known as the “loss target.” For the time horizon, BarraOne uses the value specified for value-at-risk.

BarraOne calculates this probability as the mean-zero normal cumulative distribution with respect to the loss target, time horizon, and total risk of the asset, portfolio, or group:

$$\int_{-\infty}^{x} \frac{1}{\sqrt{2\pi\sigma}} e^{-\left(\frac{(x)^2}{2\sigma^2}\right)} dx$$

For instance, if your time horizon is 100 days (out of 252 business days per year), and the total risk of the asset, portfolio, or group is 33.97, and your loss target is 5%, then x = 5, and the standard deviation σ is:

$$33.97\sqrt{\frac{100}{252}} \times \frac{1}{100}$$

or 0.214, in the mean-zero normal cumulative distribution calculation.

If you would like to use Microsoft Excel to replicate the BarraOne value for Below Target Probability, you can create a formula similar to the following:

```
=NORMDIST(–$K$1,0,F5*SQRT($K$2/252)/100,TRUE)
```

where:

- `$K$1` is the number of the cell containing the loss target value (*e.g.,* 0.05, or 5%)
- `$K$2` is the number of the cell containing the time horizon, expressed in number of business days (*e.g.,* 100)
- `F5` is the number of the cell containing the Total Risk of the position, group, or portfolio (*e.g.,* 33.97)

Below Target Probability Ex-Position

The percent chance that a portfolio will lose a specified percent of its value over a specified time horizon if a particular asset or group of assets were replaced with cash. In other words, calculate the below target probability for a portfolio with the asset or group; then calculate the below target probability for the portfolio, but in which the asset or group has been substituted with an equal value of cash. The difference between the two results is the below target probability ex-position for the asset or group.

Beta

The systematic risk coefficient that expresses the expected response of asset or portfolio excess return to excess return on a market portfolio.

In other words, beta is a measure of the sensitivity of an asset to movements in the market or other benchmark; thus, a measure of its non-diversifiable or systematic risk. A beta of one (1) indicates that, on average, the asset is expected to move in tandem with the market or benchmark.

For equities, the beta is a statistical estimate of the average change in rate of return that corresponds to a 1% change in the market; it is the regression coefficient of a security return upon the market return.

For fixed-income securities, the beta measure takes into account both the local market and currency risk of the security. Most bonds have betas between 0 and 2 (a beta of 1.0 represents responsiveness equal to that of the market portfolio), but the range includes values of less than 0 and greater than 5.

$$\frac{w_{P,eff}^{T}\left(XFX^{T}+D\right)w_{M,eff}}{\sigma_{\mathrm{M}}^{2}}$$

where:

$w_{P,eff}$ = managed portfolio or asset effective weight vector

$w_{M,eff}$ = market or benchmark effective weight vector

X = common factor exposure of assets

F = covariance matrix of common factors

D = specific covariance matrix of assets

σ_{M}^{2} = variance of market or benchmark

Also see "Market Timing Risk (Mkt Timing Risk)" on page 71, which does not include currency risk in its calculation.

▷ **Note:** Beta is zero if the market value of the group or portfolio is zero, (*e.g.*, a group containing only futures).

Beta (Benchmark) (Beta (Bmk))

The beta of an asset, portfolio, or group with respect to a specified benchmark portfolio.

At the portfolio level:

$$\sum\left(\beta_i \cdot w_{i,eff,P}\right)$$

where:

β_i = beta of asset i to benchmark

$w_{i,eff,P}$ = effective weight of asset i in portfolio P

At the group level:

$$\sum\left(\beta_i \cdot w_{i,eff,G}\right) = \frac{\sum\left(\beta_i \cdot w_{i,eff,P}\right)}{\sum\left(w_{i,P}\right)}$$

where:

β_i = beta of asset i to benchmark

$w_{i,eff,G}$ = effective weight of asset i in group G

$w_{i,eff,P}$ = effective weight of asset i in portfolio P

$w_{i,P}$ = weight of asset i in portfolio P

- **Note:** Beta is zero if the market value of the group or portfolio is zero, (*e.g.,* a group containing only futures).

Beta (Market) (Beta (Mkt))

The beta of an asset, portfolio, or group with respect to a specified market portfolio.

At the portfolio level:

$$\sum\left(\beta_i \cdot w_{i,eff,P}\right)$$

where:

β_i = beta of asset i to market

$w_{i,eff,P}$ = effective weight of asset i in portfolio P

At the group level:

$$\sum\left(\beta_i \cdot w_{i,eff,G}\right) = \frac{\sum\left(\beta_i \cdot w_{i,eff,P}\right)}{\sum\left(w_{i,P}\right)}$$

where:

β_i = beta of asset i to market

$w_{i,eff,G}$ = effective weight of asset i in group G

$w_{i,eff,P}$ = effective weight of asset i in portfolio P

$w_{i,P}$ = weight of asset i in portfolio P

- **Note:** Beta is zero if the market value of the group or portfolio is zero, (*e.g.,* a group containing only futures).

Diversification

In BarraOne, the Diversification attribute shows the diversifying effect of covariance on portfolio risk. For example, a diversification figure of 60% means that you are diversifying away 60% of portfolio risk. A higher number thus indicates greater diversification arising from covariance. This can also be thought of as the impact of the covariance calculation in standard deviation space, where 0=no diversification and 100=the maximum possible diversification.

$$1-\frac{\sigma_P}{\sum_i \left| w_{i_{eff}} \sigma_i \right|}$$

where:

σ_P = portfolio total risk

$w_{i_{eff}}$ = asset i effective weight

σ_i = asset i total risk

Implied Alpha

The expected return implied by the current portfolio holdings, assuming the portfolio is optimal. (In other words, if you were to optimize the portfolio, supplying the implied alphas as expected returns to the optimizer with the current portfolio as the initial portfolio, the optimizer could make no improvement.)

In fact, implied alpha is a scaled version of the long-term market risk premium return (6.00%), or a scaled version of risk aversion. It is scaled by taking into account the degree of risk aversion specified by the investor. To calculate implied alpha, the risk aversion parameter, the marginal contribution to risk, and the total risk of the managed portfolio are required.

$$\begin{aligned}
\text{Implied Alpha} &= 2 \cdot \lambda \cdot \sigma_{mgd} \cdot \text{MC-Risk} \\
&= 2 \cdot \left(\frac{R_{mkt,\,\text{Long}}}{2 \cdot \sigma^2_{mkt,\,\text{Long}}} \right) \cdot \sigma_{mgd} \cdot \left(\frac{\text{cov}(i, mgd)}{\sigma_{mgd}} \right) \\
&= \left(\frac{R_{mkt,\,\text{Long}}}{\sigma^2_{mkt,\,\text{Long}}} \right) \cdot \left(\text{cov}(i, mgd) \right) \\
&= R_{mkt,\,\text{Long}} \cdot \underbrace{\left(\frac{\text{cov}(i, mgd)}{\sigma^2_{mkt,\,\text{Long}}} \right)}_{\text{sensitivity measure}}
\end{aligned}$$

Implied alpha is useful as a check against your intuition, as it enables you to evaluate the assets in a portfolio and confirm that their relative weighting agrees with your expectations. For details, see Checking Portfolio Efficiency with Implied Alpha on the client support website.

Liquidation Value-at-Risk

The change in parametric value-at-risk for the overall portfolio from having a single asset or group of assets traded out for cash. In other words, calculate the parametric VaR for a portfolio with the asset or group; then calculate the parametric VaR for the portfolio without the asset or group. The difference between the two results is the liquidation VaR for the asset or group.

Value-at-Risk

Parametric value-at-risk. A measure that characterizes the potential loss—either in currency units ($) or percent of value (%)—in a given period for a given probability (confidence level). For example, a Value-at-Risk of $1,000,000 at the 95% confidence level over one year indicates there is a 95% probability one would not lose more than $1,000,000 in the coming year.

The calculation of parametric value-at-risk (percent) can be replicated in an Excel worksheet using the following formula:

$$\frac{\sigma}{100} \bullet \sqrt{\frac{h}{252}} \bullet Z$$

where:

σ = total risk of the asset, group, or portfolio

h = holding period in business days

Z = return of the NORMSINV(C) function in Microsoft Excel, where C is the confidence level, *e.g.*, 0.95

Multiply the result above by effective market value to calculate parametric value-at-risk in terms of currency units.

Bmk Value-at-Risk (%)

The parametric value-at-risk for the benchmark.

Risk Model: Portfolio Risk: Factor Group Drilldown

Factor group drilldown in the Positions Report is facilitated by Contribution, Correlation, and MCTR columns for the Commodity, Emerging Market, Hedge Fund, Industry, Private Real Estate, Spread, Style, Term Structure, and VIX factor groups.

Overview

This section explains, using sample reports, how to drill into security-level risk contributions along factors. The samples were generated by exporting reports from BarraOne to Excel. The sample numerical values are all accurate and can be used to verify the implementation.

Consider a portfolio holding Ford with weight 75% and Sony with weight 25%. The forecast total risk for this portfolio dated August 1, 2011 is 40.1726%. The total risk is attributed to factor groups and selection risk in the Risk Decomposition Report:

Risk Source	Portfolio Risk	Portfolio Correlation	Portfolio Risk Contribution
Total Risk	40.17264	1.00000	40.17264
Local Market Risk	40.49885	0.99850	40.43821
Common Factor Risk	34.13095	0.83819	28.60838
Industry	21.83860	0.80294	17.53505
Style	14.52231	0.76250	11.07333
Selection Risk	21.79989	0.54266	11.82983
Currency Risk	2.23137	-0.11902	-0.26557

The objective is to drill from the additive Portfolio Risk Contributions in the highlighted column down to the security level. This drilldown can be implemented in the BarraOne Positions Report. Each column of the Positions Report below sums to the totals highlighted with yellow in the top row. These totals agree with the corresponding groups (Industry, Style, etc.) highlighted in the Risk Decomposition Report above.

The desired report has the following form:

Asset Name	Asset ID	Eff Weight (%)	Port Risk Contribution	Local Market Risk Contribution	Common Factor Risk Contribution	Industry Risk Contribution	Style Risk Contribution	Specific Risk Contribution	Currency Risk Contribution
	3	100%	40.1726%	40.4382%	28.6084%	17.5351%	11.0733%	11.8298%	-0.2656%
FORD	USAFK41	75%	35.7192%	35.7192%	24.5336%	15.0327%	9.5009%	11.1856%	0.0000%
SONY	JPNCDC1	25%	4.4534%	4.7190%	4.0748%	2.5024%	1.5724%	0.6442%	-0.2656%
RBS	UKIBBB1	0%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%

Factor Group Risk, Correlation, MCTR, Risk Contribution

For each factor group we provide columns for Risk, Correlation, MCTR (Marginal Contribution to Total Risk), and Risk Contribution. For instance, these columns for the Style group are as follows:

Asset Name	Asset ID	Eff Weight (%)	Style Risk	Style Correlation	Style MCTR	Style Risk Contribution
	3	100%	14.52%	0.7625	11.07%	11.0733%
FORD	USAFK41	75%	17.15%	0.7388	12.67%	9.5009%
SONY	JPNCDC1	25%	15.29%	0.4115	6.29%	1.5724%
RBS	UKIBBB1	0%	21.31%	0.3693	7.87%	0.0000%

The entries in the top row match the Portfolio columns of the corresponding factor group in the Risk Decomposition Report. Moreover, the total Style Risk Contribution (11.0733%) is the sum of the security-level risk contributions due to FORD (9.5009%), SONY (1.5724%), and RBS (0.0000%).

The Factor Group G Risk is given by:

$$\text{Factor Group } G \text{ Risk} = \sqrt{X_G^n F X_G'^n}$$

where:

X_G^n = the vector of security factor exposures to group G that has exposure zero to all factors not in group G

The Factor Group G Correlation is given by:

$$\text{Factor Group } G \text{ Correlation} = \frac{\begin{pmatrix} Factor \\ Group\,G \\ MCTR \end{pmatrix}}{\begin{pmatrix} Factor \\ Group\,G \\ Risk \end{pmatrix}}$$

The Factor Group G MCTR is given by:

$$\text{Factor Group } G \text{ MCTR} = \frac{X_G^n F X_P'}{\sigma_P}$$

where:

X_P = the vector of managed portfolio factor exposures

σ_P = the total risk of the managed portfolio

The Factor Group G Risk Contribution is given by:

$$\text{Factor Group } G \text{ Risk Contribution} = \begin{pmatrix} Eff \\ Weight\ (\%) \end{pmatrix} \times \begin{pmatrix} Factor \\ Group\,G \\ MCTR \end{pmatrix}$$

Valuation Data: Duration

Duration is the primary measure of risk for fixed income instruments, as it measures the sensitivity of these instruments to interest rate changes. This section defines and discusses the following measures of duration:

- Effective Duration
- Macaulay Duration
- Modified Duration
- Duration to Worst
- Dollar Duration
- Spread Dollar Duration
- DV01
- Key Rate Durations (KRD n-year)
- Spread Duration
- Active Effective Duration
- Active Macaulay Duration
- Active Modified Duration
- Active Duration To Worst
- Active Key Rate Durations (Active KRD n-year)
- Active Spread Duration
- Contribution to Effective Duration
- Contribution to Active Effective Duration
- Contribution to Spread Duration
- Contribution to Active Spread Duration

Effective Duration

Definition

Bond price elasticity with respect to a parallel shift of the discount curve. Based upon the semi-annually compounded spot rate term structure and calculated numerically (via ±25bp shock) for all fixed income securities.

At the position level, the effective duration is displayed for a holding of 1, regardless of the user's actual holdings. BarraOne does not take into account positive or negative holdings when calculating effective duration at the position level. However, at the portfolio level, BarraOne aggregates effective duration using effective weight, so a short position will have the opposite effect on the portfolio than a long position.

In basic terms, we calculate the current price with the bond price formula. In other words, given a yield y, and semi-annual cash flows C for N periods, we solve for price P in the following equation (where 2 is the frequency of payments per year):

$$P = \sum_{n=1}^{N} \frac{C_n}{\left(1 + \frac{y}{2}\right)^n}$$

Then, we change y in the equation by adding 25 basis points to calculate a second price. Finally, we subtract 25 basis points from the original value of y to calculate a third price. Effective duration for a cash bond is then calculated using the following formula:

Effective Duration for a Cash Bond

$$D = \frac{P_- - P_+}{2P_0\Delta}$$

Let us look at a simple bond example for purposes of illustration[1]:

- Valuation Date: 2/15/2009
- Maturity Date: 2/15/2012
- Par: 1000
- Coupon 5%
- Coupon Frequency: 1
- Yield to Maturity: 6%
- Price P_0: 973.2698805

If we shock the yield y by +25 basis points to 6.25% and use this figure in the price equation, the calculation would return a price P_+ of 966.7412986. If we shock the yield y by –25 basis points to 5.75% and use this figure in the price equation, the calculation would return a price $P\_$ of 979.8593198.

Inserting these figures into the effective duration calculation gives us the following:

$$\frac{979.8593198 - 966.7412986}{(2)(973.2698805)(0.25\%)} = 2.695659536$$

1 Actual computations are more involved, as they use semi-annual compounding, and they require daycount basis, actual number of days until cashflows, *etc.*

Effective duration is a measure of the price sensitivity of bonds, particularly useful for bonds with embedded options (*e.g.,* callable bonds, putable bonds, and mortgage-backed securities). It is calculated by using the interest rate model to calculate three values for the bond (with OAS held constant): the value given the current yield curve, and the values for both up and down shocks to that curve.

The interest rate model captures the effect of changes in option value as interest rates change; averaging the changes in value for the up and down shock provides a measure of the local price sensitivity of the bond to changes in interest rates.

- A portfolio containing bond futures contracts and interest rate derivatives also has an aggregate effective duration (change in portfolio value with respect to a change in interest rates).
- The effective duration for a Eurodollar Future is set to its term (*i.e.,* no calculation is performed).
- The effective duration for a cash position is set to 0.0027378 (or 1/365.25).
- Theoretically, effective duration for a swaption should be positive if the underlying swap has a long fixed leg. The notional effective duration is calculated from the effective duration by applying a multiplier of *Market Value / Notional*.

Effective Duration for Derivatives

For most instruments, the sum of their term structure exposures (KRDs or STBs) will equal their effective duration. Note that if the price is very small (*e.g.,* when an option is well out-of-the-money and close to the option expiration date), the term structure exposures will be very large. These exposures will be reflected in very large values for Total Risk and MCTR. However, because these exposures are aggregated by market value, their effect on portfolio term structure exposures will be of the correct magnitude.

Effective Duration for an Interest Rate Derivative

$$D = \frac{P_{-} - P_{+}}{2P\Delta}$$

where:

P = price of the derivative

Aggregation

The aggregate effective duration for a portfolio of cash bonds is the weighted average of the bond durations.

Effective Duration, Aggregate Portfolio of Cash Bonds

$$D_p = \sum_{i=1}^{n} \frac{V_i}{V_p} D_i$$

where:

D_p	=	portfolio aggregate effective duration
V_i	=	bond position value (*full clean price per bond · currency units per bond · holding*)
V_p	=	portfolio market value, or ΣV_i
D_i	=	bond effective duration

A portfolio containing bond futures contracts and interest rate derivatives also has an aggregate effective duration (change in portfolio value with respect to a change in interest rates).

Effective Duration, Aggregate Portfolio of All Securities

$$D_p = \sum_{i=1}^{n} \frac{V_i}{V_p} (\text{Dollar Duration per unit holding})$$

where:

V_i	=	market value of holdings
Dollar Duration per unit holding	=	• for derivatives: $-\frac{\partial p}{\partial r}$ numerical derivative where p is the price as a fraction of face value • for bond holdings: *Effective Duration · Market Value / 100*

Positions Report (Portfolio)				Calculations	
Asset ID	Effective Duration	Weight(%)	Eff Weight(%)	Effective Duration x Eff Weight(%)	Weight(%)
6	**9.4238**	17.3729%	24.8868%		
0033AT	7.9162	4.8157%	4.8157%	38.122%	4.8157%
0035HO	0.8070	3.3711%	3.3711%	2.721%	3.3711%
0035HP	13.4343	3.4884%	3.4884%	46.864%	3.4884%
00591R	5.5181	5.6977%	5.6977%	31.440%	5.6977%
TYM09	5.9319	0.0000%	7.5139%	44.572%	0.0000%
TUU09	1.6884	0.0000%	0.0000%	0.000%	0.0000%
				Sum of Products 163.719%	
				Sum of Weights	17.3729%
				Sum of Products ÷ Sum of Weights	**9.4238%**

Macaulay Duration

Definition

Macaulay duration is the percent present-value-weighted time to receive cashflows. It can be interpreted as the time at which one-half of the present value of the bond has been received, *i.e.,* the center of mass of the percent present value by time surface. (Displayed as "N/A" for certain instruments for which the value is not computed.)

Refer to our simple bond example on page 101. This bond has the following expected cash flows, discounted using a 6% yield to maturity:

Years to Cash Flow	Cash Flow	Discounted Cash Flow	Years x Discounted Cash Flow
1	50	47.1698	47.1698
2	50	44.4999	88.9996
3	1050	881.6000	2644.8010
		Sum	2780.9704
		Sum ÷ Price	2.8573

Macaulay duration is computed by discounting time-weighted, deterministic, nominal cashflows using bond yield. It is computed and displayed by BarraOne at the asset and portfolio level for bonds (including MBS and CMOs). It is not valid for interest rate swaps. The portfolio weight of these derivative instruments is ignored when aggregating Macaulay duration.

The Macaulay duration of a callable bond that is in a call period and has an American-style exercise will be based upon the assumption that the bond can be called with 30 days notice.

Aggregation

Custom weighted average. See "Effective Duration" on page 100.

Modified Duration

Definition

Bond price elasticity with respect to yield. It is calculated as *Macaulay Duration* $\div$ *(1 + y/2)*, where *y* is bond yield, and *2* is the effective semi-annual coupon frequency.

Taking the Macaulay duration calculated on page 104, we can calculate modified duration as follows:

$$\frac{2.8573}{1+0.06/2}=\frac{2.8573}{1.03}=2.7741$$

Note that all yield numbers in BarraOne are stated in terms based upon continuously compounded semiannual coupons, regardless of the actual coupon frequency, in order to facilitate portfolio duration calculations. The percent change in bond price due to an *x* basis point increase in yield is given by – *(Modified Duration)* $\cdot$ *x* $\cdot$ *0.0001*. This is a local approximation for non-optionable bonds derived from a Taylor series expansion. Computed and displayed by BarraOne at the asset and portfolio level for bonds (including MBS).

Not valid for interest rate swaps. The portfolio weight of these instruments is ignored when aggregating modified duration. (Displayed as "N/A" for certain instruments for which the value is not computed.)

Aggregation

Custom weighted average. See "Effective Duration" on page 100.

Duration to Worst

Definition

The percent present-value-weighted time to receive all cashflows, using the lower of yield to maturity or yield to worst.

See also: "Macaulay Duration" on page 104.

Aggregation

Custom weighted average. Refer to "Effective Duration" on page 100.

Dollar Duration

Definition

Measures the dollar change in bond price for a 100 basis point change in yield. Calculated and displayed in BarraOne at the asset (position) and portfolio level for bonds (including MBS) and IR derivatives.

Local currency dollar duration per unit holding:

Effective Duration · Dirty Price /100 · Market Value · 0.01

For example, if effective duration is 0.363, price in percent of par is 91.76, and face value is 1000, then dollar duration per unit holding is 0.363 · 91.76 / 100 · 1000 · 0.01= $3.33.

Numeraire dollar duration of position:

Dollar duration per unit holding · Actual holding · Numeraire / Local FX rate

Note: This is position dollar duration expressed in numeraire currency units.

Aggregation

Sum

Spread Dollar Duration

A Spread Dollar Duration column has been added as a Valuation Data attribute to aggregate total spread exposure for fixed income assets.

Definition

Spread Dollar Duration measures the dollar change in bond price for a 100 basis point change in discounting spread (OAS). Calculated and displayed in BarraOne at the asset (position) and portfolio level for bonds (including MBS) and IR derivatives.

Local currency spread dollar duration per unit holding:

Spread Duration · Dirty Price / 100 · Market Value · 0.01

For example, if spread duration is 0.363, price in percent of par is 91.76, and face value is 1000, then spread dollar duration per unit holding is 0.363 · 91.76 / 100 · 1000 · 0.01 $3.33.

Numeraire spread dollar duration of position:

Spread dollar duration per unit holding · Actual holding · Numeraire / Local FX rate

Note: This is position spread dollar duration expressed in numeraire currency units.

Aggregation

Sum

DV01

Definition

Dollar value of an "01." Same as basis point value, or the dollar change in bond position value per a 1 basis point decrease in yield.

Dollar Duration/ 100

Aggregation

Sum

Key Rate Durations (KRD *n*-year)

Definition

The *n*-year key rate duration (KRD) is the sensitivity of a bond (or bond portfolio) to changes in the *n*-year rate. KRDs are expressed as the change in asset value for a 100-basis point shock of the relevant rate, although calculated by applying a 25bp shock to the rate.

Aggregation

Custom weighted average. See "Effective Duration" on page 100.

Spread Duration

Definition

Spread duration measures spread risk, or the sensitivity of a security's price to changes in its option adjusted spread (OAS), which is calculated off the Treasury curve. BarraOne calculates spread duration as bond price elasticity with respect to a shift of the spread as reflected in the discount factors. It is calculated numerically (via a ±25bp shock) for all fixed income securities. Its value will differ from effective duration only for securities with terms and conditions (*e.g.,* coupon) that depend upon the spot rates (*i.e.,* that have a floating index), such as a CMO, MBS, FRN, and VRN.

Spread duration is similar to effective duration except for the derivative used in the definition. Spread duration leaves the spot curve (and term structure-dependent terms and conditions) fixed, whereas effective duration varies the spot curve (and term structure-dependent terms and conditions) by a parallel shift.

$$D_s = -\frac{1}{P_0}\frac{\partial V(r(\tau), s)}{\partial s}$$

where:

$\frac{\partial V}{\partial s}$ = the partial derivative

of the valuation function V

with respect to the calibration constant s

Aggregation

Effective Market Value Weighted Average

- For regular portfolios, it is the sum product of asset Spread Duration and Eff Weight (%) ÷ the sum of asset Weight (%).
- For Assigned Value portfolios, it is the sum product of asset Spread Duration and Eff Weight (%) ÷ the sum of asset Weight(%) × portfolio Market Value ÷ portfolio Assigned Value.
- For Groups, it is the sum product of group asset Spread Duration and Eff Weight (%) ÷ the sum of group asset Weight (%).

Active Effective Duration

Definition

The difference between the asset effective duration and the aggregate effective duration of the benchmark.

$$\alpha_{active} = \alpha_i - \alpha_{bmk}$$

where:

α_i = asset-level duration

$\alpha_{bmk} = \sum_{i \in bmk} w_{i,bmk} \alpha_{i,bmk}$

$w_{i,bmk}$ = weight of asset in benchmark

$\alpha_{i,bmk}$ = effective duration of asset in benchmark

See also: "Effective Duration" on page 100.

Aggregation

Custom, defined by:

$$\alpha_{active} = \frac{\sum_{i \in group} \alpha_{i,P} w_{i,eff,P}}{\sum_{i \in group} w_{i,P}} - \frac{\sum_{i \in group} \alpha_{i,bmk} w_{i,eff,bmk}}{\sum_{i \in group} w_{i,bmk}}$$

where:

$\alpha_{i,P}$ = effective duration of asset i in portfolio

$\alpha_{i,bmk}$ = effective duration of asset i in benchmark

$w_{i,P}$ = weight of asset i in portfolio

$w_{i,eff,P}$ = effective weight of asset i in portfolio

$w_{i,bmk}$ = weight of asset i in benchmark

$w_{i,eff,bmk}$ = effective weight of asset i in benchmark

Active Macaulay Duration

Definition

The difference between the Macaulay duration of an instrument and the aggregate Macaulay duration of the benchmark.

See also: "Active Effective Duration" on page 108 and "Macaulay Duration" on page 104.

Aggregation

Custom; see "Active Effective Duration" on page 108

Active Modified Duration

Definition

The difference between the modified duration of an instrument and the aggregate modified duration of the benchmark.

See also: "Active Effective Duration" on page 108 and "Modified Duration" on page 105.

Aggregation

Custom; see "Active Effective Duration" on page 108

Active Duration To Worst

Definition

The difference between the duration to worst of an asset and the aggregate duration to worst of the benchmark.

See also: "Active Effective Duration" on page 108 and "Duration to Worst" on page 105.

Aggregation

Custom; see "Active Effective Duration" on page 108

Active Key Rate Durations (Active KRD *n*-year)

Definition

The difference between the asset KRD and the aggregate KRD exposure for the benchmark.

See also: "Active Effective Duration" on page 108 and "Key Rate Durations (KRD n-year)" on page 107.

Aggregation

Custom; see "Active Effective Duration" on page 108

Active Spread Duration

Definition

The spread duration of the asset in the managed portfolio – the spread duration of the asset in the benchmark portfolio.

Aggregation

At the portfolio level, it is the spread duration of the managed portfolio – the spread duration of the benchmark portfolio. At the group level, it is the spread duration of the group in the managed portfolio – the spread duration of the group in the benchmark portfolio.

Contribution to Effective Duration

Definition

Contribution to duration shows an asset's contribution to the aggregate group or portfolio duration and is defined as:

$$CtrDur_{i,P} = w_{i,eff,P} \cdot D_{i,P}$$

where:

$w_{i,eff} =$ effective weight of the i^{th} asset in the portfolio

$D_{i,P} =$ duration of the i^{th} asset in the portfolio

Contribution to Duration of a Group

For a group of assets, the contribution to duration is the sum of asset contributions to duration:

$$\begin{aligned} CtrDur_{group} &= \sum_{i \in group} CtrDur_P \\ &= \sum_{i \in group} w_{i,eff,P} \cdot D_{i,P} \end{aligned}$$

Aggregation

Sum

Contribution to Active Effective Duration

Definition

At the individual security level, contribution to active duration measures an asset's impact on active duration. Effectively, it is the duration of the instrument multiplied by the active weight of the asset, but note that active weight is not an input to the formula. Also note that the duration for the asset is the same, whether the asset is in the portfolio or the benchmark.

$$CtrDur_{i,P} = w_{i,eff,P} \cdot D_{i,P} - w_{i,eff,bmk} \cdot D_{i,bmk}$$

For grouped assets (*e.g.,* a sector or rating group), the Contribution to Active Effective Duration for a group is the contribution to duration of the group in a managed portfolio minus the contribution to duration of the group in the benchmark.

$$CtrDur_{active} = \sum_{i \in group} w_{i,eff,P} \cdot D_{i,P} - \sum_{i \in group} w_{i,eff,bmk} \cdot D_{i,bmk}$$

Aggregation

Custom, given by the definition of Contribution to Active Effective Duration for a group provided above

Contribution to Spread Duration

Definition

Spread Duration × Eff Weight (%).

Aggregation

Sum

Contribution to Active Spread Duration

Definition

Spread Duration × Eff Active Weight (%).

Aggregation

Custom

Valuation Data: Yield

This section describes the following ways of looking at the yield of an asset:

- Current Yield (%)
- Yield To Best (%)
- Yield to Maturity (%)
- Yield to Next (%)
- Yield to Worst (%)

Current Yield (%)

Definition

The ratio of the annual coupon rate to the clean price of the bond, or *Coupon / Price*. For example, an 8% coupon bond trading at 91% of par has a current yield of 8/91, or 8.79%. (Displayed as "N/A" for certain instruments for which the value is not computed.)

Aggregation

Weighted Average

Positions Report (Portfolio)			Calculations	
Asset ID	Eff. Weight(%)	Current Yield(%)	Eff. Weight(%) x Current Yield(%)	Eff. Weight(%)
6	24.8868%	**4.3750%**		
0033AT	4.8157%	8.6240%	41.5307%	4.8157%
0035HO	3.3711%	0.0000%	0.0000%	3.3711%
0035HP	3.4884%	0.0000%	0.0000%	3.4884%
00591R	5.6977%	6.0508%	34.4757%	5.6977%
TYM09	0.0000%	0.0000%	0.0000%	0.000%
TUU09	0.0000%	0.0000%	0.0000%	0.0000%
			Sum of Products 76.0064%	
			Sum of Eff. Weights	17.3729%
			Sum of Products ÷ Sum of Eff. Weights	**4.3750%**

Note: Only assets with a valid current yield value are considered in the aggregation calculation.

Yield To Best (%)

Definition

Highest yield of a bond with all future put dates treated as possible maturity dates and a yield-to-maturity calculation performed for each date. (Displayed as “N/A” for certain instruments for which the value is not computed.)

Note that all yield numbers in BarraOne are stated in terms based upon continuously compounded semiannual coupons, regardless of the actual coupon frequency, in order to facilitate portfolio duration calculations.

Aggregation

Effective Duration Weighted Average

See “Yield to Maturity (%)” on page 113 for a portfolio aggregation example.

Yield to Maturity (%)

Definition

Nominal internal rate of return of a bond. The constant discount rate that equates the market price to the present value of future cashflows, assuming the security is redeemed at maturity (*i.e.,* the internal rate of return if the bond were purchased today and held to maturity). In other words, given a price *P*, and semi-annual cash flows *C* for *N* periods, solve for *y* in the following equation:

$$P = \sum_{n=1}^{N} \frac{C_n}{\left(1 + \frac{y}{2}\right)^n}$$

Note that all yield numbers in BarraOne are stated in terms based upon continuously compounded semiannual coupons, regardless of the actual coupon frequency, in order to facilitate portfolio duration calculations.

Instruments included in the yield to maturity calculation are cash and all cash bonds. Excluded from the calculation are bond futures, bond options, options on bond futures, and currency derivatives (forwards, futures, options). (Displayed as “N/A” for certain instruments for which the value is not computed.)

Cash has a yield equal to the overnight rate, if available, for the respective currency. Otherwise, the yield is equal to the one-month spot rate from the term structure for that currency.

Aggregation

Effective Duration Weighted Average

$$\frac{\sum_i \left(y_i \bullet \alpha_1 \bullet w_{eff,i} \right)}{\sum_i \left(\alpha_1 \bullet w_i \right)}$$

where:

y_i = yield to maturity of asset *i*

α_i = effective duration of asset *i*

$w_{i,eff}$ = effective weight of asset *i*

w_i = weight of asset *i*

▷ **Note:** Effective Duration weighting is used for aggregation, because this scheme best approximates the IRR (internal rate of return) of the portfolio. This is a suitable measure if one assumes that principal payments will be reinvested at the same rate as the portfolio.

For an intuitive explanation of this weighting scheme, imagine that a portfolio has two bonds of different yields with an effective weight of 50% each, one bond maturing tomorrow, and one bond maturing in ten years. The YTM of the portfolio will be much more similar to the yield of the longer term bond than the yield of the shorter term bond, and effective duration weighting reflects this term difference.

See the example below for an illustration of effective duration aggregation.

Positions Report (Portfolio)					**Calculations**	
Asset ID	Yield to Maturity(%)	Effective Duration	Effective Weight(%)	Weight(%)	Yield to Maturity(%) x Effective Duration x Effective Weight(%)	Effective Duration x Weight(%)
6	**6.6811%**	9.4238	24.8868%	24.8868%		
0033AT	9.5300%	7.9162	4.8157%	4.8157%	363.302%	38.1219%
0035HO	11.0517%	0.8070	3.3711%	3.3711%	30.066%	2.7205%
0035HP	3.9637%	13.4343	3.4884%	3.4884%	185.754%	46.8368%
00591R	6.8990%	5.5181	5.6977%	5.6977%	216.908%	31.4404%
TYM09	N/A	5.9319	0.0000%	0.0000%	0.0000%	0.0000%
TUU09	N/A	1.6884	0.0000%	0.0000%	0.0000%	0.0000%
					Sum of YTM Products 796.030%	
					Sum of Products	119.1467%
					Sum of YTM Products ÷ Sum of Products	**6.6811%**

Yield to Next (%)

Definition

A rate of return measuring the performance of a callable bond from the time of purchase to the next date at which it can be redeemed. (Displayed as “N/A” for certain instruments for which the value is not computed.)

Note that all yield numbers in BarraOne are stated in terms based upon continuously compounded semiannual coupons, regardless of the actual coupon frequency, in order to facilitate portfolio duration calculations.

Aggregation

Effective Duration Weighted Average

See “Yield to Maturity (%)” on page 113 for a portfolio aggregation example.

Yield to Worst (%)

Definition

Lowest yield of a bond with all future call dates treated as possible maturity dates (accounting for any call premium) and a yield-to-maturity calculation applied to each call. (Displayed as “N/A” for certain instruments for which the value is not computed.)

Note that all yield numbers in BarraOne are stated in terms based upon continuously compounded semiannual coupons, regardless of the actual coupon frequency, in order to facilitate portfolio duration calculations.

Aggregation

Effective Duration Weighted Average

See "Yield to Maturity (%)" on page 113 for a portfolio aggregation example.

Valuation Data: Greeks

The following Greek-related measures are described in this section:

- Beta Adjusted Exposure
- Delta
- Delta Adjusted Exposure
- Gamma
- Net Leverage
- Rho
- Theta
- UCITS Exposure
- Vega
- Volatility Vega

Beta Adjusted Exposure

Definition

The beta-adjusted notional exposure of an instrument. The calculation of beta-adjusted exposure differs according to the instrument type.

Instrument Type	Beta-Adjusted Exposure
Options	$\Delta AE \times \left(\dfrac{\beta \text{ of option to Target}}{\text{elasticity}} \right)$
Certificates/Trackers	$\Delta AE \times \left(\sum_i \beta_i \text{ to Target} \right)$ where i = certificate underlying instrument

Instrument Type	Beta-Adjusted Exposure
All Other Instruments	Eff Mkt Value $\times \beta$ to Target

Notes:

- Target represents the market portfolio from the portfolio strategy, if specified. If the market portfolio is unspecified, *i.e.,* set to “CASH,” then Target represents the estimation universe of the numeraire currency.
- ΔAE represents the delta-adjusted exposure of the instrument. See “Delta Adjusted Exposure” on page 117.

Also see “UCITS Exposure” on page 120.

Aggregation

Sum

Delta

Definition

A measure of the relationship between an option’s price and an underlying futures contract or stock price. The delta value is expressed as the change in an option’s value given a one-point increase in the price of the underlying asset. If the underlying price changes by one unit, the option price is expected to change by delta units. For a call option, a delta of 0.50 means a half-point rise in premium for every dollar that the stock goes up. For a put option contract, the premium rises as stock prices fall. As options near expiration, in-the-money contracts approach a delta of 1.

Aggregation

Market Value Weighted Average

Delta Adjusted Exposure

Definition

The delta-adjusted notional exposure of an instrument. The calculation of delta-adjusted exposures differs according to instrument type.

Instrument Type	Delta-Adjusted Exposure
All others	Effective Market Value
Certificate/Tracker	$\sum_i (\Delta_i \times \text{Price}_i) \times \text{Shares} \times \text{Contract Size}$ where i = underlying instrument
Composite	$\sum_i (\Delta AE_i) \times \text{Mkt Value}$ where ΔAE_i = delta-adjusted exposure of composite constituent
Convertible Bond	$\text{Price}_i \times \text{Holdings} \times \text{CBExposureScalar} \times \text{Contract Size}$ where Price_i = convertible bond's clean price/100
Convertible Preferred	$\text{Price}_i \times \text{Holdings} \times \text{CBExposureScalar}$ where Price_i = preferred's price in bond's currency
Credit Default Swap/ Unfunded CDS Basket	–1 x Holdings x Contract Size
Credit Linked Note/ Funded CDS Basket	Effective Market Value
Equity Claim	$\Delta \times \text{Holdings} \times \text{Underlier Price} \times \text{Conversion Ratio}$
Equity Option Equity Index Future Option Volatility Option	$\Delta \times \text{Price}_i \times \text{Shares} \times \text{Contract Size}$ where i = underlying instrument
FX Forward	Holdings x Present Value of Receive Leg
Variance Future Equity Volatility Future	Holdings x Contract Size x Underlier Price
Variance Swap Volatility Swap	Holdings x Notional

Instrument Type	Delta-Adjusted Exposure
Bond Option Bond Future Option Eurodollar Future Option	$\Delta \times \text{Holdings} \times \text{Contract Size} \times \text{Underlier Contract Size} \times \text{Underlier Price} \div 100$
FX Option FX Future Option	$\Delta \times \text{Holdings} \times \text{Contract Size} \times \text{Price}$ where Price is the Strike Price of the option (converted to the Base Currency of the portfolio at the applicable FX rate of Quote Currency/ Base Currency)
IR Swap FX Swap	Holdings x Contract Size
StructureTool Asset	Contract size in local currency
Swaption	$\Delta \times \text{Holdings} \times \text{Contract Size} \times \text{Underlier Contract Size}$
Total Return Swap	Holdings x Contract Size
User Link Proxy	[Inherited from underlying asset]

Notes:

- All figures are modified to display (numeraire) currency by multiplying by the exchange rate, if necessary.
- BarraOne will use the user-defined price, if available; otherwise, the historical price will be used.

Also see "Beta Adjusted Exposure" on page 115 and "UCITS Exposure" on page 120.

Aggregation

Sum

Gamma

Definition

Rate of change of an option's delta with respect to the price of the underlying security. This is the second-order derivative of the option price with respect to the underlying security. This is similar to a bond's convexity, capturing the non-linearity of the option price's sensitivity.

Applicable to equity options, convertible bonds, bond options.

Aggregation

None

Net Leverage

Net Leverage is available as an optional Valuation Data column in BarraOne as a companion column to UCITS Exposure. While UCITS Exposure is a gross exposure calculation for individual assets, groups, and portfolios, Net Leverage aggregates exposures based on a set of rules regarding the effects of netting and hedging on groups and portfolios only.

Netting in this context is the effect of a combination of positions in financial derivative instruments on the same underlying asset, irrespective of the due dates of the derivative contracts, in the case where the purpose of the positions is solely to eliminate linked risks.

Hedging in this context is the effect of a combination of positions in financial derivative instruments, for which the underlying asset may not be the same, in the case where the purpose of the positions is solely to offset linked risks.

For each portfolio that employs netting or hedging, the user specifies, as a strategy setting, the Net Leverage Hedging Cut-Off value as a percentage. This represents the minimum correlation between the derivative instrument and its underlying asset necessary for Net Leverage to be calculated for the portfolio.

For purposes of the calculation of Net Leverage for a portfolio, the following rules will then be applied:

1. The exposure of each position in the portfolio is taken from its UCITS Exposure. Composite positions are evaluated based on the exposures of their constituents.

2. If assets are grouped by instrument type, then offsetting derivative positions (e.g., long and short calls on an asset) are netted for each group by adding their UCITS Exposure values. If assets are grouped by underlier, then the exposures for instruments with a common underlier (e.g., an index option and an index future) are netted for each group.

3. Only the following instruments are applicable for hedging, and the sum of these hedged exposures is used to compute the Net Leverage at the portfolio level:
   - Equity (index) Options, Equity (Index) Futures, and Equity (index) Future Options:
     - If these instrument types have same underling index, they net with each other
     - If the underlying indices have interacting equities, these derivatives net with each other with penalty
     - Theses instrument types hedge with their underlying indices without penalty
     - Theses instrument types hedge with the equities contained in their underlying indices with penalty

- Bond Future (short): hedged with a bond with of the same issuer and similar maturity as bonds from the “deliverable bonds list”
- Eurodollar Future (long): hedged with a short Eurodollar Future of the same rate but different maturity date if the correlation is sufficiently high
- Eurodollar Future (long): hedged with a cash asset of the same rate if the cash asset has an equal or higher maturity
- Interest Rate Swap: the payer leg is hedged with a cash asset of the same rate and frequency and an equal or later maturity, interpreted as a change from fixed to floating
- Total Return Swap: the payer leg is hedged with a cash asset of the same rate and frequency and an equal or later maturity, interpreted as a change from fixed to floating
- Currency Swap: both legs are considered as long and short bond positions and hedged with a cash asset of the same rate and frequency
- Credit Derivatives: hedged with a bond position of the same issuer as the CDS underlier(s)
- FX derivative: hedged with a cash position that offsets a currency mismatch exposure

Rho

Definition

The change in an option’s value implied by a unit increase in interest rates.

Aggregation

None

Theta

Definition

The change in option value resulting from a small decrease in the time to expiration, attributable to the option’s time value premium.

Aggregation

None

UCITS Exposure

Definition

The UCITS notional exposure of an instrument. The calculation of UCITS exposure differs according to the instrument type.

Instrument Type	UCITS Exposure
Bond Future	Holdings x Contract Size x Cheapest to Deliver Price %

Instrument Type	UCITS Exposure
Bond Future Option	Delta x Holdings x Contract Size x Underlier MV (where MV is dollar price per unit of contract size)
Bond Option	Delta x Holdings x Contract Size x Underlier Market Value
Cap/Floor	Holdings x Contract Size
Cash Flow Asset	Holdings x Notional
Convertible Bond Convertible Preferred	Holdings x Delta x CB Parity
CDS CDS Index	Seller: Max(Market Value, Holdings x Contract Size) Buyer: Market Value
CLN CLN Index	Holdings x Contract Size x Underlier Price
Equity Claim	Delta x Holdings x Contract Size x Underlier Price x Conversion Ratio
Equity Future Contract for Difference	Holdings x Contract Size x Underlier Price
Equity Index Future Option Equity Index Option	Delta x Holdings x Contract Size x Underlier Market Value
Eurodollar Future	Holdings x Contract Size
Eurodollar Future Option	Delta x Holdings x Contract Size
Forward Rate Agreement (FRA)	Holdings x Contract Size
FX Future	Holdings x Contract Size x FX Rate (numeraire currency/contract currency)
FX Forward	Holdings x Contract Size x (Sum of leg exposures): • Currency Leg exposure: If Currency = Numeraire Currency: 0; else: FX Rate (Numeraire Currency / Currency) • Quote Currency Leg exposure: If Quote Currency = Numeraire Currency: 0; else: Contract FX Rate x FX Rate (Numeraire Currency / Quote Currency)
FX Option FX Future Option	Delta x Holdings x Contract Size x (Sum of leg exposures): • Currency Leg exposure: If Currency = Numeraire Currency: 0; else: FX Rate (Numeraire Currency / Currency) • Quote Currency Leg exposure: If Quote Currency = Numeraire Currency: 0; else: Contract FX Rate x FX Rate (Numeraire Currency / Quote Currency)

Instrument Type	UCITS Exposure
FX Swap	Holdings x (Sum of leg exposures): • Long Leg exposure: If Currency = Numeraire Currency: 0; else: Contract Size x FX Rate (Numeraire Currency / Currency) • Short Leg exposure: If Currency = Numeraire Currency: 0; else: Contract Size x FX Rate (Numeraire Currency / Currency)
IR Swap	Holdings x Contract Size
IR Swaption	Delta x Holdings x Contract Size x Underlier Contract Size
Total Return Swap (TRS)	Market value of long leg
Variance Future	Holdings x Contract Size x Underlier Price
Variance Swap Volatility Swap	If Vega notional is true, Variance Notional is Notional / (2 x Strike) If Vega notional is false, Variance Notional is Notional
Volatility Option	Delta x Holdings x Notional Contract Size x Underlier Level
Equity Volatility Future	Holdings x Contract Size x Underlier Price

Notes:

- UCITS Exposures are always positive, so BarraOne uses the absolute value of each calculation.
- BarraOne converts the exposures of all non-FX instruments into Numeraire Currency units. For example if a stock's Price Currency is different from its Numeraire Currency, then the exposure is adjusted accordingly. The conversion to numeraire currency units implicit is implicit in the definition of FX instruments, so no adjustment is needed.
- Contract size for FX derivatives is the receive amount.

Also see "Beta Adjusted Exposure" on page 115 and "Delta Adjusted Exposure" on page 117.

Aggregation

Sum

Vega

Definition

Vega (or kappa) represents the sensitivity of an option premium to a one percent change in the volatility expectation for the return of the underlying asset. Vega in BarraOne is expressed in an asset's base currency. For example, if an equity option with a base currency of SEK has vega of 0.366180, this means that a 1% change in the volatility expectation for the return of the underlying equity asset will result in a 0.36618 SEK change in the equity premium. Note that this number is not affected by the selected report currency.

The more volatile the asset, the greater the value of a bought option. Because volatility is a multiplier of time in the model, volatility has a greater effect for options that have a long term to expiry. Thus, vega (kappa) will be larger for options on these assets.

Aggregation

None

Volatility Vega

Definition

Volatility vega represents the sensitivity of an equity volatility derivative price to a one percent change in the volatility expectation for the return of the underlying index.

Aggregation

None

Valuation Data: Convertible Bonds

Some measures specific to convertible bonds are described below:

- CB BreakEven Period
- CB Exposure Scalar
- CB Investment Value
- CB Parity
- CB TheorPremium

Note: Ordinarily, the market price of a convertible bond and its volatility are used to calibrate a spread. If this calibration fails (because the returned spread falls outside of the bounds accepted by BarraOne), then the volatility and the BIM model spread are used instead to calibrate a fitted price. This fitted price is then used in place of the market price in most calculations. However, the market price is still used to compute the portfolio weights and the market value displayed in BarraOne.

CB BreakEven Period

Definition

Number of years needed for the convertible bond's effective yield to "catch up" with the return on the underlying equity.

$$\text{Breakeven Period} = \frac{CB\ TheorPremium}{Coupon\ (\%) - Dividend\ \ Yield\ \ (\%)}$$

Aggregation

None

CB Exposure Scalar

Definition

The convertible bond exposure scalar is an expression of the instrument's delta (price sensitivity of the asset to a change in the price of the underlying equity asset), with the bond price converted to equity terms.

$$\text{CB Exposure Scalar} = \frac{\Delta \times \textit{Conversion Ratio}}{\dfrac{\textit{Market Value of Convertible}}{\textit{Price of Equity Underlier}}}$$

Aggregation

None

CB Investment Value

Definition

The value of the bond without the option to convert to stock (that is, pure bond value). It is valued using our bond models, rather than a trinomial tree.

Aggregation

None

CB Parity

Definition

The conversion value of the convertible bond if the issue (with a value of only one holding) were converted at the current stock price.

CB Parity = Conversion Ratio × current equity price

Aggregation

None

CB TheorPremium

Definition

The theoretical premium of the convertible bond over the straight value of expected cashflows. In other words, it is the difference between the market value and the parity value.

Aggregation

None

Valuation Data: Miscellaneous

This section describes selected Valuation Data columns available in a Positions Report:

- Accrued Interest (%)
- Active Option-Adjusted Convexity (Active OA Convexity)
- Basis
- Calibration Flag
- Calibration Price
- Dirty Price
- Discount Curve
- Fitted Price
- Fitted Price Source
- Interest Rate Volatility Duration (IR Volatility Duration)
- Implied Repo Rate (%)
- Implied Volatility (Implied Vol)
- Market Capitalization
- Model Spread (bp)
- Option-Adjusted Convexity (OA Convexity)
- Option-Adjusted Spread in Basis Points (OAS (bp))
- Option-Adjusted Spread to Swap Curve in Basis Points (OAS to Swap (bp))
- Option-Adjusted Spread to Treasury (OAS To Treasury)
- PSA Forecast (%)
- Price
- Price Currency
- Price Source
- Price Spot
- RC Price - End
- RC Price Source
- RC Price - Start
- Return (%)
- Return Source
- Spread Curve
- Spread Curve Source
- Time to Coupon
- Time to Maturity

- Upfront Curve
- Upfront Curve Source
- Weighted Average Life

Accrued Interest (%)

Definition

The value of the interest that a bond has earned since the most recent coupon payment (or the date on which interest began accruing, which is typically the issue date). It is the amount that a buyer has to pay the seller as compensation for interest earned up to the sale date.

The definition of accrued interest is dependent upon the instrument and is calculated according to local market conventions. It is usually calculated according to the specified day count basis, from the previous coupon date to the valuation date.

Aggregation

Effective Weighted Average

Positions Report (Portfolio)			**Calculations**	
Asset ID	Eff Weight(%)	Accrued Interest(%)	Eff Weight(%) x Accrued Interest(%)	Eff Weight(%)
6	24.8868%	**1.0152%**		
0033AT	4.8157%	2.3625%	11.3771%	4.8157%
0035HO	3.3711%	0.0000%	0.0000%	3.3711%
0035HP	3.4884%	0.0000%	0.0000%	3.4884%
00591R	5.6977%	2.4375%	13.8882%	5.6977%
TYM09	7.5139%	0.0000%	0.0000%	7.5139%
TUU09	0.0000%	0.0000%	0.0000%	0.0000%
			Sum of Products 25.2653%	
			Sum	24.8868%
			Sum of Products ÷ Sum	**1.0152%**

Active Option-Adjusted Convexity (Active OA Convexity)

Definition

The option-adjusted convexity of the asset in the managed portfolio – the option-adjusted convexity of the asset in the benchmark portfolio.

Aggregation

At the portfolio level, it is the option-adjusted convexity of the managed portfolio – the option-adjusted convexity of the benchmark portfolio. At the group level, it is the option-adjusted convexity of the group in the managed portfolio – the option-adjusted convexity of the group in the benchmark portfolio.

Basis

Definition

Basis is a measure of relative value for bond futures and is the difference between a bond's price and its delivery price (*Basis = bond price – futures price x conversion factor*). Basis has two components: net basis and carry.

Aggregation

Market Value Weighted Average

Calibration Flag

Indicates the success or failure to calibrate a spread from a price for fixed income instruments (Success, Fail, N/A).

Calibration Price

This is the clean price expressed in percent of par and imported by the user. If no imported price exists, then it displays zero (0).

Credit Spread Duration

The following *Valuation Data* attributes are provided:

- Active Credit Spread KRD n-year
- Active Credit Spread Duration
- Contribution to Active Credit Spread Duration
- Contribution to Credit Spread Duration
- Credit Spread Duration
- Credit Spread KRD *n*-year

Analytics

If an asset's Issuer Type is "Government," then credit duration is zero. For all other Issuer Types, credit duration equals spread duration. For instrument types without an Issuer Type field, BarraOne uses the following rules:

- Bond Options: credit duration = 0

- Bond Futures: credit duration = 0
- Total Return Swaps: credit duration = spread duration
- MBS: credit duration = spread duration
- Intex: credit duration = spread duration
- CDS, CLN, CDS Baskets: credit duration = spread duration
- Link Proxies = same as underlier
- All other derivatives: credit duration = 0

Dirty Price

Definition

The bond clean price plus accrued interest.

Aggregation

Market Value Weighted Average

Discount Curve

The name of the interest rate curve used to discount the instrument, *e.g.,* Treasury, LIBOR, Muni.

Fitted Price

Definition

The sum of the present values of all the cash flows an asset creates. The price for a security is estimated by a valuation model, calculated by discounting its cashflows (adjusted to reflect embedded optionality, if necessary) by the appropriate discount rate, given the security's characteristics in the terms defined by the valuation model. The values of the interest rates and spreads used to construct discount rates are estimated at each point by finding the values that best fit a universe of bond prices.

For fixed and floating bonds, the fitted price is based upon:

- the cash flow structure of the security (fixed, floating, schedule, coupon, *etc.*)
- the spot term structure
- the highest priority spread in the Price/Spread priority list: either the model spread (this could be sector-by-rating spreads for corporate bonds, emerging market spreads for corporate bonds, no spreads for government bonds, or just swap spreads for other bonds—the spread that is added to the discount curve is identified using the country, currency, sector, and rating of the bond and is computed by BarraOne on a daily basis); or a user-supplied spread

For fixed bonds, the calculation is very simple, because the cash flows are known. The cash flows are discounted using the spot term structure and model spread (if any), and then the discounted cash flows are summed to arrive at a fitted price.

The "Hull-White Model" on page 425 is used for determining the set of possible interest rate scenarios for a swaption, mortgage-backed security, adjustable rate mortgage, floating rate note, or variable rate note, or the underlying fixed income security of a future or option. Other instruments use the implied forward rate from the term structure. Once the cash flows are determined using either method, the cash flows are discounted using the spot term structure and model spread (if any), and then the discounted cash flows are summed to arrive at a fitted price.

Aggregation

Market Value Weighted Average

Fitted Price Source

Definition

The name of the spread that was used to compute the fitted price (*e.g.,* Model Spread, User Spread). BarraOne supports multiple price/spread sources and a price/spread source hierarchy. Spreads are importable and are used for computing exposures, valuation, and weights for the following asset types:

- User bonds (not applicable to system bonds)
- Convertibles (system and user assets)
- CDS (price is quoted in spread)
- Structured products

Aggregation

Count

Interest Rate Volatility Duration (IR Volatility Duration)

The volatility calculated on an option for a given market price and four variables: the price of the underlying, time to expiration, the strike price, and the short-term interest rate.

Implied Repo Rate (%)

Definition

The financing rate of a bond determined by its current price and its delivery price; derived by considering delivery into the futures contract to be a repurchase agreement. Conceptually, this is the breakeven rate that eliminates the arbitrage profits between the cash market and the futures market.

Aggregation

Market Value Weighted Average

Implied Volatility (Implied Vol)

Definition

The volatility calculated on an option for a given market price and four variables: the price of the underlying, time to expiration, the strike price, and the short-term interest rate.

Aggregation

None

Market Capitalization

Definition

The product of the market price and the total amount of a security outstanding. This represents the total market value of the security in the hands of its investors. To calculate the capitalization of a corporation, multiply the number of outstanding shares of stock by the current market price of a share. Reported only for equity instruments.

Aggregation

Market Value Weighted Average

Model Spread (bp)

Sector-by-rating spread for corporate bonds, emerging market spread for corporate bonds, no spread for government bonds, or just swap spread for other bonds—the spread that is added to the discount curve is determined using the country, currency, sector, and rating of the bond and is computed by BarraOne on a daily basis.

Option-Adjusted Convexity (OA Convexity)

Definition

The sensitivity of a security's effective duration to changes in interest rates, calculated taking its embedded options into account.

Aggregation

Effective Market Value Weighted Average

- For regular portfolios, it is the sum product of asset OA Convexity and Eff Weight (%) ÷ the sum of asset Weight (%).
- For Assigned Value portfolios, it is the sum product of asset OA Convexity and Eff Weight (%) ÷ the sum of asset Weight(%) × portfolio Market Value ÷ portfolio Assigned Value.
- For Groups, it is the sum product of group asset OA Convexity and Eff Weight (%) ÷ the sum of group asset Weight (%).

Option-Adjusted Spread in Basis Points (OAS (bp))

Definition

The spread over the asset's discount curve that equates the price of a security to the present value of its cashflows, with the latter adjusted to reflect any embedded options.

The OAS column displays the highest priority spread available based on aging rules. BarraOne supports multiple price/spread sources and a price/spread source hierarchy. Spreads are importable and are used for computing exposures, valuation, and weights for the following asset types:

- User bonds (not applicable to system bonds)
- Convertibles (system and user assets)
- CDS (price is quoted in spread)
- Structured products

If only a price is provided, then this price is fed into the Barra bond valuation model to calculate a theoretical option-adjusted spread that satisfies the model.

Aggregation

Spread Duration Weighted Average

$$\sum_i \left(\frac{V_{i,eff}\alpha_i}{V_i\alpha_i} y_i \right)$$

where:

$V_{i,eff}$ = effective value of asset i

V_i = market value of asset i

α_i = spread duration of asset i

y_i = OAS (treasury or swap) of asset i

Option-Adjusted Spread to Swap Curve in Basis Points (OAS to Swap (bp))

Definition

The spread over the swap curve that equates the price of a security to the present value of its cashflows, with the latter adjusted to reflect any embedded options.

- If Treasury is used as the discount curve, OAS to Swap = OAS – Swap Spread. (Treasuries, or government bonds, are not exposed to the swap spread factor in the risk model. However, treasuries will display a negative option-adjusted swap spread for valuation purposes, because the EURIBOR yield curve is used for valuation.)
- If LIBOR is used as the discount curve, OAS to Swap = OAS
- If Real or Muni term structures are used as the discount curve, OAS to Swap is N/A

Aggregation

Spread Duration Weighted Average

$$\sum_i \left(\frac{V_{i,eff}\alpha_i}{V_i\alpha_i} y_i \right)$$

where:

$V_{i,eff}$ = effective value of asset i

V_i = market value of asset i

α_i = spread duration of asset i

y_i = OAS (treasury or swap) of asset i

Option-Adjusted Spread to Treasury (OAS To Treasury)

Indicates to which curve the OAS is calculated (i.*e.,* Treasury), while the OAS (bp) column may be with respect to any discount curve.

PSA Forecast (%)

Definition

A value that provides a sense of prepayment forecasts from the Barra prepayment model. It is calculated assuming an unvarying yield curve. The cashflows corresponding to this PSA speed have the same average single monthly mortality (SMM) as the cashflows from the Barra prepayment model. The weight used in the average SMM calculation in both cases is the remaining amount outstanding. (Displayed as "N/A" for certain instruments for which the value is not computed.)

Aggregation

Market Value Weighted Average

Price

Definition

The reported market price of an instrument. Typically delivered as part of the daily market data update. BarraOne supports multiple price/spread/implied volatility sources and a price/spread/implied volatility source hierarchy. This column displays the highest priority price available based on aging rules. If only a spread is provided and there are no prices available, then the price is calculated based on the spread. (Prices for unissued securities are reported as "N/A.")

See also: "Price Source" on page 133.

Aggregation

Equal Value Weighted Average

Price Currency

Definition

Indicates the currency in which a price is delivered to BarraOne. When viewing asset prices in BarraOne, the price will reflect the user's numeraire view. Thus, an instrument's price may be displayed in GBP when the underlying price currency is USD.

Aggregation

Count

Price Source

Definition

Source of the reported price. BarraOne supports multiple price/spread/implied volatility sources and a price/spread/implied volatility source hierarchy. This field indicates the actual source of the reported price for a given issue.

If an asset's price is based on an imported spread, then the Price Source column displays the name of the spread attribute. Spreads are importable and are used for computing exposures, valuation, and weights for the following asset types:

- User bonds (not applicable to system bonds)
- Convertibles (system and user assets)
- CDS (price is quoted in spread)
- Structured products

Aggregation

Count

Price Spot

Definition

For index futures, the spot price or current price of the underlying index.

Aggregation

None

RC Price - End

Definition

The ending clean price used in Returns Calculator.

Aggregation

None

RC Price Source

Definition

The data source of the clean price used in Returns Calculator.

Aggregation

None

RC Price - Start

Definition

The starting clean price used in Returns Calculator.

Aggregation

None

Return (%)

Definition

The daily return for an asset, expressed in percent. This value is used in Performance Attribution, historical VaR analysis, and VaR backtesting. Note that any returns that are calculated on the fly by BarraOne will not be displayed in this column, but they will still be used in BarraOne.

Aggregation

None

Return Source

Definition

Source of the reported return for the asset. Returns may be imported by the user or supplied by BarraOne or a third-party vendor. Return source names may be defined by the user as attributes with an association of “Return.”

Aggregation

None

Spread Curve

Definition

The premium paid annually by the protection buyer throughout the life of a CDS, expressed in basis points, and displayed as pipe-delimited association pairs, *e.g.,* "6M= 50|1Y=100|5Y=120."

Aggregation

None

Spread Curve Source

Definition

Source of the reported spread curve for the asset.

Aggregation

None

Time to Coupon

Definition

The time remaining until the next coupon date. BarraOne expresses the time to coupon in years, calculated as the number of days divided by 365.

Aggregation

Market Value Weighted Average

Time to Maturity

Definition

The time remaining until the last unpaid principal for a security is repaid. BarraOne expresses the time to maturity in years, calculated as the number of days to maturity divided by 365.

Aggregation

Market Value Weighted Average

Upfront Curve

Definition

The premium paid up front when the protection buyer enters a CDS contract, expressed in percent, and displayed as pipe-delimited association pairs, *e.g.,* "6M= 50|1Y=100|5Y=120."

Aggregation

None

Upfront Curve Source

Definition

Source of the reported upfront curve for the asset.

Aggregation

None

Weighted Average Life

Definition

The dollar-weighted time, in years, till return of principal. Note that this attribute uses only principal flows and that the weight of each principal flow is based on its undiscounted value. (Displayed as “N/A” for certain instruments for which the value is not computed.)

Aggregation

Market Value Weighted Average

Credit Analytics

This section describes selected Credit Analytics columns available in a Positions Report. Two data models, Barra Default Probability (BDP) and Barra Implied Ratings, provide credit managers and asset owners an alternative to agency ratings for determining credit quality.

Barra Default Probability

Until recently, there have been two standard approaches to default probability: structural models and reduced-form models. Structural models attempt to relate the default probability to the capital structure of the firm — the mix of equity and debt, or, equivalently, the relative valuation of assets and liabilities. Reduced-form models remain silent about the cause of default and model the statistical properties of the default event itself via Poisson-type distributions.

A new class of recently developed models introduces the notion of incomplete information. The Barra Default Probability Model is a specific instance of such a model. In the BDP model, the firm value evolves according to a geometric Brownian motion process, as in the Merton and Black-Cox models. Default occurs when the firm value becomes less than a *default barrier* for the first time.

The default barrier is distinct from the debt and is assumed to be a random variable with a known, constant distribution function. The distribution of possible default values enables us to capture the uncertainty in the publicly available information about the firm. The default barrier may be thought of as a generalization of the debt level — in the Merton model the debt level is the default barrier, and in the Black-Cox model it is a given determination function.

Modeling the default barrier as a random variable is justified by two considerations. First, investors generally have incomplete information about the true liabilities of the firm due to out-of- date balance sheet information, off-balance sheet financing, or misleading or fraudulent accounting practices. Secondly, even if the firm’s liabilities were known with a high degree of certainty, the default barrier might still be uncertain, since the firm’s management may choose to default for reasons that may include cash-flow problems or attempts to optimize shareholder wealth by choosing the timing of default.

The default probability is an expectation of default barrier passage over all possible realizations of the stochastic firm value process. In other words, the default probability is the likelihood for the firm's value to drop below the uncertain default barrier over the forecasting period.

Barra Default Probability and associated data have the issuer ID as the primary key, and these attributes are displayed and used with individual bonds. BDP-related data have a maximum age of one month. Each attribute uses market value weighting.

The credit analytics may be displayed as system attributes, used for grouping, or used as optimizer constraints. They are delivered for bonds within the coverage universe.

Barra Implied Ratings

Barra Implied Ratings are calculated by calibrating typical OAS levels for sector-by-rating buckets. Since OAS levels are calculated from market prices, the Implied Ratings metric reacts much more quickly than agency ratings to credit deteriorations, and at the same time it provides data to credit managers within the familiar ratings framework.

Yield spreads between corporate and government bonds compensate investors for risk due to rating changes and defaults, liquidity, and disparate tax treatments. They can be computed as long as a price is available, in particular for non-rated issuers. The link between agency ratings and credit spreads has produced abundant literature (*e.g.,* West, 1973; Liu and Thakor, 1984; Altman 1989; Kao and Wu, 1990), and the general trend is well identified, with average spreads increasing as credit quality decreases. Individual spreads also vary significantly about their mean. (Altman (1989) and Taylor and Perraudin (2001) have more recently shown the presence of highly persistent inconsistencies between credit ratings and bond yields, even after correction for disparate liquidity and tax effects.

In the implied classification, ratings are determined by Option Adjusted Spread (OAS) level. The only question is where the boundaries between classes should be drawn. Our approach to answering this question is based on the assumption that agency ratings are, on average, informative. We create a penalty function that is increased only by a bond whose implied classification differs from its agency classification. The variables in the penalty function are the thresholds between implied rating classes. The values that minimize the penalty function are taken to be the implied classification thresholds.

Liquidity Data

Equity and fixed income liquidity data is available in BarraOne, subject to user licensing. They are available in all risk analysis reports, but they are not supported for Performance Attribution.

Asset-specific liquidity data is any characteristic of an asset (security or derivative contract) that is relevant when observing or analyzing the liquidity of that asset.

Bid-ask spread is the most direct measure of asset liquidity, as it measures the round-trip transaction cost of buying and selling an asset. Bid-ask spread measures liquidity for small transaction sizes, with an immediate time horizon. This is a limitation of the bid-ask spread measure — it provides no insight into the cost of executing large orders.

However, bid-ask spread serves several important functions in liquidity analytics. For small position sizes, the bid-ask measure is adequate. For a portfolio that contains only small positions, market impact does not need to be taken into account.

Fixed Income Liquidity Data

Fixed income liquidity data includes MSCI's Bond Liquidity Measure (BLM). BLM is a bond bid-ask spread estimated using MSCI's proprietary bid-ask spread estimation models.

BLM was developed to provide a reliable measure of bond liquidity for a broad universe of bonds. Because the vast majority of bonds is not regularly traded or quoted by dealers, bid-ask spreads are unknown for these bonds. Even for bonds that are regularly quoted, the quoting frequency is very low compared to equities and other exchange-traded instruments. Also, in many cases, existing quotes are just indications, not firm quotes, and they may often be stale, unrefreshed data. As a result, the market bid-ask spreads are too noisy to be a reliable and consistent measure of liquidity. With the bid-ask spread estimation models, MSCI is able to estimate bid-ask spreads for a universe of 240,000 bonds (as of June 2012) using market bid-ask spread quotes for approximately 20,000 bonds. Models cover global supranational, sovereign, agency, and corporate bonds.

Models are estimated using high-quality quote data sourced from leading vendors. Separate models are estimated for high-yield and investment-grade corporate bonds and for sovereign bonds. The models offer different levels: in decreasing order of accuracy and increasing order of generality, there exist a) issuer-level models that estimate issuer-level baseline yield bid-ask spreads, b) rating-based models that estimate issuer-level features based on rating and sector information, and c) the OAS-based models that estimate bid-ask spread based solely on issue-level characteristics. In all models, spreads are adjusted by issue-level characteristics that take into account duration and age. Additional adjustments (such as subordination, callability, issuer size for corporate bonds, and inflation protection, etc. for sovereign bonds) are applied, depending upon the model. The models are re-estimated regularly, using up-to-date market data with monthly frequency.

The value displayed for fixed income bid-ask spreads in BarraOne is the ratio of the bid-ask spread to the average of the bid price and ask price, expressed in basis points (x10,000):

$$10000\frac{\left(\text{Ask Price}-\text{Bid Price}\right)}{0.5\left(\text{Ask Price}+\text{Bid Price}\right)}$$

Equity Liquidity Data

Equity bid-ask spreads are sourced from exchanges.

Data Description

LAST_BID_ASK_DATE

The date of the last available bid/ask spread for the asset.

LAST_BID_ASK

The last available bid/ask spread for the asset.

AVG_30D_BID_ASK

The average bid/ask spread over the last 30 days.

AVG_60D_BID_ASK

The average bid/ask spread over the last 60 days.

AVG_90D_BID_ASK

The average bid/ask spread over the last 90 days.

Fundamental Data

Fundamental data attributes are available as optional asset-level columns (and available for grouping and sorting) in many BarraOne reports, subject to the user's license.

⊳ **Note:** To access this data, the user must be a subscriber to all four modules of the ACWI IMI (DM, EM, Small Cap, Large Cap).

The attributes are updated on a monthly basis with a one-year history for 17,000 global assets, and they are located in the respective Customize window under Fundamental Data > MSCI > Ratios. The following attributes are provided:

- 1-year Dividend Growth Rate
- 5-year Dividend Growth Rate
- Book Value per Share
- CEPS (cash earnings per share)
- Dividend Yield
- Dividend per Share
- EPS (earnings per share)
- P/BV (price per book value)

- P/CE (price per cash earnings)
- P/E (price per earnings)
- P/S (price per sales)
- Payout Ratio
- ROE (return on equity)
- Sales per Share

Notional Analytics

Assets (*e.g.,* options) for which the market value is small but the notional amount is substantial often have large risk forecasts and large duration values displayed in BarraOne. Some users find these values both unintuitive and unactionable. Notional analytics enable BarraOne to display certain values based upon the notional amount of the asset, rather than the market value, thus removing leverage from the values. The following table shows the assets for which notional-based values differ from market-value-based values, along with the multplier(s) used to convert the values from market-value based to notional based.

Table 15: Notional-Based Attribute Multipliers

Instrument	Multiplier
Equity Claims	$\frac{\text{Option Price}}{\text{Underlier Price}}$
Equity Options	
Equity Index Future Options	
Commodity Future Options	
Bond Options	
Bond Future Options	
FX Forwards	$\frac{\left\lvert \text{Market Value} / \text{Holdings} \right\rvert}{\text{Contract Size}}$
Credit Default Swaps	
CDS Baskets	
Credit Linked Notes	
Total Return Swaps	
Forward Rate Agreements	
IR Swaps (Vanilla and Basis)	
Zero Coupon Swaps	
Inflation Swaps	
Currency Swaps	
FX Options	
FX Future Options	
Caps/Floors	

Table 15: Notional-Based Attribute Multipliers (Continued)

Instrument	Multiplier
IR Swaptions	$\dfrac{\left\lvert \text{Market Value} / \text{Holdings} \right\rvert}{\text{Contract Size} / \text{Underlier Contract Size}}$
Eurodollar Future Options	

Notes:

- Contract size for FX derivatives is the receive amount.
- If market value and notional amount (*i.e.,* contract size) are in different currencies, then the corresponding FX rate must also be applied.
- For any asset not listed, the market-value based value and the notional-based value will be identical.

Aggregation

For all columns for which BarraOne computes asset-level notional analytics, BarraOne computes portfolio-level analytics using the non-notional portfolio level attribute × the absolute value of (the portfolio market value ÷ the absolute value of the portfolio-level delta-adjusted exposures). In the case of non-net base value, wherever portfolio market value would otherwise be used for scaling, the assigned value is substituted. The same rule applies for both portfolios and groups.

Credit Spread Duration

The following *Notional Analytics* attributes are provided:

- Credit Spread KRD *n*-year (Notional)
- Credit Spread Duration (Notional)

Analytics

If an asset's Issuer Type is "Government," then credit duration is zero. For all other Issuer Types, credit duration equals spread duration. For instrument types without an Issuer Type field, BarraOne uses the following rules:

- Bond Options: credit duration = 0
- Bond Futures: credit duration = 0
- Total Return Swaps: credit duration = spread duration
- MBS: credit duration = spread duration
- Intex: credit duration = spread duration
- CDS, CLN, CDS Baskets: credit duration = spread duration

- Link Proxies = same as underlier
- All other derivatives: credit duration = 0

Active Notional Analytics

Active notional analytics represent deleveraged marginal contributions and weights for active attributes. The following selected columns illustrate active notional analysis.

- Portfolio Weight (Notional) = delta-adjusted exposure of asset ÷ managed portfolio market value.
- Benchmark Weight (Notional) = delta-adjusted exposure of asset ÷ benchmark portfolio market value.
- Active Weight (Notional) = Portfolio Weight (Notional) – Benchmark Weight (Notional). In a tree, this value is calculated in the same way as Active Weight, i.e., it is the Portfolio Weight (Notional) – Total Benchmark Weight (Notional) ÷ relative absolute value of the Portfolio Weight (Notional).

The following examples illustrate the calculation when the Total Benchmark Weight (Notional) is 30%:

- Example 1:

	Portfolio Weight (Notional)	Benchmark Weight (Notional)	Active Weight (Notional)
Bond A, portfolio 1	5%	30% × 5% ÷ (5%+10%) = 10%	5% – 10% = –**5%**
Bond A, position 2	10%	30% × 10% ÷ (5%+10%) = 20%	10% – 20% = –**10%**

- Example 2: (when the Portfolio Weight (Notional) sums to 0, then Benchmark Weight (Notional) is equally distributed)

	Portfolio Weight (Notional)	Benchmark Weight (Notional)	Active Weight (Notional)
Bond A, portfolio 1	5%	30% ÷2 = 15%	5% – 15% = –**10%**
Bond A, position 2	–5%	30% ÷ 2 = 15%	–5% – 20% = –**20%**

Other columns are calculated in the same manner as their non-notional counterparts and adjusted with notional weights.

Aggregation

Aggregation for active notional columns is performed using the same logic as other notional columns, i.e., for all columns for which BarraOne computes asset-level notional analytics, BarraOne computes portfolio-level analytics using the non-notional portfolio level attribute × the absolute value of (the portfolio market value ÷ the absolute value of the portfolio-level delta-adjusted exposures). In the case of non-net base value, wherever portfolio market value would otherwise be used for scaling, the assigned value is substituted. The same rule applies for both portfolios and groups.

Credit Spread Duration

The following *Active Notional Analytics* attributes are provided:

- Active Credit Spread KRD *n*-year (Notional)
- Active Credit Spread Duration (Notional)

Analytics

If an asset's Issuer Type is "Government," then credit duration is zero. For all other Issuer Types, credit duration equals spread duration. For instrument types without an Issuer Type field, BarraOne uses the following rules:

- Bond Options: credit duration = 0
- Bond Futures: credit duration = 0
- Total Return Swaps: credit duration = spread duration
- MBS: credit duration = spread duration
- Intex: credit duration = spread duration
- CDS, CLN, CDS Baskets: credit duration = spread duration
- Link Proxies = same as underlier
- All other derivatives: credit duration = 0

Descriptive Data

This section describes selected Descriptive Data columns available in a Positions Report:

- Asset Source
- Country
- Country of Exposure
- Country of Incorporation
- Country of Quotation
- Dividend Yield (%)
- Geo Focus Code

- Global Class Code
- Goodness Of Fit
- Goodness Of Fit Descriptor
- Proxy Flag
- Index Family
- Issuer
- IssuerShortName
- LSR Root Id
- Parent IssuerID
- Parent Issuer Name
- MAC IssuerID
- MAC Issuer Name
- Rating (S&P, Moody's, JCR, R&I, SWX, Bond Quality Mapping, Model)
- Series
- Ultimate IssuerID
- Ultimate Issuer Name
- Version

Asset Source

Definition

The source of the terms and conditions for the asset, *i.e.,* User, Intex, or Barra (from any vendor except Intex).

Aggregation

None

Country

Definition

Country of risk exposure for most assets, including equities. Country of quotation (the listing country) for ADRs. Country of issuance for fixed income assets, or country of borrower if available. Country associated with the currency for unit exposure assets. (For underliers with multiple country exposures, *e.g.,* composites, this is returned as "XXX.")

Aggregation

None

Country of Exposure

Definition

Country of risk exposure for all assets, excluding fixed income assets. Country of issuance for fixed income assets, or country of borrower if available. (For derivatives, this is the same as the country of exposure for the underlying asset. (For underliers with multiple country exposures, *e.g.,* composites, this is returned as "XXX.")

Aggregation

None

Country of Incorporation

Definition

The country of issuance for fixed income assets.

Aggregation

None

Country of Quotation

Definition

The country of issuance for ADRs.

Aggregation

None

Dividend Yield (%)

Definition

The annual percentage return from dividends for an equity security. Note that this is an historical yield that follows Barra methodology (annualized dividends per share / price), as opposed to predicted yield.

Barra defines regular cash dividends as those paid from annual operating profits and/or accumulated earnings. To estimate the current annualized dividend, Barra takes the sum of all the dividends announced in the last 12 months.

Aggregation

The weighted average dividend yield from securities with a dividend yield (*i.e.,* the sum product of asset weight and asset dividend yield, divided by the sum of the asset weights).

Geo Focus Code

The geographical focus of a mutual fund is the geographical region or country where the fund's portfolio is strategically concentrated.

Global Class Code

The global class of a mutual fund reflects the investment strategy of the fund. For instance, it may indicate the target asset classes, the market, style and sector choices, etc. Examples are "Equity France Sm&Mid Cap," "Bond CHF Short Term," and "Mixed Assets HKD Aggressive."

Goodness Of Fit

Goodness of fit is a measure of the success of the style analysis for a mutual fund. It is the out-of-sample adjusted R-squared of the regression of the fund returns against the returns of the style portfolios. Note that when the exposures and specific risk of a fund are estimated through peer-averaging, no value is reported for the goodness of fit measure.

Goodness Of Fit Descriptor

A description of the goodness of fit measure reported.

Proxy Flag

The proxy flag of a mutual fund is "True" if one of two circumstances occur: 1) either the fund's exposure and specific risk are estimated through peer-averaging, or 2) they are estimated through style analysis, but the goodness of fit is below a certain threshold (60%). Note that peer-averaging replaces style analysis when the available history of the fund's performance is too short to carry out style analysis.

Index Family

Definition

The index family for a Markit-supplied CDS index.

Aggregation

None

Issuer

Definition

The name of the issuer of an asset.

Aggregation

None

IssuerShortName

Definition

A system-provided unique code that identifies the issuer of an asset.

Aggregation

None

LSR Root Id

Definition

An identifier that specifies the linked specific risk root of an asset. For instance, a link proxy inherits the linked specific risk from its underlier. (Refer to "Linked Specific Risk" on page 295.)

Aggregation

None

MAC IssuerID

Definition

Multi-asset class issuer ID. An identifier that specifies the issuer of a system-provided bond or equity instrument.

Aggregation

None

MAC Issuer Name

Definition

Multi-asset class issuer name. The name of the issuer of a system-provided bond or equity instrument.

Aggregation

None

Parent IssuerID

Definition

An identifier that specifies the immediate parent of the issuer of a system-provided asset.

Aggregation

None

Parent Issuer Name

Definition

The name of the immediate parent of the issuer of a system-provided asset.

Aggregation

None

Rating (S&P, Moody's, JCR, R&I, SWX, Bond Quality Mapping, Model)

Definition

S&P, Moody's, JCR, R&I Ratings

BarraOne receives Moody's, S&P, JCR, and R&I agency credit ratings from a variety of data vendors. BarraOne uses and displays the rating for each agency from the data vendor with the highest priority assigned by Barra.

SWX Ratings

SWX credit ratings are provided for Swiss bonds. This is a composite rating that combines U.S. agency ratings with unpublished ratings from Swiss banks. This rating service has the largest coverage of Swiss franc denominated bonds and is the preferred rating source for Swiss clients.

Bond Quality Mapping

Bond Quality Mapping is derived from averages of issuer-level ratings from credit agencies. Each credit rating has a numerical value in BarraOne. If both Moody's and S&P credit ratings are available for a bond, the numerical values of the credit ratings are averaged. (If only one agency's credit rating is available, its numerical value is used without averaging.) This value may then translated into a Model Rating for the purpose of assigning the bond to the appropriate sector-by-rating bucket.

Note that Bond Quality Mappings are not as granular as those from rating agencies. For instance, S&P ratings A-, A, and A+ will map to a BarraOne composite rating of A, and similarly for Moody's. Therefore, the risk exposure in BarraOne will not change when an agency rating changes to a different gradation within the same general rating category. Also note that bonds rated below CCC (17) do not enter the model estimation.

Table 16: Bond Ratings

S&P	Moody's	JCR	R&I	Numeric Equivalent
AAA	Aaa	AAA	AAA	0

Table 16: Bond Ratings (Continued)

AA+	Aa1	AA+	AA+	1
AA	Aa2	AA	AA	2
AA–	Aa3	AA–	AA–	3
A+	A1	A+	A+	4
A	A2	A	A	5
A–	A3	A–	A–	6
BBB+	Baa1	BBB+	BBB+	7
BBB	Baa2	BBB	BBB	8
BBB–	Baa3	BBB–	BBB–	9
BB+	Ba1	BB+	BB+	10
BB	Ba2	BB	BB	11
BB–	Ba3	BB–	BB–	12
B+	B1	B+	B+	13
B	B2	B	B	14
B–	B3	B–	B–	15
CCC+	Caa1	N/A	CCC+	16
CCC	Caa2	CCC	CCC	17
CCC–	Caa3	N/A	CCC–	18
N/A	N/A	N/A	N/A	19
CC	Ca	CC	CC	20
N/A	N/A	N/A	N/A	21
N/A	N/A	N/A	N/A	22
C	C	C	N/A	23
N/A	N/A	N/A	N/A	24
D	N/A	D	D	25

Model Rating

If the currency of a bond is JPY, then the highest available asset-level rating based on the following priority is used as the Model Rating:

- R&I
- JCR
- S&P
- Moody
- Bond Quality Mapping

If the currency of a bond is CHF, then the highest available asset-level rating based on the following priority is used as the Model Rating:

- SWX Composite Rating

- Average of S&P and Moody
- Bond Quality Mapping

For all other bonds, the highest available asset-level rating based on the following priority is used as the Model Rating:

- Average of S&P and Moody
- Bond Quality Mapping

Aggregation

Weighted average credit rating for a fixed income portfolio. The average rating for a portfolio is the mark-to-market weighted average of the ratings of all the instruments included in the aggregation, where the weights are based upon the absolute value of the numeraire exposure of the instruments. Each rating is assigned a value, and the averaging computation converts each instrument's rating into the respective value for that rating.

A weighted average is computed, and the weighted average is converted back into a rating. If the value of the average rating is within 0.1 of the nearest integer, only the rating associated with the nearest integer is displayed. If the value of the rating is more than 0.1 greater or less than the nearest integer, the rating associated with the nearest integer and the next closest rating are both displayed.

For example, if the average rating is 10.1, BarraOne might display "A." However, an average rating of 10.14 would be displayed as "A/A-." The integer is translated to a rating.

- Bonds with a rating type "USTSY" are mapped to +++/+++. U.S. Agency bonds, or bonds with a non-standard rating type such as "USAGY" indicative of a U.S. Agency bond, are mapped to +++/+++.
- MBS pools issued by the U.S. agencies GNMA, FNMA or FHLMC are rated AAA/Aaa when there is no explicit rating in the database.
- Non-agency MBS and all CMO/ABS tranches use the ratings in the database, or are considered "Not rated" if no rating is available.
- The following characters in ratings are ignored: r, +, -.
- Commercial paper ratings P1, P2, P3 are ignored.
- The following entries in the bond database for the rating will be ignored, and the rating will be considered not available: N/R, NA, N/A, NR, ..., Null, <*blank*>.
- Bonds without a valid rating, cash assets, and derivatives will not be included in the average rating calculation.

Note: The average rating number cannot be used as an indicator of the creditworthiness of portfolio, but rather as a linear indicator of all ratings of the securities included in it. This indicator can be misleading on the aggregation level, especially for a portfolio with short positions. The average portfolio rating can give an idea what kinds of securities are involved without the notion of position sign. For example, if portfolio rating is very low or very high, then one can conclude that the portfolio is constructed mostly with very poor or very well rated securities. If the value is somewhere in the middle, it does not indicate anything, because it does not make sense to sum AA with BBB bonds using security exposure weight.

Series

Definition

The series of a Markit-supplied CDS index.

Aggregation

None

Ultimate IssuerID

Definition

An identifier that specifies the ultimate (top level) parent of the issuer of a system-provided asset.

Aggregation

None

Ultimate Issuer Name

Definition

The name of the ultimate (top level) parent of the issuer of a system-provided asset.

Aggregation

None

Version

Definition

The version of a Markit-supplied CDS index.

Aggregation

None

MSCI ESG Research

BarraOne includes Environmental, Social, Governance data, subject to user licensing. These ESG data attributes are delivered monthly and are available as data columns for use in the Positions Report, other reports, the Screening tool, and as grouping options. The information is organized in the Customize Positions Report window under “MSCI ESG Research” as follows:

- Business Involvement Screening Research
- Government Ratings
- Impact Monitor
- Intangible Value Assessment (IVA)

▷ **Notes:**

- Data history begins 1 Jan 2012.
- This data is not available for the Performance module.
- Access to this feature is subject to the user's license.
- IVA attributes with a numeric score are aggregated using market value weighting at the group and portfolio level.

MSCI Economic Exposure

MSCI Economic Exposure Data is asset-level information with indicators of economic exposure. These indicators show how much exposure an asset has to a certain country/region as measured by the revenue coming from that country. The columns are available based upon the user's license, and they may be used for grouping, sorting, filtering, as an input for Allocation-Selection attribution, optimization, as an input for the Formula Builder, *etc.*

A folder named *MSCI Economic Exposure* in the "Available Columns" area of the Customize Positions Report window contains the following items:

- Revenue, a data item that contains the total revenues of each asset, converted to the analysis numeraire currency.
- Six folders:
  - Revenue per country: Columns that contain revenue information per country. A number between 0 and +inf, in decimal format with two decimal places by default, converted to the analysis numeraire currency.
  - % revenue per country: Columns that contain % revenue (*i.e.,* revenue per country as a percent of total revenue) information per country. A number between 0 and 1 in percent format with two decimal places by default.
  - Country estimation: Columns that indicate the degree to which the columns contained in Revenue per country and % revenue per country are estimated. A number between 0 and 1 in percent format with two decimal places by default.
  - Revenue per region: Columns that contain revenue information per region. A number between 0 and +inf, in decimal format with two decimal places by default, converted to the analysis numeraire currency.
  - % revenue per region: Columns that contain % revenue (*i.e.,* revenue per region as a % of total revenue) information per region. A number between 0 and 1 in percent format with two decimal places by default.
  - Region estimation: Columns that indicate the degree to which the columns contained in Revenue per region and % revenue per region are estimated. A number between 0 and 1 in percent format with two decimal places by default.

The structure of the MSCI Economic Exposure folder is illustrated below. Folders are indicated in bold italics.

MSCI Economic Exposure
- Revenue
- ***Revenue per country***
  - USA - revenue
  - Canada - revenue
  - Mexico - revenue
  - …
- ***% revenue per country***
  - USA - % revenue
  - Canada - % revenue
  - Mexico - % revenue
  - …
- ***Country estimation***
  - USA - % estimated
  - Canada - % estimated
  - Mexico - % estimated
  - …
- ***Revenue per region***
  - NAm - revenue
  - LatAm - revenue
  - WEur - revenue
  - …
- ***% revenue per region***
  - NAm - % revenue
  - LatAm - % revenue
  - WEur - % revenue
  - …
- ***Region estimation***
  - NAm - % estimated
  - LatAm - % estimated
  - WEur - % estimated
  - …

This information is especially useful for asset managers and asset owners who would like to be able to produce the following information:

1 Compute the managed portfolio's total and active economic exposure to a specific country (*e.g.,* China) or region (*e.g.,* Europe) by percentage. For example, solve for analyzing exposure to a single, or a small number (5 or fewer) of countries or regions. The 90% use case is analyzing exposure to 1-2 countries at once, not the whole gamut of countries and regions.

2 Answer the question: “What is my exposure to Greece by Market Cap Weight, Economic Exposure, and Risk Contribution?”

3 Analyze how much total and active risk comes from companies with high *vs.* low exposure to a specific country or region. For example, group a portfolio’s exposure to China by high, medium, and low exposure, and see how much risk comes from each group. For example, create user-defined groupings of Economic Exposure percentages.

4 Build a portfolio with companies having no more than a certain percentage of exposure to specific country or region. For example, use Economic Exposure as an asset-level optimizer constraint.

5 Build a portfolio that has no more than a total certain percentage exposure to a specific region or country. For example, use Economic Exposure as a portfolio-level optimizer constraint.

6 Where does a global equity mandate get its economic exposure? For example, add a few countries or regions as columns, and summarize the portfolio exposure to each (sorting must be done outside of BarraOne).

7 Use the MPC report for multiple manager comparison to analyze what percentage economic exposure a basket of managers has to specific a country or region.

Note: Every covered equity asset has economic exposure data, but may not have exposure to all regions. When exposure to a region is 0, then it is displayed as “N/A.”

Residual Exposure Reporting

Optional columns in BarraOne provide flexible, additive risk reporting that offers clients a way to drill down into sources of risk based on the residual exposures of the managed and active portfolio. Columns added to the Positions Report facilitate residual-exposure-based specific risk contribution drilldown or security risk contribution drilldown reporting.

The following section describes the Positions Report columns for BarraOne to generate residual-exposure-based reports. Each report attributes the risk of the managed and active portfolio. The examples are based on the “Example Portfolios” on page 15.

Specific Risk Contribution Drilldown

The Positions Report provides a drilldown view into the Portfolio Risk Contribution and Active Portfolio Risk Contribution that are displayed in the Selection Risk row of the Risk Decomposition Report. (Refer to the “Residual Exposure Risk Decomposition Report” on page 19.)

The Selection Risk contributions in the Positions Report are additive: in the example below (allowing for rounding errors), the total Specific Port Risk Contrib (0.10%) of all assets in the Positions Report is equal to the Portfolio Risk Contribution of the Selection Risk row in the Risk Decomposition Report.

The Specific Port Risk Contrib of each security is further decomposed into three components: 1) the residual effective weight, 2) the specific risk, and 3) the specific correlation with the managed portfolio. For example, the Specific Port Risk Contrib of Sony (–1.02%) is the product of the security's Port Residual Effective Weight (–20.10%), Specific Risk (does not appear in application) (23.71%), and Specific Correlation (0.22).

The specific marginal contribution to total risk is the product of the specific risk and the specific correlation with the managed portfolio. For instance, the Specific MCTR of Sony (5.10%) is the product of the security's Specific Risk (does not appear in application) (23.71%) and Specific Correlation (0.22).

An example Positions Report specific risk contribution drilldown is given by:

Asset ID	Asset Name	Port Residual Effective Weight (%)	Bmk Residual Effective Weight (%)	Active Residual Effective Weight (%)	Specific Correlation	Specific MCTR	Specific Port Risk Contrib	Specific Active Correlation	Specfic MCAR	Specific Active Risk Contribution
FINAAL4	NOKIA OYJ	-7.87%	0.00%	-7.87%	0.08	1.79%	-0.14%	-0.20	-4.48%	0.35%
FRAAGO1	SOC GENERALE	4.39%	0.00%	4.39%	0.02	0.37%	0.02%	0.07	1.06%	0.05%
JPNCDC1	SONY	-20.10%	0.00%	-20.10%	0.22	5.10%	-1.02%	-0.54	-12.76%	2.57%
JPNCIW1	TOYOTA MOTOR	27.23%	0.00%	27.23%	0.19	3.94%	1.07%	0.55	11.26%	3.06%
UKIALX1	LLOYDS BANKING GROUP	5.93%	0.00%	5.93%	0.04	0.68%	0.04%	0.11	1.94%	0.12%
UKIBBB1	ROYAL BK SCOT GRP	-3.27%	0.00%	-3.27%	0.04	0.94%	-0.03%	-0.09	-2.36%	0.08%
USAFK41	FORD MTR CO DEL	9.18%	0.00%	9.18%	0.10	3.07%	0.28%	0.28	8.77%	0.81%
USAFVO1	GENERAL ELECTRIC CO	-8.91%	0.00%	-8.91%	0.07	1.34%	-0.12%	-0.18	-3.36%	0.30%
Total					0.01	0.10%	0.10%	0.87	7.33%	7.33%

Note: The Total row in the table does not appear in the Positions Report, but it is displayed here only for purposes of the discussion above. Compare the values in the Total row corresponding to the equivalent columns in the Selection Risk row of the "Residual Exposure Risk Decomposition Report" on page 19.

These are the additional calculations and columns available for the Positions Report:

Port Residual Effective Weight (%)

$$w_{eff}^{P,R} = w_{eff}^{P} - \beta_{loc}^{P} w_{eff}^{M}$$

where:

w_{eff}^{P} = the portfolio effective weight vector

β_{loc}^{P} = the portfolio local beta (defined earlier)

w_{eff}^{M} = the market portfolio effective weight vector

Note : The residual effective weight vector has nonzero values for market portfolio assets not held.

Bmk Residual Effective Weight (%)

$$w_{eff}^{B,R} = w_{eff}^{B} - \beta_{loc}^{B} w_{eff}^{M}$$

where:

w_{eff}^{B} = the benchmark effective weight vector

β_{loc}^{B} = the benchmark local beta (defined earlier)

w_{eff}^{M} = the market portfolio effective weight vector

Note : The residual effective weight vector has nonzero values for market portfolio assets not held.

Active Residual Effective Weight (%)

$$w_{eff}^{A,R} = w_{eff}^{A} - \beta_{loc}^{A} w_{eff}^{M}$$

where:

w_{eff}^{A} = the effective active weight vector

β_{loc}^{A} = the active local beta (defined earlier)

w_{eff}^{M} = the market portfolio effective weight vector

Note: The residual effective weight vector has nonzero values for market portfolio assets not held.

Specific Risk (does not appear in application)

$$\text{Specific Risk} = \sqrt{w_{eff}^{n} \Delta w_{eff}^{n'}}$$

where:

w_{eff}^{n} = the effective weight vector of the security

Note: In contrast with selection risk, this is not beta adjusted.

Specific Correlation

$$\text{Specific Correlation} = \frac{\begin{pmatrix}\text{Specific}\\ \text{MCTR}\end{pmatrix}}{\begin{pmatrix}\text{Specific}\\ \text{Risk}\end{pmatrix}}$$

Specific MCTR

$$\text{Specific MCTR} = \frac{w_{\text{eff}}^{n} \Delta w_{eff}^{P'}}{\sigma^{P}}$$

where:

w_{eff}^{n} = the effective weight vector of the security

$w_{eff}^{P'}$ = the effective weight vector of the managed portfolio

σ^{P} = the portfolio total risk

Specific Port Risk Contrib

$$\text{Specific Port Risk Contrib} = \begin{pmatrix}\text{Port Residual}\\ \text{EffectiveWeight (\%)}\end{pmatrix} \times \begin{pmatrix}\text{Specific}\\ \text{MCTR}\end{pmatrix}$$

Specific Active Correlation

$$\text{Specific Active Correlation} = \frac{\begin{pmatrix}\text{Specific}\\ \text{MCAR}\end{pmatrix}}{\begin{pmatrix}\text{Specific}\\ \text{Risk}\end{pmatrix}}$$

Specific MCAR

$$\text{Specific MCAR} = \frac{w_{\text{eff}}^{n} \Delta w_{\mathit{eff}}^{A'}}{\sigma^{A}}$$

where:

w_{eff}^{n} = the effective weight vector of the security

$w_{\mathit{eff}}^{A'}$ = the effective weight vector of the active portfolio

σ^{A} = the active portfolio total risk

Specific Active Risk Contribution

$$\text{Specific Active Risk Contribution} = \begin{pmatrix}\text{Active Residual}\\ \text{Effective Weight (\%)}\end{pmatrix} \times \begin{pmatrix}\text{Specific}\\ \text{MCAR}\end{pmatrix}$$

Security Risk Contribution Drilldown — Managed Portfolio

The Positions Report provides a security-level drilldown view into the Portfolio Risk Contribution displayed in the Total Risk, Currency Risk, and Local Market Risk rows of the Risk Decomposition Report. (Refer to the “Residual Exposure Risk Decomposition Report” on page 19.)

The security risk contributions in the Positions Report are additive: in the example below (allowing for rounding errors), the total Port Risk Contrib (29.42%) of all assets in the Positions Report is equal to the Portfolio Risk Contribution of the Total Risk row in the Risk Decomposition Report; the total Currency Risk Contrib (–0.04%) of all assets in the Positions Report is equal to the Portfolio Risk Contribution of the Currency Risk row in the Risk Decomposition Report; the total Local Market Contrib (29.45%) of all assets in the Positions Report is equal to the Portfolio Risk Contribution of the Local Market Risk row in the Risk Decomposition Report.

This decomposition is also respected at the security level. For instance, the Port Risk Contrib of NOKIA OYJ (2.64%) is the sum of the security's Currency Risk Contrib (0.24%) and Local Market Contrib (2.40%). The security risk of Nokia is due to the implicit euro exposure of Nokia; therefore, the risk contributions are those of the euro (compare Currency MCTR for Nokia in the report below with the MCTR value for euro in the “Currency Risk Contribution Drilldown” on page 203).

The Port Risk Contrib, Currency Risk Contrib, and Local Market Contrib of each security is further decomposed into three components: 1) the security effective weight, 2) the risk of the security return, currency return, or local market return, and 3) the correlation of the security return component with the portfolio. For instance, the Local Market Contrib of NOKIA OYJ (2.40%) is the product of the security's Eff Weight (10.44%), Local Market Risk (37.70%), and Local Market Corr (0.61).

The source marginal contribution to total risk is the product of the source risk and the source correlation. For instance, the Local Market MCTR of NOKIA OYJ (22.97%) is the product of the security's Local Market Risk (37.70%) and Local Market Corr (0.61).

An example Positions Report security risk contribution drilldown for a managed portfolio is given by:

Asset ID	Asset Name	Eff Weight (%)	Eff Bmk Weight (%)	Eff Active Weight	Total Risk	Corr	MC to Total Risk	Port Risk Contrib	Currency Risk	Currency Corr	Currency MCTR	Currency Risk Contrib	Local Market Risk	Local Market Corr	Local Market MCTR	Local Market Contrib
FINAAL4	NOKIA OYJ	10.44%	19.60%	-9.16%	38.70%	0.65	25.26%	2.64%	9.13%	0.25	2.28%	0.24%	37.70%	0.61	22.97%	2.40%
FRAAGO1	SOC GENERALE	4.39%	0.00%	4.39%	43.62%	0.73	31.76%	1.39%	9.13%	0.25	2.28%	0.10%	41.52%	0.71	29.48%	1.29%
JPNCDC1	SONY	26.67%	50.07%	-23.39%	36.11%	0.72	25.88%	6.90%	11.13%	-0.09	-0.97%	-0.26%	37.39%	0.72	26.84%	7.16%
JPNCIW1	TOYOTA MOTOR	27.23%	0.00%	27.23%	34.88%	0.76	26.53%	7.22%	11.13%	-0.09	-0.97%	-0.26%	36.63%	0.75	27.49%	7.49%
UKIALX1	LLOYDS BANKING GRO	5.93%	0.00%	5.93%	52.91%	0.70	37.15%	2.20%	8.41%	0.17	1.44%	0.09%	52.68%	0.68	35.71%	2.12%
UKIBBB1	ROYAL BK SCOT GRP	4.33%	8.13%	-3.80%	64.19%	0.67	42.95%	1.86%	8.41%	0.17	1.44%	0.06%	63.81%	0.65	41.51%	1.80%
USAFK41	FORD MTR CO DEL	9.18%	0.00%	9.18%	57.77%	0.68	39.35%	3.61%	0.00%	0.00	0.00%	0.00%	57.77%	0.68	39.35%	3.61%
USAFVO1	GENERAL ELECTRIC C(	11.83%	22.20%	-10.37%	40.58%	0.75	30.33%	3.59%	0.00%	0.00	0.00%	0.00%	40.58%	0.75	30.33%	3.59%
Total					29.42%	1.00	29.42%	29.42%	6.41%	-0.01	-0.04%	-0.04%	30.14%	0.98	29.45%	29.45%

▷ **Note:** The Total row in the table does not appear in the Positions Report, but it is displayed here only for purposes of the discussion above. Compare the values in the Total row corresponding to the equivalent rows in the Portfolio Risk Contribution column of the "Residual Exposure Risk Decomposition Report" on page 19.

These are the additional columns available for the Positions Report:

Corr

$$\text{Corr}=\frac{(\text{MC to Total Risk})}{(\text{Total Risk})}$$

Port Risk Contrib

$$\text{Port Risk Contrib}=\left(\begin{array}{c}\text{Eff}\\ \text{Weight (\%)}\end{array}\right)\times(\text{MC to Total Risk})$$

Currency Corr

$$\text{Currency Corr}=\frac{\begin{pmatrix}\text{Currency}\\ \text{MCTR}\end{pmatrix}}{\begin{pmatrix}\text{Currency}\\ \text{Risk}\end{pmatrix}}$$

Currency MCTR

$$\text{Currency MCTR} = \sum_k X_{nk} MCTR_k$$

where:

X_{nk} = the exposure of security n to currency k

$MCTR_k$ = the MCTR of currency factor k

Currency Risk Contrib

$$\text{Currency Risk Contrib}=\begin{pmatrix}\text{Eff}\\ \text{Weight (\%)}\end{pmatrix}\times\begin{pmatrix}\text{Currency}\\ \text{MCTR}\end{pmatrix}$$

Local Market Corr

$$\text{Local Market Corr}=\frac{\begin{pmatrix}\text{Local}\\ \text{Market}\\ \text{MCTR}\end{pmatrix}}{\begin{pmatrix}\text{Local}\\ \text{Market}\\ \text{Risk}\end{pmatrix}}$$

Local Market MCTR

$$\text{Local Market MCTR}=(\text{MCTR})-\begin{pmatrix}\text{Currency}\\ \text{MCTR}\end{pmatrix}$$

Local Market Contrib

$$\text{Local Market Contrib}=\begin{pmatrix}\text{Eff}\\ \text{Weight (\%)}\end{pmatrix}\times\begin{pmatrix}\text{Local}\\ \text{MCTR}\end{pmatrix}$$

Security Risk Contribution Drilldown — Active Portfolio

The Positions Report provides a security-level drilldown view into the Active Portfolio Risk Contribution displayed in the Total Risk, Currency Risk, and Local Market Risk rows of the Risk Decomposition Report. (Refer to the "Residual Exposure Risk Decomposition Report" on page 19.)

The security risk contributions in the Positions Report are additive: in the example below (allowing for rounding errors), the total Active Risk Contrib (10.31%) of all assets in the Positions Report is equal to the Active Portfolio Risk Contribution of the Total Risk row in the Risk Decomposition Report; the total Active Currency Risk Contrib (0.00%) of all assets in the Positions Report is equal to the Active Portfolio Risk Contribution of the Currency Risk row in the Risk Decomposition Report; the total Active Local Market Contrib (10.31%) of all assets in the Positions Report is equal to the Active Portfolio Risk Contribution of the Local Market Risk row in the Risk Decomposition Report.

This decomposition is also respected at the security level. For instance, the Active Risk Contrib of NOKIA OYJ (–0.27%) is the sum of the security's Active Currency Risk Contrib (–0.01%) and Active Local Market Contrib (–0.25%). The security risk of Nokia is due to the explicit euro exposure of Nokia; therefore, the risk contributions are those of the euro (compare Active Currency MCTE for Nokia in the report below with the Active Currency MCTE for euro in the example Factor Exposure Breakdown Report on page 204).

The Active Risk Contrib, Active Currency Risk Contrib, and Active Local Market Contrib of each security is further decomposed into three components: 1) the security active effective weight, 2) the active risk of the security return, currency return, or local market return, and 3) the correlation of the security active return component with the portfolio. For instance, the Active Local Market Contrib of NOKIA OYJ (-0.25%) is the product of the security's Active Eff Weight (–9.16%), Active Local Market Risk (29.05%), and Active Local Market Corr (0.10).

The source marginal contribution to tracking error is the product of the source risk and the source correlation. For instance, the Active Local Market MCTE of NOKIA OYJ (2.78%) is the product of the security's Active Local Market Risk (29.05%) and the Active Local Market Corr (0.10).

An example Positions Report security risk contribution drilldown for an active portfolio is given by:

Asset ID	Asset Name	Eff Weight (%)	Eff Bmk Weight (%)	Eff Active Weight (%)	Active Total Risk	Active Correlation	MC to Total Tracking Error	Active Risk Contrib	Active Currency Risk	Active Currency Corr	Active Currency MCTE	Active Currency Risk Contrib	Active Local Market Risk	Active Local Market Corr	Active Local Market MCTE	Active Local Market Contrib
FINAAL4	NOKIA OYJ	10.44%	19.60%	-9.16%	28.82%	0.10	2.90%	-0.27%	8.64%	0.01	0.12%	-0.01%	29.05%	0.10	2.78%	-0.25%
FRAAGO1	SOC GENERALE	4.39%	0.00%	4.39%	32.36%	0.38	12.31%	0.54%	8.64%	0.01	0.12%	0.01%	31.03%	0.39	12.18%	0.53%
JPNCDC1	SONY	26.67%	50.07%	-23.39%	20.39%	-0.30	-6.07%	1.42%	5.77%	-0.05	-0.31%	0.07%	20.02%	-0.29	-5.76%	1.35%
JPNCIW1	TOYOTA MOTOR	27.23%	0.00%	27.23%	30.21%	0.80	24.16%	6.58%	5.77%	-0.05	-0.31%	-0.08%	30.19%	0.81	24.47%	6.66%
UKIALX1	LLOYDS BANKING GROUP	5.93%	0.00%	5.93%	41.18%	0.38	15.65%	0.93%	9.27%	0.09	0.85%	0.05%	41.37%	0.36	14.80%	0.88%
UKIBBB1	ROYAL BK SCOT GRP	4.33%	8.13%	-3.80%	50.81%	0.22	11.12%	-0.42%	9.27%	0.09	0.85%	-0.03%	50.76%	0.20	10.28%	-0.39%
USAFK41	FORD MTR CO DEL	9.18%	0.00%	9.18%	47.84%	0.51	24.63%	2.26%	6.13%	0.04	0.27%	0.02%	47.81%	0.51	24.36%	2.24%
USAFVO1	GENERAL ELECTRIC CO	11.83%	22.20%	-10.37%	27.69%	0.25	7.04%	-0.73%	6.13%	0.04	0.27%	-0.03%	28.18%	0.24	6.77%	-0.70%
Total					10.31%	1.00	10.31%	10.31%	0.57%	-0.01	0.00%	0.00%	10.33%	1.00	10.31%	10.31%

▷ **Note:** The Total row in the table does not appear in the Positions Report, but it is displayed here only for purposes of the discussion above. Compare the values in the Total row corresponding to the equivalent rows in the Active Portfolio Risk Contribution column of the "Residual Exposure Risk Decomposition Report" on page 19.

These are the additional columns available for the Positions Report:

Active Correlation

$$\text{Active Correlation} = \frac{\left(\begin{array}{c}\text{MC to Total}\\ \text{Tracking Error}\end{array}\right)}{\left(\begin{array}{c}\text{Active}\\ \text{Total Risk}\end{array}\right)}$$

Active Risk Contrib

$$\text{Active Risk Contrib} = \left(\begin{array}{c}\text{Eff Active}\\ \text{Weight (\%)}\end{array}\right) \times (\text{MCTE})$$

Active Currency Corr

$$\text{Active Currency Corr} = \frac{\left(\begin{array}{c}\text{Active}\\ \text{Currency}\\ \text{MCTE}\end{array}\right)}{\left(\begin{array}{c}\text{Active}\\ \text{Currency}\\ \text{Risk}\end{array}\right)}$$

Active Currency MCTE

$$\text{Active Currency MCTE} = \sum_k X_{nk} CMCTE_k$$

where:

X_{nk} = the exposure of security n to currency k

$CMCTE_k$ = the currency MCTE of currency k

Active Currency Risk Contrib

$$\text{Active Currency Risk Contrib} = \begin{pmatrix} \text{Eff Active} \\ \text{Weight (\%)} \end{pmatrix} \times \begin{pmatrix} \text{Active} \\ \text{Currency} \\ \text{MCTE} \end{pmatrix}$$

Active Local Market Corr

$$\text{Active Local Market Corr} = \frac{\begin{pmatrix} \text{Active} \\ \text{Local} \\ \text{Market} \\ \text{MCTE} \end{pmatrix}}{\begin{pmatrix} \text{Active} \\ \text{Local Market} \\ \text{Risk} \end{pmatrix}}$$

Active Local Market MCTE

$$\text{Active Local Market MCTE} = (\text{MCTE}) - \begin{pmatrix} \text{Active} \\ \text{Currency} \\ \text{MCTE} \end{pmatrix}$$

Active Local Market Contrib

$$\text{Active Local Market Contrib} = \begin{pmatrix} \text{Eff Active} \\ \text{Weight (\%)} \end{pmatrix} \times \begin{pmatrix} \text{Active} \\ \text{Local} \\ \text{Market} \\ \text{MCTE} \end{pmatrix}$$

Marginal Contribution to Residual Risk Reporting

In the MCRR version of the Risk Decomposition Report (see "Marginal Contribution to Residual Risk Reporting" on page 22, the Total Risk is decomposed into Mkt Timing Risk and Residual Risk columns, and each column is further decomposed among rows of factor groups and Selection Risk.

Optional columns are available in the Positions Report to facilitate reporting using this MCRR approach, which is applicable when the user would like to drill into the both the Market Timing Risk Contribution and Residual Risk Contribution on the basis of the market timing return and the residual return components of each source of risk. Columns added to the Positions Report facilitate residual-return-based factor group risk contribution drilldown reporting.

Specific Risk Contribution Drilldown — Managed Portfolio

The Positions Report provides a drilldown view into the Portfolio Risk Contribution, Portfolio Mkt Timing Risk Contribution, and Portfolio Residual Risk Contribution of the Selection Risk component of the Risk Decomposition Report. (Refer to the "Risk Decomposition Report (Residual Return Based) — Managed Portfolio" on page 23.) An example specific risk contribution drilldown for the managed portfolio is displayed below.

The specific risk contributions in the Positions Report are additive: in the example below (allowing for rounding errors), the sum of Specific Port Risk Contrib (3.16%) for all assets in the Positions Report is equal to the Portfolio Risk Contribution of Selection Risk in the Risk Decomposition Report; the sum of the Specific Mkt Timing Contribution (2.93%) for all assets in the Positions Report is equal to the Portfolio Mkt Timing Risk Contribution of Selection Risk; the sum of the Specific Residual Contrib (0.23%) for all assets in the Positions Report is equal to the Portfolio Residual Risk Contribution of Selection Risk.

This decomposition is respected at the security level. For instance, the Specific Port Risk Contrib of NOKIA OYJ (0.19%) is the sum of the security's Specific Mkt Timing Contribution (0.31%) and Specific Residual Contrib (–0.13%).

The Specific Port Risk Contrib, Specific Mkt Timing Contribution, and Specific Residual Contrib of each security are further decomposed into three components: 1) the portfolio effective weight, 2) the specific, specific market timing, or specific residual components of return with respect to the market portfolio, and 3) the correlation of the component with the managed portfolio. For instance, the Specific Residual Contrib of NOKIA OYJ (–0.13%) is the product of the security's Eff Weight (10.44%), Specific Residual Risk (22.23%), and Specific Residual Corr (–0.05).

The specific component Marginal Contribution to Total Risk of a security is the product of the component risk and the component correlation with the managed portfolio. For instance, the Specific Residual MCTR of NOKIA OYJ (–1.21%) is the product of the security's Specific Residual Risk (22.23%) and Specific Residual Corr (–0.05).

An example Positions Report specific risk contribution drilldown for the managed portfolio is given by:

Asset ID	Asset Name	Eff Weight (%)	Eff Bmk Weight (%)	Eff Active Weight (%)	Specific Correlation	Specific MCTR	Specific Port Risk Contrib	Specific Local Beta	Specific Mkt Timing Risk	Specific Mkt Timing Corr	Specific Mkt Timing MCTR	Specific Mkt Timing Contribution	Specific Residual Risk	Specific Residual Corr	Specific Residual MCTR	Specific Residual Contrib
FINAAL4	NOKIA OYJ	10.44%	19.60%	-9.16%	0.08	1.79%	0.19%	0.11	3.26%	0.92	3.01%	0.31%	22.23%	-0.05	-1.21%	-0.13%
FRAAGO1	SOC GENERALE	4.39%	0.00%	4.39%	0.02	0.37%	0.02%	0.00	0.00%	0.00	0.00%	0.00%	15.76%	0.02	0.37%	0.02%
JPNCDC1	SONY	26.67%	50.07%	-23.39%	0.22	5.10%	1.36%	0.30	9.27%	0.92	8.55%	2.28%	21.83%	-0.16	-3.46%	-0.92%
JPNCIV1	TOYOTA MOTOR	27.23%	0.00%	27.23%	0.19	3.94%	1.07%	0.00	0.00%	0.00	0.00%	0.00%	20.64%	0.19	3.94%	1.07%
UKIALX1	LLOYDS BANKING GRO	5.93%	0.00%	5.93%	0.04	0.68%	0.04%	0.00	0.00%	0.00	0.00%	0.00%	18.38%	0.04	0.68%	0.04%
UKIBBB1	ROYAL BK SCOT GRP	4.33%	8.13%	-3.80%	0.04	0.94%	0.04%	0.06	1.72%	0.92	1.58%	0.07%	25.27%	-0.03	-0.64%	-0.03%
USAFK41	FORD MTR CO DEL	9.18%	0.00%	9.18%	0.10	3.07%	0.28%	0.00	0.00%	0.00	0.00%	0.00%	31.38%	0.10	3.07%	0.28%
USAFVO1	GENERAL ELECTRIC C	11.83%	22.20%	-10.37%	0.07	1.34%	0.16%	0.08	2.44%	0.92	2.25%	0.27%	18.11%	-0.05	-0.91%	-0.11%
Total					0.33	3.16%	3.16%	0.10	3.17%	0.92	2.93%	2.93%	9.10%	0.03	0.23%	0.23%

Note: The Total row in the table does not appear in the Positions Report, but it is displayed here only for purposes of the discussion above. Compare the values in the Total row corresponding to the equivalent columns in the Selection Risk row of the "Risk Decomposition Report (Residual Return Based) — Managed Portfolio" on page 23.

These are the additional calculations and columns available for the Positions Report:

Specific Risk (does not appear in application)

$$\text{Specific Risk} = \sqrt{w_{eff}^{n} \Delta w_{eff}^{n'}}$$

where:

w_{eff}^{n} = the effective weight vector of the security

Note: In contrast with selection risk, this is not beta adjusted.

Specific Correlation

$$\text{Specific Correlation} = \frac{\begin{pmatrix}\text{Specific} \\ \text{MCTR}\end{pmatrix}}{\begin{pmatrix}\text{Specific} \\ \text{Risk}\end{pmatrix}}$$

Specific MCTR

$$\text{Specific MCTR} = \frac{w_{\mathrm{eff}}^{n} \Delta w_{eff}^{P'}}{\sigma^{P}}$$

where:

w_{eff}^{n} = the effective weight vector of the security

$w_{eff}^{P'}$ = the effective weight vector of the managed portfolio

σ^{P} = the portfolio total risk

Specific Port Risk Contrib

$$\text{Specific Port Risk Contrib} = \begin{pmatrix} \text{Port Residual} \\ \text{EffectiveWeight (\%)} \end{pmatrix} \times \begin{pmatrix} \text{Specific} \\ \text{MCTR} \end{pmatrix}$$

Specific Local Beta

$$\text{Specific Local Beta} = \frac{w_n \Delta w^{M'}}{\sigma_{LM}^2}$$

where:

w_n = the effective weight vector with effective weight 1 for the given security and effective weight 0 for all other securities

$w^{M'}$ = the effective weight vector of the market portfolio

σ_{LM} = the local market risk of the market portfolio

Specific Mkt Timing Risk

$$\text{Specific Mkt Timing Risk} = \begin{vmatrix} \text{Specific} \\ \text{Local} \\ \text{Beta} \end{vmatrix} \times \sigma_{LM}$$

where:

| | denotes absolute value

σ_{LM} = is the local market risk of the market portfolio

Specific Mkt Timing Corr

$$\text{Specific Mkt Timing Corr} = \frac{\begin{pmatrix} \text{Specific} \\ \text{Mkt Timing} \\ \text{MCTR} \end{pmatrix}}{\begin{pmatrix} \text{Specific} \\ \text{Mkt Timing} \\ \text{Risk} \end{pmatrix}}$$

Specific Mkt Timing MCTR

$$\text{Specific Mkt Timing MCTR} = \begin{pmatrix} \text{Specific} \\ \text{Local} \\ \text{Beta} \end{pmatrix} \times LMCTR^M$$

The auxiliary quantity $LMCTR^M$ is given by:

$$LMCTR^M = \frac{X^M F X^{P'} + w^M \Delta w^{P'}}{\sigma_{RP}}$$

where:

X^M = the vector of market portfolio exposures to non-currency factors

$X^{P'}$ = the vector of managed portfolio exposures to all factors, including currency

w^M = the effective weight vector of the market portfolio

$w^{P'}$ = the effective weight vector of the managed portfolio

σ_{RP} = the total risk of the managed portfolio

Specific Mkt Timing Contribution

$$\text{Specific Mkt Timing Contribution} = \left(\text{Eff Weight (\%)}\right) \times \begin{pmatrix}\text{Specific}\\ \text{Mkt Timing}\\ \text{MCTR}\end{pmatrix}$$

Specific Residual Risk

$$\text{Specific Residual Risk} = \sqrt{\begin{pmatrix}\text{Specific}\\ \text{Risk}\end{pmatrix}^2 - \begin{pmatrix}\text{Specific}\\ \text{Mkt Timing}\\ \text{Risk}\end{pmatrix}^2}$$

Specific Residual Corr

$$\text{Specific Residual Corr} = \frac{\begin{pmatrix}\text{Specific}\\ \text{Residual}\\ \text{MCTR}\end{pmatrix}}{\begin{pmatrix}\text{Specific}\\ \text{Residual}\\ \text{Risk}\end{pmatrix}}$$

Specific Residual MCTR

$$\text{Specific Residual MCTR} = \begin{pmatrix}\text{Specific}\\ \text{MCTR}\end{pmatrix} - \begin{pmatrix}\text{Specific}\\ \text{Mkt Timing}\\ \text{MCTR}\end{pmatrix}$$

Specific Residual Contrib

$$\text{Specific Residual Contrib} = (\text{Eff Weight } (\%)) \times \begin{pmatrix} \text{Specific} \\ \text{Residual} \\ \text{MCTR} \end{pmatrix}$$

Specific Risk Contribution Drilldown — Active Portfolio

The Positions Report provides a drilldown view into the Active Portfolio Risk Contribution, Active Portfolio Mkt Timing Risk Contribution, and Active Portfolio Residual Risk Contribution of the Selection Risk component of the Risk Decomposition Report. (Refer to the "Risk Decomposition Report (Residual Return Based) — Active Portfolio" on page 26.) An example specific risk contribution drilldown for the active portfolio is displayed below.

The specific risk contributions in the Positions Report are additive: in the example below (allowing for rounding errors), the sum of Specific Active Risk Contribution (7.87%) for all assets in the Positions Report is equal to the Active Portfolio Risk Contribution of Selection Risk in the Risk Decomposition Report; the sum of the Specific Mkt Timing Active Contrib (0.58%) for all assets in the Positions Report is equal to the Active Mkt Timing Risk Contribution of Selection Risk; the sum of the Specific Residual Active Contrib (7.28%) for all assets in the Positions Report is equal to the Active Residual Risk Contribution of Selection Risk.

This decomposition is also respected at the security level. For instance, the Specific Active Risk Contribution of NOKIA OYJ (0.41%) is the sum of the security's Specific Mkt Timing Active Contrib (0.06%) and Specific Residual Active Contrib (0.35%).

The Specific Active Risk Contribution, Specific Mkt Timing Active Contrib, and Specific Residual Active Contrib of each security is further decomposed into three components: 1) the effective active weight, the risk of the security's specific, specific market timing, or specific residual components of return with respect to the market portfolio, and the correlation of the component with the active portfolio. For instance, the Specific Residual Active Contrib of NOKIA OYJ (0.35%) is the product of the security's Eff Active Weight (–9.16%), Specific Residual Risk (22.23%), and Specific Residual Active Correlation (–0.17).

The specific component marginal contribution to active risk of a security is the product of the component risk and the component correlation with the active portfolio. For instance, the Specific Residual MCAR (Marginal Contribution to Active Risk) of NOKIA OYJ (–3.80%) is the product of the security's Specific Residual Risk (22.23%) and Specific Residual Active Correlation (–0.17).

An example Positions Report specific risk contribution drilldown for the active portfolio is given by:

Asset ID	Asset Name	Eff Weight (%)	Eff Bmk Weight (%)	Eff Active Weight (%)	Specific Local Beta	Specific Active Correlation	Specfic MCAR	Specific Active Risk Contribution	Specific Mkt Timing Risk	Specific Mkt Timing Active Corr	Specific Mkt Timing MCAR	Specific Mkt Timing Active Contrib	Specific Residual Risk	Specific Residual Active Correlation	Specific Residual MCAR	Specific Residual Active Contrib
FINAAL4	NOKIA OYJ	10.44%	19.60%	-9.16%	0.11	-0.20	-4.48%	0.41%	3.26%	-0.21	-0.68%	0.06%	22.23%	-0.17	-3.80%	0.35%
FRAAGO1	SOC GENERALE	4.39%	0.00%	4.39%	0.00	0.07	1.06%	0.05%	0.00%	0.00	0.00%	0.00%	15.76%	0.07	1.06%	0.05%
JPNCDC1	SONY	26.67%	50.07%	-23.39%	0.30	-0.54	-12.76%	2.99%	9.27%	-0.21	-1.94%	0.45%	21.83%	-0.50	-10.82%	2.53%
JPNCIW1	TOYOTA MOTOR	27.23%	0.00%	27.23%	0.00	0.55	11.26%	3.06%	0.00%	0.00	0.00%	0.00%	20.64%	0.55	11.26%	3.06%
UKIALX1	LLOYDS BANKING GROUP	5.93%	0.00%	5.93%	0.00	0.11	1.94%	0.12%	0.00%	0.00	0.00%	0.00%	18.38%	0.11	1.94%	0.12%
UKIBBB1	ROYAL BK SCOT GRP	4.33%	8.13%	-3.80%	0.06	-0.09	-2.36%	0.09%	1.72%	-0.21	-0.36%	0.01%	25.27%	-0.08	-2.00%	0.08%
USAFK41	FORD MTR CO DEL	9.18%	0.00%	9.18%	0.00	0.28	8.77%	0.81%	0.00%	0.00	0.00%	0.00%	31.38%	0.28	8.77%	0.81%
USAFVO1	GENERAL ELECTRIC CO	11.83%	22.20%	-10.37%	0.08	-0.18	-3.36%	0.35%	2.44%	-0.21	-0.51%	0.05%	18.11%	-0.16	-2.85%	0.30%
Total					-0.09	0.58	7.87%	7.87%	2.78%	0.21	0.58%	0.58%	13.16%	0.55	7.28%	7.28%

Note: The Total row in the table does not appear in the Positions Report, but it is displayed here only for purposes of the discussion above. Compare the values in the Total row corresponding to the equivalent columns in the Selection Risk row of the "Risk Decomposition Report (Residual Return Based) — Active Portfolio" on page 26.

These are the additional calculations and columns available for the Positions Report:

Specific Local Beta

$$\text{Specific Local Beta} = \frac{w_n \Delta w^{M'}}{\sigma_{LM}^2}$$

where:

w_n = the effective weight vector with effective weight 1 for the given security and effective weight 0 for all other securities

$w^{M'}$ = the effective weight vector of the market portfolio

σ_{LM} = the local market risk of the market portfolio

Specific Risk (does not appear in application)

$$\text{Specific Risk} = \sqrt{w_{eff}^{n} \Delta w_{eff}^{n'}}$$

where:

w_{eff}^{n} = the effective weight vector of the security

Note : In contrast with selection risk, this is not beta adjusted.

Specific Active Correlation

$$\text{Specific Active Correlation}=\frac{\begin{pmatrix}\text{Specific}\\ \text{Residual}\\ \text{MCAR}\end{pmatrix}}{\begin{pmatrix}\text{Specific}\\ \text{Residual}\\ \text{Risk}\end{pmatrix}}$$

Specific MCAR

$$\text{Specific MCAR}=\frac{w_{\text{eff}}^{n}\Delta w_{eff}^{A'}}{\sigma^{A}}$$

where:

w_{eff}^{n} = the effective weight vector of the security

$w_{eff}^{A'}$ = the effective weight vector of the active portfolio

σ^{A} = the active portfolio total risk

Specific Active Risk Contribution

$$\text{Specific Active Risk Contribution}=\begin{pmatrix}\text{Eff Active}\\ \text{Weight (\%)}\end{pmatrix}\times\begin{pmatrix}\text{Specific}\\ \text{Residual}\\ \text{MCAR}\end{pmatrix}$$

Specific Mkt Timing Risk

$$\text{Specific Mkt Timing Risk}=\begin{vmatrix}\text{Specific}\\ \text{Local}\\ \text{Beta}\end{vmatrix}\times\sigma_{LM}$$

where:

| | denotes absolute value

σ_{LM} = the local market risk of the market portfolio

Specific Mkt Timing Active Corr

$$\text{Specific Mkt Timing Active Corr} = \frac{\begin{pmatrix}\text{Specific}\\ \text{Mkt Timing}\\ \text{MCAR}\end{pmatrix}}{\begin{pmatrix}\text{Specific}\\ \text{Mkt Timing}\\ \text{Risk}\end{pmatrix}}$$

Specific Mkt Timing MCAR

$$\text{Specific Mkt Timing MCAR} = \begin{pmatrix}\text{Specific}\\ \text{Local}\\ \text{Beta}\end{pmatrix} \times LMCAR^M$$

The auxiliary quantity $LMCAR^M$ is given by:

$$LMCAR^M = \frac{X^M FX^{A'} + w^M \Delta w^{A'}}{\sigma_{RA}}$$

where:

X^M = the vector of market portfolio exposures to non-currency factors

$X^{A'}$ = the vector of all active portfolio factor exposures, including currency factors

w^M = the effective weight vector of the market portfolio

$w^{A'}$ = the effective weight vector of the active portfolio

σ_{RA} = the total risk of the active portfolio

Specific Mkt Timing Active Contrib

$$\text{Specific Mkt Timing Active Contrib} = \begin{pmatrix}\text{Eff Active}\\ \text{Weight (\%)}\end{pmatrix} \times \begin{pmatrix}\text{Specific}\\ \text{Mkt Timing}\\ \text{MCAR}\end{pmatrix}$$

Specific Residual Risk

$$\text{Specific Residual Risk} = \sqrt{\begin{pmatrix}\text{Specific}\\ \text{Risk}\end{pmatrix}^2 - \begin{pmatrix}\text{Specific}\\ \text{Mkt Timing}\\ \text{Risk}\end{pmatrix}^2}$$

Specific Residual Active Correlation

$$\text{Specific Residual Active Correlation} = \frac{\begin{pmatrix}\text{Specific}\\ \text{Residual}\\ \text{MCAR}\end{pmatrix}}{\begin{pmatrix}\text{Specific}\\ \text{Residual}\\ \text{Risk}\end{pmatrix}}$$

Specific Residual MCAR

$$\text{Specific Residual MCAR} = \begin{pmatrix}\text{Specific}\\ \text{MCAR}\end{pmatrix} - \begin{pmatrix}\text{Specific}\\ \text{Mkt Timing}\\ \text{MCAR}\end{pmatrix}$$

Specific Residual Active Contrib

$$\text{Specific Residual Active Contrib} = \begin{pmatrix}\text{Eff Active}\\ \text{Weight (\%)}\end{pmatrix} \times \begin{pmatrix}\text{Specific}\\ \text{Residual}\\ \text{MCAR}\end{pmatrix}$$

Security Risk Contribution Drilldown — Managed Portfolio

The Positions Report provides a security-level drilldown view into the Portfolio Risk Contribution, Portfolio Mkt Timing Risk Contribution, and Portfolio Residual Risk Contribution of the Local Market Risk component of the Risk Decomposition Report. (Refer to the "Risk Decomposition Report (Residual Return Based) — Managed Portfolio" on page 23.) An example security-level risk contribution drilldown for the managed portfolio is displayed below.

The security risk contributions in the Positions Report are additive: in the example below (allowing for rounding errors), the sum of Local Market Contrib (29.45%) for all assets in the Positions Report is equal to the Portfolio Risk Contribution of Local Market Risk in the Risk Decomposition Report; the sum of the Mkt Timing Risk Contribution (26.21%) for all assets in the Positions Report is equal to the Portfolio Mkt Timing Risk Contribution of Local Market Risk in the Risk Decomposition Report; the sum of the Residual Risk Contrib (3.25%) for all assets in the Positions Report is equal to the Portfolio Residual Risk Contribution of Local Market Risk.

This decomposition is also respected at the security level. For instance, the total Local Market Contrib of NOKIA OYJ (2.40%) is the sum of the security's Mkt Timing Risk Contribution (2.38%) and Residual Risk Contrib (0.02%).

The Local Market Contrib, Mkt Timing Risk Contribution, and Residual Risk Contrib of each security is further decomposed into three components: 1) the security's portfolio effective weight, 2) the risk of the security local, market timing, or residual return with respect to the market portfolio, and 3) the correlation of the security return component with the managed portfolio. For instance, the Residual Risk Contrib of NOKIA OYJ (0.02%) is the product of the security's Eff Weight (10.44%), Residual Risk (28.49%), and Residual Correlation (0.01).

The security's component marginal contribution to total risk is the product of the component risk and the component correlation with the managed portfolio. For instance, the Residual MCTR of NOKIA OYJ (0.17%) is the product of the security's Residual Risk (28.49%) and Residual Correlation (0.01).

An example Positions Report local market, market timing, and residual risk contribution drilldown for the managed portfolio is given by:

Asset ID	Asset Name	Eff Weight (%)	Eff Bmk Weight (%)	Eff Active Weight (%)	Local Market Risk	Local Market Corr	Local Market MCTR	Local Market Contrib	Asset Local Beta (Mkt)	Mkt Timing Risk	Mkt Timing Corr	Mkt Timing MCTR	Mkt Timing Risk Contribution	Residual Risk	Residual Correlation	Residual MCTR	Residual Risk Contrib
FINAAL4	NOKIA OYJ	10.44%	19.60%	-9.16%	37.70%	0.61	22.97%	2.40%	0.81	24.70%	0.92	22.80%	2.38%	28.49%	0.01	0.17%	0.02%
FRAAGO1	SOC GENERALE	4.39%	0.00%	4.39%	41.52%	0.71	29.48%	1.29%	0.91	27.71%	0.92	25.58%	1.12%	30.92%	0.13	3.90%	0.17%
JPNCDC1	SONY	26.67%	50.07%	-23.39%	37.39%	0.72	26.84%	7.16%	1.04	31.60%	0.92	29.18%	7.78%	19.98%	-0.12	-2.33%	-0.62%
JPNCIW1	TOYOTA MOTOR	27.23%	0.00%	27.23%	36.63%	0.75	27.49%	7.49%	0.73	22.27%	0.92	20.56%	5.60%	29.08%	0.24	6.93%	1.89%
UKIALX1	LLOYDS BANKING GROUP	5.93%	0.00%	5.93%	52.68%	0.68	35.71%	2.12%	1.08	32.69%	0.92	30.18%	1.79%	41.31%	0.13	5.53%	0.33%
UKIBBB1	ROYAL BK SCOT GRP	4.33%	8.13%	-3.80%	63.81%	0.65	41.51%	1.80%	1.31	39.78%	0.92	36.73%	1.59%	49.89%	0.10	4.79%	0.21%
USAFK41	FORD MTR CO DEL	9.18%	0.00%	9.18%	57.77%	0.68	39.35%	3.61%	1.07	32.49%	0.92	29.99%	2.75%	47.77%	0.20	9.36%	0.86%
USAFVO1	GENERAL ELECTRIC CO	11.83%	22.20%	-10.37%	40.58%	0.75	30.33%	3.59%	0.96	29.22%	0.92	26.98%	3.19%	28.16%	0.12	3.35%	0.40%
Total					30.14%	0.98	29.45%	29.45%	0.93	28.39%	0.92	26.21%	26.21%	10.13%	0.32	3.25%	3.25%

Note: The Total row in the table does not appear in the Positions Report, but it is displayed here only for purposes of the discussion above. Compare the values in the Total row corresponding to the equivalent columns in the Local Market Risk row of the "Risk Decomposition Report (Residual Return Based) — Managed Portfolio" on page 23.

These are the additional calculations and columns available for the Positions Report:

Local Market Corr

$$\text{Local Market Corr}=\frac{\left(\begin{array}{c}\text{Local}\\ \text{Market}\\ \text{MCTR}\end{array}\right)}{\left(\begin{array}{c}\text{Local}\\ \text{Market}\\ \text{Risk}\end{array}\right)}$$

Local Market MCTR

$$\text{Local Market MCTR} = (\text{MCTR}) - \begin{pmatrix} \text{Currency} \\ \text{MCTR} \end{pmatrix}$$

Local Market Contrib

$$\text{Local Market Contrib} = \begin{pmatrix} \text{Eff} \\ \text{Weight (\%)} \end{pmatrix} \times \begin{pmatrix} \text{Local} \\ \text{MCTR} \end{pmatrix}$$

Asset Local Beta (Mkt)

$$\text{Asset Local Beta (Mkt)} = \frac{X_n F X^{M'} + w_n \Delta w^{M'}}{\sigma_{LM}^2}$$

where:

X_n = the vector of asset exposures to non-currency factors with exposure 0 to all currency factors

$X^{M'}$ = the vector of market portfolio exposures to non-currency factors with exposure 0 to all currency factors

w_n = the effective weight vector with effective weight 1 for the given security and effective weight 0 for all other securities

$w^{M'}$ = the the effective weight vector of the market portfolio

σ_{LM} = the local market risk of the market portfolio

Mkt Timing Corr

$$\text{Mkt Timing Corr} = \frac{\begin{pmatrix} \text{Mkt} \\ \text{Timing} \\ \text{MCTR} \end{pmatrix}}{\begin{pmatrix} \text{Mkt} \\ \text{Timing} \\ \text{Risk} \end{pmatrix}}$$

Mkt Timing MCTR

$$\text{Mkt Timing MCTR} = \begin{pmatrix} \text{Asset} \\ \text{Local} \\ \text{Beta (Mkt)} \end{pmatrix} \times LMCTR^{M}$$

The auxiliary quantity $LMCTR^M$ is given by:

$$LMCTR^M = \frac{X^M F X^{P'} + w^M \Delta w^{P'}}{\sigma_P}$$

where:

X^M = the vector of market portfolio exposures to non-currency factors

$X^{P'}$ = the vector of managed portfolio exposures to all factors, including currency

w^M = the effective weight vector of the market portfolio

$w^{P'}$ = the effective weight vector of the managed portfolio

σ_P = the total risk of the managed portfolio

Mkt Timing Risk Contribution

$$\text{Mkt Timing Risk Contribution} = (\text{Eff Weight}(\%)) \times \begin{pmatrix} \text{Mkt} \\ \text{Timing} \\ \text{MCTR} \end{pmatrix}$$

Residual Risk

$$\text{Residual Risk} = \sqrt{\begin{pmatrix} \text{Local} \\ \text{Market} \\ \text{Risk} \end{pmatrix}^2 - \begin{pmatrix} \text{Mkt} \\ \text{Timing} \\ \text{Risk} \end{pmatrix}^2}$$

Residual Correlation

$$\text{Residual Correlation} = \frac{\begin{pmatrix} \text{Residual} \\ \text{MCTR} \end{pmatrix}}{\begin{pmatrix} \text{Residual} \\ \text{Risk} \end{pmatrix}}$$

Residual MCTR

$$\text{Residual MCTR} = \begin{pmatrix} \text{Local} \\ \text{Market} \\ \text{MCTR} \end{pmatrix} - \begin{pmatrix} \text{Mkt} \\ \text{Timing} \\ \text{MCTR} \end{pmatrix}$$

Residual Risk Contrib

$$\text{Residual Risk Contrib} = (\text{Eff Weight (\%)}) \times \begin{pmatrix} \text{Residual} \\ \text{MCTR} \end{pmatrix}$$

Security Risk Contribution Drilldown — Active Portfolio

The Positions Report provides a security-level drilldown view into the Active Portfolio Risk Contribution, Active Portfolio Mkt Timing Risk Contribution, and Active Portfolio Residual Risk Contribution of the Local Market Risk component of the Risk Decomposition Report. (Refer to the "Risk Decomposition Report (Residual Return Based) — Active Portfolio" on page 26.) An example security-level risk contribution drilldown for the managed portfolio is displayed below.

The security risk contributions in the Positions Report are additive: in the example below (allowing for rounding errors), the sum of Active Local Market Contrib (10.31%) for all assets in the Positions Report is equal to the Active Portfolio Risk Contribution of Local Market Risk in the Risk Decomposition Report; the sum of the Active Mkt Timing Risk Contrib (0.42%) for all assets in the Positions Report is equal to the Active Mkt Timing Risk Contribution of Local Market Risk in the Risk Decomposition Report; the sum of the Active Residual Risk Contrib (9.89%) for all assets in the Positions Report is equal to the Active Residual Risk Contribution of Local Market Risk.

This decomposition is also respected at the security level. For instance, the Active Local Market Contrib of NOKIA OYJ (–0.25%) is the sum of the security's Active Mkt Timing Risk Contrib (–0.11%) and Active Residual Risk Contrib (–0.14%).

The Active Local Market Contrib, Active Mkt Timing Risk Contrib, and Active Residual Risk Contrib of each security is further decomposed into three components: 1) the security effective active weight, 2) the risk of the security local return relative to the benchmark, or the risk of the security market timing or residual return components of the security relative local return with respect to the market portfolio, and 3) the correlation of the security return component with the managed portfolio. For instance, the Active Residual Risk Contrib of NOKIA OYJ (–0.14%) is the product of the security's Eff Active Weight (–9.16%), Active Residual Risk (28.49%), and Active Residual Corr (0.06).

The security's component marginal contribution to tracking error is the product of the component risk and the component correlation with the active portfolio. For instance, the Active Residual MCTE of NOKIA OYJ (1.57%) is the product of the security's Active Residual Risk (28.49%) and Active Residual Corr (0.06).

An example Positions Report local market, market timing, and residual risk contribution drilldown for the active portfolio is given by:

Asset ID	Asset Name	Eff Weight (%)	Eff Bmk Weight (%)	Eff Active Weight (%)	Active Local Market Risk	Active Local Market Corr	Active Local Market MCTE	Active Local Market Contrib	Asset Active Local Beta (Mkt)	Active Mkt Timing Risk	Active Mkt Timing Corr	Active Mkt Timing MCTE	Active Mkt Timing Risk Contrib	Active Residual Risk	Active Residual Corr	Active Residual MCTE	Active Residual Risk Contrib
FINAAL4	NOKIA OYJ	10.44%	19.60%	-9.16%	29.05%	0.10	2.78%	-0.25%	-0.19	5.69%	0.21	1.19%	-0.11%	28.49%	0.06	1.59%	-0.15%
FRAAGO1	SOC GENERALE	4.39%	0.00%	4.39%	31.03%	0.39	12.18%	0.53%	-0.09	2.68%	0.21	0.56%	0.02%	30.92%	0.38	11.62%	0.51%
JPNCDC1	SONY	26.67%	50.07%	-23.39%	20.02%	-0.29	-5.76%	1.35%	0.04	1.22%	-0.21	-0.26%	0.06%	19.98%	-0.28	-5.51%	1.29%
JPNCIW1	TOYOTA MOTOR	27.23%	0.00%	27.23%	30.19%	0.81	24.47%	6.66%	-0.27	8.11%	0.21	1.70%	0.46%	29.08%	0.78	22.77%	6.20%
UKIALX1	LLOYDS BANKING GROUP	5.93%	0.00%	5.93%	41.37%	0.36	14.80%	0.88%	0.08	2.30%	-0.21	-0.48%	-0.03%	41.31%	0.37	15.28%	0.91%
UKIBBB1	ROYAL BK SCOT GRP	4.33%	8.13%	-3.80%	50.76%	0.20	10.28%	-0.39%	0.31	9.40%	-0.21	-1.97%	0.07%	49.89%	0.25	12.25%	-0.47%
USAFK41	FORD MTR CO DEL	9.18%	0.00%	9.18%	47.81%	0.51	24.36%	2.24%	0.07	2.10%	-0.21	-0.44%	-0.04%	47.77%	0.52	24.80%	2.28%
USAFVO1	GENERAL ELECTRIC CO	11.83%	22.20%	-10.37%	28.18%	0.24	6.77%	-0.70%	-0.04	1.16%	0.21	0.24%	-0.03%	28.16%	0.23	6.53%	-0.68%
Total					10.33%	1.00	10.31%	10.31%	-0.07	2.00%	0.21	0.42%	0.42%	10.13%	0.98	9.89%	9.89%

Note: The Total row in the table does not appear in the Positions Report, but it is displayed here only for purposes of the discussion above. Compare the values in the Total row corresponding to the equivalent columns in the Local Market Risk row of the "Risk Decomposition Report (Residual Return Based) — Active Portfolio" on page 26.

These are the additional columns and calculations available for the Positions Report:

Active Local Market Corr

$$\text{Active Local Market Corr} = \frac{\begin{pmatrix}\text{Active}\\ \text{Local}\\ \text{Market}\\ \text{MCTE}\end{pmatrix}}{\begin{pmatrix}\text{Active}\\ \text{Local Market}\\ \text{Risk}\end{pmatrix}}$$

Active Local Market MCTE

$$\text{Active Local Market MCTE} = (\text{MCTE}) - \begin{pmatrix}\text{Active}\\ \text{Currency}\\ \text{MCTE}\end{pmatrix}$$

Active Local Market Contrib

$$\text{Active Local Market Contrib} = \begin{pmatrix} \text{Eff Active} \\ \text{Weight (\%)} \end{pmatrix} \times \begin{pmatrix} \text{Active} \\ \text{Local} \\ \text{Market} \\ \text{MCTE} \end{pmatrix}$$

Asset Active Local Beta (Mkt)

$$\text{Asset Active Local Beta (Mkt)} = \begin{pmatrix} \text{Asset Local} \\ \text{Beta (Mkt)} \end{pmatrix} - \frac{w_n}{w_n^{eff}} \beta_{loc}^B$$

Asset Local Beta (Mkt) is given by:

$$\text{Asset Local Beta (Mkt)} = \frac{X_n F X^{M'} + w_n \Delta w^{M'}}{\sigma_{LM}^2}$$

where:

X_n = the vector of asset exposures to non-currency factors with exposure 0 to all currency factors

$X^{M'}$ = the vector of market portfolio exposures to non-currency factors with exposure 0 to all currency factors

w_n = the effective weight vector with effective weight 1 for the given security and effective weight 0 for all other securities

$w^{M'}$ = the the effective weight vector of the market portfolio

σ_{LM} = the local market risk of the market portfolio

β_{loc}^B *is the local beta of the benchmark portfolio given by:*

$$\beta_{loc}^B = \frac{X^B F X^{M'} + w^B \Delta w^{M'}}{\sigma_{LM}^2}$$

where:

X^B = the vector of benchmark portfolio exposures to non-currency factors with exposure 0 to all currency factors

$X^{M'}$ = the vector of market portfolio exposures to non-currency factors with exposure 0 to all currency factors

w^B = the benchmark portfolio effective weight vector

$w^{M'}$ = the market portfolio effective weight vector

σ_{LM} = the local market risk of the market portfolio

Active Mkt Timing Corr

$$\text{Active Mkt Timing Corr} = \frac{\begin{pmatrix}\text{Active}\\ \text{Mkt}\\ \text{Timing}\\ \text{MCTE}\end{pmatrix}}{\begin{pmatrix}\text{Active}\\ \text{Mkt Timing}\\ \text{Risk}\end{pmatrix}}$$

Active Mkt Timing MCTE

$$\text{Active Mkt Timing MCTE} = \begin{pmatrix}\text{Asset Active}\\ \text{Local}\\ \text{Beta (Mkt)}\end{pmatrix} \times LMCAR^{M}$$

The auxiliary quantity $LMCAR^{M}$ is given by:

$$LMCAR^{M} = \frac{X^{M} FX^{A'} + w^{M} \Delta w^{A'}}{\sigma_{RA}}$$

where:

X^{M} = the vector of market portfolio exposures to non-currency factors

$X^{A'}$ = the vector of all active portfolio factor exposures, including currency factors

w^{M} = the effective weight vector of the market portfolio

$w^{A'}$ = the effective weight vector of the active portfolio

σ_{RA} = the total risk of the active portfolio

Active Mkt Timing Risk Contrib

$$\text{Active Mkt Timing Risk Contrib} = \begin{pmatrix}\text{Eff Active}\\ \text{Weight (\%)}\end{pmatrix} \times \begin{pmatrix}\text{Active}\\ \text{Mkt}\\ \text{Timing}\\ \text{MCTE}\end{pmatrix}$$

Active Residual Risk

$$\text{Active Residual Risk} = \sqrt{\begin{pmatrix}\text{Active}\\ \text{Local}\\ \text{Market}\\ \text{Risk}\end{pmatrix}^{2} - \begin{pmatrix}\text{Active}\\ \text{Mkt}\\ \text{Timing}\\ \text{Risk}\end{pmatrix}^{2}}$$

Active Residual Corr

$$\text{Active Residual Corr} = \frac{\begin{pmatrix}\text{Active}\\ \text{Residual}\\ \text{MCTE}\end{pmatrix}}{\begin{pmatrix}\text{Active}\\ \text{Residual}\\ \text{Risk}\end{pmatrix}}$$

Active Residual MCTE

$$\text{Active Residual MCTE} = \begin{pmatrix}\text{Active}\\ \text{Local}\\ \text{Market}\\ \text{MCTE}\end{pmatrix} - \begin{pmatrix}\text{Active}\\ \text{Mkt}\\ \text{Timing}\\ \text{MCTE}\end{pmatrix}$$

Active Residual Risk Contrib

$$\text{Active Residual Risk Contrib} = \begin{pmatrix}\text{Eff Active}\\ \text{Weight (\%)}\end{pmatrix} \times \begin{pmatrix}\text{Active}\\ \text{Residual}\\ \text{MCTE}\end{pmatrix}$$

Factor Group Contribution Drilldown: Managed Portfolio

Note: The following calculations are not displayed as columns in the Positions Report, but they are required to compute the columns that are displayed:

Factor Group Local Beta (Mkt)

$$\text{Factor Group } G \text{ Local Beta (Mkt)} = \frac{X_l F X^{M'}}{\sigma_{LM}^2}$$

where:

X_l has exposure 1 to the given factor and exposure 0 to all other factors

$X^{M'}$ = the vector of market portfolio exposures to non-currency factors

σ_{LM} = the local market risk of the market portfolio

Factor Group Market Timing Risk

$$\text{Factor Group } G \text{ Mkt Timing Risk} = \left| \begin{matrix} \text{Factor Group } G \\ \text{Local Beta (Mkt)} \end{matrix} \right| \times \sigma_{LM}$$

where:

σ_{LM} = the local market risk of the market portfolio

| | denotes absolute value

Factor Group Mkt Timing MCTR

$$\text{Factor Group } G \text{ Mkt Timing MCTR} = \left(\begin{matrix} \text{Factor Group } G \\ \text{Local Beta (Mkt)} \end{matrix} \right) \times LMCTR^M$$

The auxiliary quantity $LMCTR^M$ is given by:

$$LMCTR^M = \frac{X^M F X^{P'} + w^M \Delta w^{P'}}{\sigma_P}$$

where:

X^M = the vector of market portfolio exposures to non-currency factors

$X^{P'}$ = the vector of managed portfolio exposures to all factors, including currency

w^M = the effective weight vector of the market portfolio

$w^{P'}$ = the effective weight vector of the managed portfolio

σ_P = the total risk of the managed portfolio

Factor Group Residual Risk

$$\text{Factor Group } G \text{ Residual Risk} = \sqrt{\begin{pmatrix} \text{Factor Group } G \\ \text{Risk} \end{pmatrix}^2 - \begin{pmatrix} \text{Factor Group } G \\ \text{Mkt Timing Risk} \end{pmatrix}^2}$$

The following columns are displayed in the application. Note that the column names are identical for residual return and residual exposure methodologies. Thus, each of these columns should be interpreted as residual when the “Residual Return Contribution” checkbox is marked in the Customize Positions Report dialog. They are calculated as described below:

Factor Group MCTR

$$\text{Factor Group } G \text{ Residual MCTR} = \begin{pmatrix} \text{Factor Group } G \\ \text{MCTR} \end{pmatrix} - \begin{pmatrix} \text{Factor Group } G \\ \text{Mkt Timing MCTR} \end{pmatrix}$$

Factor Group Correlation

$$\text{Factor Group } G \text{ Residual Correlation} = \frac{\begin{pmatrix} \text{Factor Group } G \\ \text{Residual MCTR} \end{pmatrix}}{\begin{pmatrix} \text{Factor Group } G \\ \text{Residual Risk} \end{pmatrix}}$$

Factor Group Contribution

$$\text{Factor Group } G \text{ Residual Contribution} = \left(\text{Eff Weight } (\%)\right) \times \begin{pmatrix} \text{Factor Group } G \\ \text{Residual MCTR} \end{pmatrix}$$

Active Portfolio

Note: The following calculations are not displayed as columns in the Positions Report, but they are required to compute the columns that are displayed:

Active Factor Group Local Beta (Mkt)

$$\text{Active Factor Group } G \text{ Local Beta (Mkt)} = \frac{(X_l^m - X_l^b)FX^{M'}}{\sigma_{LM}^2}$$

where:

X_l^m has exposure 1 to the given factor and exposure 0 to all other factors for the managed portfolio

X_l^b has exposure 1 to the given factor and exposure 0 to all other factors for the benchmark portfolio

$X^{M'}$ = the vector of market portfolio exposures to non-currency factors

σ_{LM} = the local market risk of the market portfolio

Active Factor Group Local Beta (Mkt) for Futures

$$\text{Active Factor Group } G \text{ Local Beta (Mkt) for futures} = \frac{X_l FX^{M'}}{\sigma_{LM}^2}$$

where:

X_l has exposure 1 to the given factor and exposure 0 to all other factors

$X^{M'}$ = the vector of market portfolio exposures to non-currency factors

σ_{LM} = the local market risk of the market portfolio

Active Factor Group Market Timing Risk

$$\text{Active Factor Group } G \text{ Mkt Timing Risk} = \left| \begin{array}{c} \text{Active Factor Group } G \\ \text{Local Beta (Mkt)} \end{array} \right| \times \sigma_{LM}$$

where:

σ_{LM} = the local market risk of the market portfolio

| | denotes absolute value

Active Factor Group Mkt Timing MCTE

$$\text{Factor Group } G \text{ Mkt Timing MCTE} = \left(\begin{array}{c} \text{Active Factor Group } G \\ \text{Local Beta (Mkt)} \end{array} \right) \times LMCAR^M$$

The auxiliary quantity $LMCAR^M$ is given by:

$$LMCAR^M = \frac{X^M FX^{A'} + w^M \Delta w^{A'}}{\sigma_{RA}}$$

where:

X^M = the vector of market portfolio exposures to non-currency factors

$X^{A'}$ = the vector of all factor active portfolio exposures, including currency factors

w^M = the effective weight vector of the market portfolio

$w^{A'}$ = the effective weight vector of the active portfolio

σ_{RA} = the total risk of the active portfolio

Active Factor Group Residual Risk

$$\text{Active Factor Group } G \text{ Residual Risk} = \sqrt{\begin{pmatrix}\text{Active Factor Group } G \\ \text{Risk}\end{pmatrix}^2 - \begin{pmatrix}\text{Active Factor Group } G \\ \text{Mkt Timing Risk}\end{pmatrix}^2}$$

The following columns are displayed in the application. Note that the column names are identical for residual return and residual exposure methodologies. Thus, each of these columns should be interpreted as residual when the “Residual Return Contribution” checkbox is marked in the Customize Positions Report dialog. They are calculated as described below:

Active Factor Group MCTE

$$\text{Active Factor Group } G \text{ Residual MCTE} = \begin{pmatrix}\text{Factor Group } G \\ \text{MCTE}\end{pmatrix} - \begin{pmatrix}\text{Active Factor Group } G \\ \text{Mkt Timing MCTE}\end{pmatrix}$$

Active Factor Group Correlation

$$\text{Active Factor Group } G \text{ Residual Correlation} = \frac{\begin{pmatrix}\text{Active Factor Group } G \\ \text{Residual MCTE}\end{pmatrix}}{\begin{pmatrix}\text{Active Factor Group } G \\ \text{Residual Risk}\end{pmatrix}}$$

Active Factor Group Contribution

$$\text{Active Factor Group } G \text{ Residual Contribution} = \begin{pmatrix}\text{Active} \\ \text{Eff Weight (\%)}\end{pmatrix} \times \begin{pmatrix}\text{Active Factor Group } G \\ \text{Residual MCTE}\end{pmatrix}$$

Local Market Risk Breakdown Report

Overview

While the Risk Decomposition Report gives you an overall breakdown of portfolio risk, the Local Market Risk Breakdown Report lets you view portfolio risk by local market. The report breaks down the local market portion of your overall risk into its sources (market timing, common factor, and asset selection risk), and it shows risk values by:

- local market (for example, “How much risk is coming from Japan?”)
- risk component (for example, “How much risk is coming from Industries?”)

By showing both values in a matrix format, the report lets you further isolate:

- the risk component (industries, term structures, *etc.*) that contributes most to a local market’s risk (“Where is most of my risk in Japan coming from?”)
- the markets where you are taking the most risk along a particular dimension (“Which market is contributing most to my Industry risk?”)

▲ Local Market	Mkt Timing Risk	Common Factor	Selection Risk	Local Market Risk
Australia	0.00000000	0.21245931	0.08774987	**0.22986735**
Canada	0.00000000	0.18183084	0.26520166	**0.32154996**
Finland	0.00000000	0.10413221	0.10687757	**0.14921907**
France	0.00000000	0.95824701	0.83987809	**1.27421840**
Germany	0.00000000	0.03119935	0.03427486	**0.04634831**
Hong Kong	0.00000000	0.12577248	0.05593588	**0.13765007**
Italy	0.00000000	0.26972474	0.11231175	**0.29217352**
Japan	0.00000000	18.17863301	7.82596002	**19.79162319**
Netherlands	0.00000000	0.27293638	0.08584477	**0.28611814**
New Zealand	0.00000000	0.00000000	0.00000000	**0.00732921**
Portugal	0.00000000	0.00941303	0.00850184	**0.01268411**
Singapore	0.00000000	0.02740390	0.01764684	**0.03259424**
Spain	0.00000000	0.18868043	0.07190649	**0.20191792**
Sweden	0.00000000	0.09876881	0.04236583	**0.10747159**
Switzerland	0.00000000	0.10240047	0.08066082	**0.13035345**
United Kingdom	0.00000000	1.25343090	0.27908378	**1.28412491**
United States	0.00000000	2.33131068	0.56935370	**2.39982773**
Market Interaction	N/A	N/A	N/A	**N/A**
Total	**0.00000000**	**20.24259621**	**7.90497668**	**21.73134505**

Figure 5: Sample Local Market Risk Breakdown Report

Sources of Risk

The Local Market Breakdown Report focuses on the local markets in BarraOne's overall risk decomposition framework, as highlighted here:

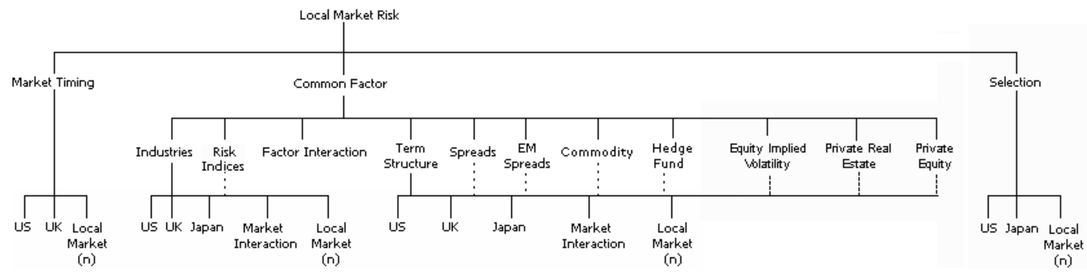


Figure 6: Risk Decomposition Framework

The report breaks local market risk into its components of market timing, common factor, and selection risk. By customizing the report, you can view risk in standard deviation, variance, or percent contribution to risk.

Note: If you prefer not to use Barra's breakdown of local market risk (into market timing, common factor, and asset selection), you can create your own risk breakdown by grouping by local market and viewing contributions to any risk dimension you choose.

Interpreting the Report

The Local Market Risk Breakdown Report may be interpreted as follows:

- Each row of the report displays the risk decomposition of an individual local market, as defined in the Barra Risk Model. For example, the row for the U.S. Market shows the amount of risk within the U.S. market arising from market timing, common factor, and selection risk. (You can customize the report to show common factor risk sources—industries, spreads, and so on—as well.) This aggregates, in the Local Market Risk column, to the amount of local market risk arising from bets made in the U.S. portion of the portfolio.
- Each column is a source of risk in the BarraOne risk decomposition. Looking down an individual column, you can determine which local market is contributing the most to market timing, selection, or common factor risk (or to the common factor risk sources like industries and spreads, if you customize the report to display them). Each column sums to the amount of local market risk arising from bets made along that risk dimension.

  Note: Because standard deviation is not an additive measure of risk, you must display risk values in terms of variance or percent contribution to risk to have them sum to a total amount.

- Each cell shows the amount of one source of risk—market timing, selection, or common factor (and its components, if you customize the report to show them)—arising from a particular market. For example, you might find an interesting amount of risk arising from common factor bets made in the United States. Because common factor risk can be decomposed further, you can click the hyperlinked value for US Common Factor risk (or one of its components) to view your portfolio's exposures to US common factors.

Marginal Contributions to Risk

Marginal contributions to risk measure the sensitivity of the portfolio to a marginal (1%) change in exposure, with higher numbers indicating greater sensitivity. MCTR shows the impact on total risk; MCAR show the impact on active risk.

Marginal contributions to risk are displayed in units of percent (like risk). Thus, for example, if your portfolio's total risk is 9.20, and the MCTR column shows 0.04 for the Australia market, increasing your Australian exposure by 1% would increase your portfolio's total risk to 9.24. This enables you to identify which local markets would have the largest marginal impact on the total risk of your portfolio. These are also the markets in which a small reduction in exposure would have the greatest diversifying effect.

▷ **Note:** The marginal contribution of a local market will differ from the marginal contribution of a distinct country group in the Positions Report. In the Positions Report, aggregation at the group level is the sum of the products of the absolute value of Effective Weight and Marginal Contribution for the respective members of the group, divided by the sum of the absolute value of Effective Weight of the members of the group. Whereas in the Local Market Risk Breakdown Report, aggregation of the Marginal Contribution for a local market is the sum of the products of Effective Weight and Marginal Contribution for the respective members of the local market.

Market Interaction

Market Interaction measures the correlation among local market bets—the degree to which they exhibit similar or dissimilar outcomes.

A positive number means they reinforce each other and thus increase the local market risk of the portfolio.

A negative number means they tend to move in opposite directions, and thus have a diversifying effect, reducing local market risk.

Market Interaction values are available only when viewing risk in terms of variance or percent contribution to risk.

Grouping by Region

If you prefer to view risk by region instead of local market, you can create your own regional grouping scheme for the Local Market attribute, to group local markets into the regions you define (such as Europe, Asia, and so on). Then you can choose the grouping scheme when customizing the report. You can also view the local markets within each regional group and the risk arising from each.

If you create regional groupings, the report displays a value called Regional Interaction to measure the correlation among local markets within a region. Market Interaction, in that case, shows the correlation among regions.

Available Columns

Common Factor

A characteristic shared by a group of securities that influences the returns of those securities. Securities with similar characteristics exhibit similar return behavior, which may be distinct from the rest of the market. In Barra multiple-factor risk models, the common factors determine correlations between asset returns. Examples of common factors are industries, styles, term structure, and spreads.

Local Market

The country that Barra uses to model a security.

Local Market Risk

The part of risk due to exposure to local market factors such as styles, industries, term structure movements, and changes in spreads. Local market risk arises from decisions made with local markets.

Market Timing Risk (Mkt Timing Risk)

The part of risk due to exposure to the market or the portfolio’s beta. In standard deviation terms, it is equal to the absolute value of beta times the risk of the market. In variance terms, it is beta squared times the variance of the market.

> **Note:** To account for the separation of currency risk, the beta calculation omits currency exposures (*i.e.,* all currency factor exposures are set to 0 for both the covariance and variance calculations). Compare to “Beta” on page 93, which does include currency exposures.

Selection Risk

Risk that is specific to an asset and is uncorrelated (or negligibly correlated) with the risks of other assets. That is, asset selection risk is the portion of an asset's or portfolio's risk that is unexplained by the risk model. Also called specific, unique, idiosyncratic, or independent risk. The calculation of asset selection risk requires the asset-level weights of the managed portfolio and the asset-level asset selection variances.

$$\sigma_{P,sp}^2 = \sum_{i=1}^{N} w_{i,mgd}^2 \cdot \sigma_{i,sp}^2$$

where:

$w_{i,mgd}^2$ = the square of the stock's portfolio weight

$\sigma_{i,sp}^2$ = the asset selection variance

Linked Selection Risk

Where assets in a portfolio share an issuer, the following rule applies in the calculation of linked selection risk:

$$\sigma_{P,sp}^2 = w_P D\, w_P^{'}$$

where:

D = the specific covariance matrix of N x N size

N = is the total number of assets in the portfolio

then:

$D_{i,j} = \sigma_{i,sp}\sigma_{j,sp}$ where assets i and j are linked

$D_{i,j} = 0$ otherwise

Factor Exposure Breakdown Report

Overview

After seeing which local markets contribute the most to your portfolio's common factor risk, you can use the Factor Exposure Breakdown Report to determine which factor exposures are driving that risk. Factor exposure is a term used to quantify the magnitude of an asset's (or portfolio's) sensitivity to Barra Integrated Model (BIM) factors.

The report lets you focus in on the industries, term structures, currencies, and other factors in the Barra Risk Model that contribute to the risk of each local market.

Table 17: Sample Factor Exposure Breakdown Report

Factor	Volatility	Exposure			Risk			MCTR	MCAR	Cont. to TR	Cont. to AR
		Portfolio	Benchmark	Active	Portfolio	Benchmark	Active				
US Computer Hardware	28.60	66.667	57.798	8.869	19.067	16.531	2.537	0.233	0.054	18.362	1.390
US Computer Software	29.89	31.333	39.670	-8.337	9.366	11.857	2.492	0.236	0.023	8.738	-0.544
US Currency Sensitivity	1.85	-0.281	-0.342	0.061	0.520	0.634	0.113	0.002	0.001	-0.057	0.014
US Dollar	0.00	100.000	100.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
US Earnings Variation	2.45	-0.367	-0.364	-0.003	0.901	0.894	0.006	0.003	0.001	-0.113	-0.001
US Earnings Yield	4.13	0.235	0.207	0.028	0.971	0.857	0.114	0.006	0.003	0.160	0.021
US Growth	1.84	0.215	0.054	0.161	0.396	0.099	0.297	0.004	0.003	0.099	0.121
US Internet	30.39	1.333	1.688	-0.355	0.405	0.513	0.108	0.199	0.028	0.313	-0.029
US Leisure	35.08	0.667	0.844	-0.177	0.234	0.296	0.062	0.250	0.050	0.196	-0.026
US Leverage	3.22	-0.610	-0.611	0.001	1.964	1.966	0.002	0.012	0.003	-0.826	0.001
US Momentum	6.37	-0.853	-0.762	-0.092	5.435	4.850	0.585	-0.017	-0.010	1.681	0.259
US Size	2.92	0.798	0.958	-0.160	2.328	2.794	0.466	0.004	-0.003	0.341	0.160
US Size Non-Linearity	3.83	0.174	0.182	-0.008	0.665	0.697	0.032	0.005	0.003	0.097	-0.008
US Trading Activity	2.43	-0.638	-0.655	0.017	1.551	1.594	0.042	0.007	0.002	-0.554	0.009
US Value	2.88	-0.435	-0.430	-0.005	1.252	1.238	0.015	0.001	0.001	-0.056	-0.002
US Volatility	9.02	0.348	0.250	0.098	3.134	2.252	0.883	0.057	0.017	2.352	0.480
US Yield	2.52	-0.661	-0.581	-0.081	1.664	1.462	0.203	-0.004	-0.000	0.334	0.007

Portfolio, Benchmark, and Active Columns

The following columns display different types of information.

This column	Shows this
Portfolio	Values for your portfolio
Benchmark	Values for the benchmark portfolio. If the benchmark is CASH, this column shows zeros.
Active	The difference between your portfolio and the benchmark. If your benchmark is CASH, active values are the same as portfolio values.

Exposure Units

Different factor exposure types are measured in different ways; that is, the values in the exposure columns reflect different units of measurement, as outlined in the following table:

Factor Exposure Type	Measurement Units
Style	Standard Deviations
Term Structure	Years
Spread	Years
Industry	Percent of Portfolio Value
Emerging Market Spread	Years
Currency	Percent of Portfolio Value
Commodity	Unit Exposure to Commodity Factor
Hedge Fund	Percent of Portfolio Value

For style factors, exposure is expressed in standard deviations, and for industries it is expressed in percent of portfolio value. For term structure, spread, and emerging market factors, exposures represent the sensitivity of the bond or portfolio to shocks in those term structures or spread curves, and can therefore be understood as a form of duration.

Groups

All risk values at the aggregate level must be calculated using factor exposures from the variance/covariance matrix, because volatility, or risk numbers, are not meaningful in the aggregate. Therefore, risk numbers at the group level are not computed as the factor exposure of the group multiplied by the volatility of the group.

Notes:

- When a market is not selected, the Contribution to Total Risk (Cont. to TR) for all factors in the Factor Exposure Breakdown Report will sum to match the Portfolio Risk for Common Factors (the square root of $\sigma^2 - \sigma^2_{selection}$) in the Risk Decomposition Report. (When a market is selected, then the numbers in the Risk Decomposition Report will be calculated in residual space, while the Factor Exposure breakdown Report is still calculated in total space, so the values will not sum to match.)

  However, the Contribution to Total Risk (Cont. to TR) for a factor group (*e.g.,* Industry) in the Factor Exposure Breakdown Report will not sum to match the Portfolio Risk for the same factor group (*e.g.,* Industry) in the Risk Decomposition Report, because the factor group in the Factor Exposure Breakdown Report considers factor interactions between, while the Risk Decomposition Report does not consider factor interactions between groups. (Note that interactions within groups are considered in both cases.) Additionally, these numbers will not sum to match because risk contributions are derived using a scaling factor (active total risk/active common factor risk).

- When a market is not selected, the Contribution to Active Total Risk (Cont. to AR) for all factors in the Factor Exposure Breakdown Report will sum to match the Active Risk for Common Factors in the Risk Decomposition Report. (When a market is selected, then the numbers in the Risk Decomposition Report will be calculated in residual space, while the Factor Exposure breakdown Report is still calculated in total space, so the values will not sum to match.)

  However, the Contribution to Active Total Risk (Cont. to AR) for a factor group (*e.g.,* Industry) in the Factor Exposure Breakdown Report will not sum to match the Active Risk for the same factor group (*e.g.,* Industry) in the Risk Decomposition Report, because the factor group in the Factor Exposure Breakdown Report considers factor interactions between groups, while the Risk Decomposition Report does not consider factor interactions between groups. (Note that interactions within groups are considered in both cases.) Additionally, these numbers will not sum to match because risk contributions are derived using a scaling factor (active total risk/active common factor risk).

Risk

The risk associated with a factor is calculated as the portfolio's exposure to that factor multiplied by the volatility of the factor.

Marginal Contributions to Risk

Marginal contributions to risk measure the sensitivity of the portfolio to a marginal (1%) change in factor exposure, with higher numbers indicating greater sensitivity. MCTR shows the impact on total risk; MCAR shows the impact on active total risk. If your benchmark is CASH, MCAR shows the same value as MCTR.

For example, if your portfolio's total risk is 9.20, and if the MCTR column shows 0.04 for the Euro, then increasing your Euro exposure by 1% would increase your portfolio's total risk to 9.24. This enables you to identify which common factors would have the largest marginal impact on the total risk of your portfolio. These are also the factors in which a small reduction in exposure would have the greatest diversifying effect.

▷ **Note:** BarraOne displays asset-level and factor-level marginal contributions in basis points. The portfolio's aggregate marginal contribution, however, is displayed in percent, but this figure is not a meaningful analytic at the portfolio level.

Reducing Factor Exposure

If the Marginal Contribution column reveals a factor exposure you want to reduce, you can try out a trade scenario to see the effect a reduction would have, like this:

1. View the Positions Report.
2. Customize the display to show columns for the factor in which you are interested (such as Currency in our Euro example) and Marginal Contribution to Total Risk. Also, sort the report first by Currency and second by Marginal Contribution to Total Risk.
3. Identify the position with Euro currency exposure that has the greatest Marginal Contribution to Total Risk.
4. In the rightmost column of the asset's row, click trade. This launches the Trade Scenario tool, so you can see the effect on portfolio risk of trading the asset.

Unexpected Currency Risk

For some portfolios, the report might show currency risk where you expect none. This is due to the presence of ADRs in the portfolio.

For example, if you look at the Currency risk of the S&P500 and set the base currency to U.S. Dollar, you will still see risk values for other currencies, due to exposure to the currencies of non-U.S. issuers.

Shift-Twist-Butterfly to Key Rate Duration Translation

Users can choose to view fixed income risk using either Shift-Twist-Butterfly (STBs) factors or key rate durations (KRDs). BarraOne computes factor risk with STBs but can translate between KRD and STB representations of the fixed income factor model.

Example

At the following link, you can view a spreadsheet that illustrates how BarraOne translates the more granular Shift, Twist, and Butterfly (STB) weights to the less granular Key Rate Duration vertices: https://support.msci.com/docs/DOC-3793. This spreadsheet also illustrates how BarraOne calculates KRD factor volatility, even when we do not have KRD factors.

There are fewer KRD vertices than STB vertices, *i.e.,* depending upon the model, there are only eight KRD vertices, but there are eleven STB vertices, so the eight must be properly distributed to the eleven. The **h** matrix in the spreadsheet shows how each KRD vertex is allocated to each STB vertex, and the table below has the same information, but transposed. These allocation weights are hardcoded in BarraOne.

Step 1. Retrieve a full list of STB curves (STB matrix) from the BarraOne database.

Step 2. Remove the first and the thirteenth vertices from each of the STB shapes, and then transpose the STB weights from the raw data file, resulting in the **g** matrix in the spreadsheet.

Step 3. Use matrix multiplication on the **g** and **h** matrices in the spreadsheet. What this table shows is how the more granular S, T, and B weights have been allocated to each of the less granular KRD vertices. The STB to KRD translation is now complete.

Step 4. BarraOne computes exposures.

Step 5. The weights in Step 5 are multiplied against each Key Rate Duration to compute the STB exposures of the instrument using KRDs. Essentially, this now gives you exposures to the Barra interest rate factors using KRDs computed from any other system.

Step 6. This step shows how the STB covariance matrix is used to compute STB volatility.

Step 7. This step shows how the KRD covariance matrix is used to compute KRD volatility.

Available Columns

Factor

A common factor is a characteristic shared by a group of securities that influences the returns of those securities. Securities with similar characteristics exhibit similar return behavior, which may be distinct from the rest of the market. In Barra multiple-factor risk models, the common factors determine correlations between asset returns. Examples of common factors are industries, styles, term structure, and spreads.

When the existence of a factor is established, it becomes a convenient way of isolating common elements in securities and of tracking events in financial markets. One important application is to attribute elements of value and elements of investment returns to underlying factors. Refer to the *BIM Model Handbook* for detailed information.

Volatility

A measure of a BIM factor's return. Mathematically, this is expressed as the standard deviation from the average return of the factor. In general, high volatility means high unpredictability, and therefore greater risk.

Portfolio Exposure

A term used to quantify the magnitude of a portfolio's sensitivity to factors. For style factors, exposure is expressed in standard deviations, and for industries it is expressed in percent of portfolio value. For term structure, spread, and emerging market factors, exposures represent the sensitivity of the bond or portfolio to shocks in those term structures or spread curves, and can therefore be understood as a form of duration.

Benchmark Exposure

A term used to quantify the magnitude of a benchmark portfolio's sensitivity to factors. For style factors, exposure is expressed in standard deviations, and for industries it is expressed in percent of portfolio value. For term structure, spread, and emerging market factors, exposures represent the sensitivity of the bond or portfolio to shocks in those term structures or spread curves, and can therefore be understood as a form of duration.

Active Exposure

The portfolio's exposure to a factor minus the benchmark's exposure, displayed when both a benchmark and a market are selected. Active exposure captures the magnitude and direction of the portfolio's biases across common factors.

$$X_{\mathrm{Active}} = X_{\mathrm{P}} - X_{\mathrm{B}}$$

where:

X_{Active}	= active exposure
$X_{P,B}$	= portfolio, benchmark exposure

Portfolio Risk

The portfolio risk associated with a factor is calculated as the absolute value of the portfolio's exposure to that factor multiplied by the volatility of the factor.

Benchmark Risk

The benchmark risk associated with a factor is calculated as the absolute value of the benchmark's exposure to that factor multiplied by the volatility of the factor.

Active Risk

The active total risk associated with a factor is calculated as the absolute value of active exposure to that factor multiplied by the volatility of the factor. This figure enables you to identify areas of factor exposure that have the greatest impact on the active total risk of the portfolio.

Marginal Contribution to Total Risk (MCTR)

Marginal contribution to total risk measures the effect on the total risk of a portfolio of a small (1%) increase in exposure to a position, group, or common factor. This type of sensitivity analysis allows one to see which assets or common factors would have the largest impact on the total risk of the portfolio, on the margin. For example, an asset's MCTR is approximately the increase in predicted total risk (the amount that would be added to total risk) that would result if you increased the asset's weight by one percent of portfolio value and decreased cash by one percent to keep the portfolio value constant. For an industry, the MCTR is the total risk change due to a 1% increase in the industry weight. A style factor's MCTR represents the change in total risk that would result from an increase in the portfolio's exposure to the style by 0.01 standard deviations.

At the factor level, MCTR can be defined as:

$$MCTR_k = \frac{\partial \sigma^P}{\partial x_k^P} \equiv \frac{1}{\sigma^P} \boldsymbol{\delta}_k^T \cdot F \cdot \boldsymbol{x}^{\boldsymbol{P}}$$

At the factor group level, MCTR can be defined as:

$$MCTR_g = \begin{cases} \sum_{k \in I^g} MCTR_k \cdot \dfrac{\left|x_k^P\right|}{\sum_{k \in I^g} \left|x_k^P\right|} & \text{if} \sum_{k \in I^g} \left|x_k^P\right| \neq 0 \\ 0 & \text{otherwise} \end{cases}$$

where:

x_k^P = portfolio exposure to common factor *k*.

Marginal Contribution to Active Total Risk (MCAR)

Marginal contribution to active total risk measures the effect of a small (1%) increase in exposure to a position, group, or common factor on the active total risk, or total tracking error, of a portfolio. This type of sensitivity analysis allows one to see which assets or common factors would have the largest impact on the active total risk of the portfolio, on the margin. For example, an asset's MCAR is approximately the increase in predicted active total risk (the amount that would be added to total tracking error) that would result if you increased the asset's weight by one percent of portfolio value and decreased cash by one percent to keep the portfolio value constant. For an industry, the MCAR is the active total risk change due to a 1% increase in the industry weight. A style factor's MCAR represents the change in active total risk that would result from an increase in the portfolio's exposure to the style by 0.01 standard deviations.

At the factor level, MCAR can be defined as:

$$MCAR_i = \frac{\partial \sigma^A}{\partial x_k^A} \equiv \frac{1}{\sigma^A} \boldsymbol{\delta}_k^T \cdot F \cdot \boldsymbol{x}^{\boldsymbol{A}}$$

At the factor group level, MCAR can be defined as:

$$MCAR_g = \begin{cases} \sum_{k \in I^g} MCAR_k \cdot \frac{\left|x_k^A\right|}{\sum_{k \in I^g} \left|x_k^A\right|} & \text{if} \sum_{k \in I^g} \left|x_k^A\right| \neq 0 \\ 0 & \text{otherwise} \end{cases}$$

where:

x_k^A = portfolio active exposure to common factor *k*.

Contribution to Total Risk (Cont. to TR)

The percent contribution to total risk decomposes the portfolio's common factor risk along the factors.

$$CTR_i = x_i MCTR_i S$$

where

x_i = Total exposure of portfolio to factor *i*

$MCTR_i$ = Marginal contribution to total risk from factor *i*

$$S = \frac{\sigma_{total}}{\sqrt{\sigma_{total}^2 - \sigma_{specific}^2}}$$

Note that $\sqrt{\sigma_{total}^2 - \sigma_{specific}^2}$ is the total common factor risk of the portfolio (including currency and market/currency covariance), and that $\sum_i^N CTR_i = \sqrt{\sigma_{total}^2 - \sigma_{specific}^2} = \sigma_{CF}$ (where N is the total number of factors in an analysis) for a given portfolio.

Note: If the market portfolio is set to "CASH," then specific risk and selection risk are identical, and specific risk in this context will match the selection risk in the Risk Decomposition Report. However, selection risk is interpreted in the residual space relative to its market portfolio, whereas specific risk is interpreted in total risk space (*i.e.,* market = "CASH.")

Contribution to Active Total Risk (Cont. to AR)

The percent contribution to active total risk decomposes the portfolio's common factor risk versus its benchmark along the factors.

$$CAR_i = x_{i,act} MCAR_i S_{act}$$

where

$x_{i,act}$ =Active exposure of portfolio to factor i

$MCAR_i$ =Marginal contribution to active risk from factor i

$$S_{act} = \frac{\sigma_{active}}{\sqrt{\sigma^2_{active} - \sigma^2_{specific,active}}}$$

Note that the sum of all CAR values will equal the active common factor risk of the portfolio (including currency risk and currency/market interaction).

Note: If the market portfolio is set to "CASH," then specific risk and selection risk are identical, and specific risk in this context will match the selection risk in the Risk Decomposition Report. However, selection risk is interpreted in the residual space relative to its market portfolio, whereas specific risk is interpreted in total risk space (*i.e.,* market = "CASH.")

Residual Exposure Reporting

Optional columns in BarraOne provide flexible, additive risk reporting that offers clients a way to drill down into sources of risk based on the residual exposures of the managed and active portfolio. Columns added to the Factor Exposure Breakdown Report facilitate residual-exposure-based factor group risk contribution drilldown (non-currency) and currency risk contribution drilldown reporting.

The Factor Exposure Breakdown Report provides a drilldown view into the Portfolio Risk Contribution and Active Portfolio Risk Contribution of the Common Factor Risk row in the Risk Decomposition Report. (Refer to the "Residual Exposure Risk Decomposition Report" on page 19.)

The Factor risk contributions in the Factor Exposure Breakdown Report are additive: in the example below (allowing for rounding errors), the total Cont. to TR (Residual) (1.87%) of all industries in the Factor Exposure Breakdown Report is equal to the Portfolio Risk Contribution of the Industry row in the Risk Decomposition Report.

The risk contribution from each factor is further decomposed into three components: 1) the residual exposure to the factor, 2) the volatility of the factor, and 3) the correlation of the factor with the portfolio. (For the managed, benchmark, and active portfolios, the Residual Exposure to the factor is the portfolio exposure to the factor minus the product of the portfolio local beta and the market factor exposure.) For instance, the Cont. to TR (Residual) of US Heavy Electrical Equipment (–1.38%) is the product of the factor's Portfolio Residual Exposure (–4.81%), Volatility (36.58%), and Portfolio Correlation (0.78). Although US Heavy Electrical Equipment is the most volatile industry factor on a standalone basis, it is positively correlated with the portfolio, and hence the negative exposure to the factor reduces portfolio risk.

The marginal contribution to total risk of a factor is the product of the factor volatility and its correlation with the portfolio. For instance, the MCTR of US Heavy Electrical Equipment (28.62%) is the product of the factor's Volatility (36.58%) and Portfolio Correlation (0.78).

The following section describes the Factor Exposure Breakdown Report columns for BarraOne to generate residual-exposure-based reports. Each report attributes the risk of the managed and active portfolio. The examples are based on the "Example Portfolios" on page 15.

Non-Currency Factor Group Risk Contribution Drilldowns

Industry Risk Contribution Drilldown

An example Factor Exposure Breakdown Report industry risk contribution drilldown is given by:

Factor	Volatility	MCTR	MCAR	Residual Exposure			Portfolio Correlation	Active Portfolio Correlation	Cont. to TR (Residual)	Cont. to AR (Residual)
				Portfolio	Benchmark	Active				
JP Automobiles And Parts	26.16%	19.30%	5.56%	25.87%	0.00%	25.87%	0.74	0.21	4.99%	1.44%
US Motor Vehicles and Parts	37.90%	28.08%	7.03%	5.60%	0.00%	5.60%	0.74	0.19	1.57%	0.39%
FR Banking	26.13%	19.57%	3.51%	4.39%	0.00%	4.39%	0.75	0.13	0.86%	0.15%
UK Banks	38.52%	25.28%	5.04%	2.66%	0.00%	2.66%	0.66	0.13	0.67%	0.13%
JP Consumer and Business Lo	30.30%	19.29%	1.51%	1.36%	0.00%	1.36%	0.64	0.05	0.26%	0.02%
US Financial Services	29.38%	21.59%	3.84%	1.35%	0.00%	1.35%	0.73	0.13	0.29%	0.05%
US Consumer Durables	32.20%	23.99%	3.65%	-0.36%	0.00%	-0.36%	0.75	0.11	-0.09%	-0.01%
US Media	35.91%	26.62%	3.55%	-0.62%	0.00%	-0.62%	0.74	0.10	-0.17%	-0.02%
US Medical Products	25.77%	18.01%	1.77%	-0.89%	0.00%	-0.89%	0.70	0.07	-0.16%	-0.02%
JP Insurance	27.88%	16.89%	0.91%	-1.01%	0.00%	-1.01%	0.61	0.03	-0.17%	-0.01%
JP Consumer Services	20.94%	14.04%	0.84%	-1.61%	0.00%	-1.61%	0.67	0.04	-0.23%	-0.01%
US Heavy Electrical Equipmen	36.58%	28.62%	3.56%	-4.81%	0.00%	-4.81%	0.78	0.10	-1.38%	-0.17%
JP Games	25.19%	14.81%	-1.27%	-5.23%	0.00%	-5.23%	0.59	-0.05	-0.77%	0.07%
FI Technology Hardware	28.25%	19.56%	0.59%	-7.87%	0.00%	-7.87%	0.69	0.02	-1.54%	-0.05%
JP Office and Home Electronic	25.53%	18.59%	1.51%	-12.26%	0.00%	-12.26%	0.73	0.06	-2.28%	-0.19%
Total	4.44%	1.87%	1.78%				0.42	0.40	1.87%	1.78%

Note: The Total row in the table does not appear in the Factor Exposure Breakdown Report, but it is displayed here only for purposes of the discussion above. Compare the values in the Total row corresponding to the equivalent columns in the Industry row of the "Residual Exposure Risk Decomposition Report" on page 19.

These are additional calculations and columns for the Factor Exposure Breakdown Report:

Portfolio Residual Exposure Vector

$$X^{P,R} = X^{P} - \beta_{loc}^{P} X_{loc}^{M}$$

where:

X^{P} = the portfolio exposure vector for all factors

β_{loc}^{P} = the portfolio local beta (defined earlier)

X_{loc}^{M} = the market exposure vector to all non-currency factors having exposure 0 to all currency factors

Benchmark Residual Exposure Vector

$$X^{B,R} = X^{B} - \beta_{loc}^{B} X_{loc}^{M}$$

where:

X^{B} = the benchmark exposure vector to all factors

β_{loc}^{B} = the benchmark local beta (defined earlier)

X_{loc}^{M} = the market exposure vector to all non-currency factors having exposure 0 to all currency factors

Active Residual Exposure Vector

$$X^{A,R} = X^{A} - \beta_{loc}^{A} X_{loc}^{M}$$

where:

X^{A} = the active exposure vector to all factors

β_{loc}^{A} = the active local beta (defined earlier)

X_{loc}^{M} = the market exposure vector to all non-currency factors having exposure 0 to all currency factors

Portfolio Correlation

$$\text{Portfolio Correlation} = \frac{(\text{MCTR})}{(\text{Volatility})}$$

Active Portfolio Correlation

$$\text{Active Portfolio Correlation} = \frac{(\text{MCAR})}{(\text{Volatility})}$$

Cont. to TR (Residual)

$$\text{Cont. to TR (Residual)} = \begin{pmatrix} \text{Portfolio} \\ \text{Residual} \\ \text{Exposure} \end{pmatrix} \times (\text{MCTR})$$

Cont. to AR (Residual)

$$\text{Cont. to AR (Residual)} = \begin{pmatrix} \text{Active} \\ \text{Residual} \\ \text{Exposure} \end{pmatrix} \times (\text{MCAR})$$

Total Cont. to TR (Residual)-the sum of the factor Cont. to TR (Residual)s:

$$\text{Cont. to TR (Residual)}_{Total} = \sum_{l} \begin{pmatrix} \text{Cont. to TR} \\ \text{(Residual)} \end{pmatrix}_{l}$$

Total MCTR-equal to total Cont. to TR (Residual):

$$\text{MCTR}_{Total} = \text{Cont. to TR (Residual)}_{Total}$$

Total Cont. to AR (Residual)-the sum of the factor Cont. to AR (Residual)s:

$$\text{Cont. to AR (Residual)}_{Total} = \sum_{l} \begin{pmatrix} \text{Cont. to AR} \\ \text{(Residual)} \end{pmatrix}_{l}$$

Total MCAR-equal to total Cont. to AR (Residual)

$$\text{MCAR}_{Total} = \text{Cont. to AR (Residual)}_{Total}$$

Style Risk Contribution Drilldown

The Factor Exposure Breakdown Report style risk contribution drilldown has the same columns as the industry risk contribution drilldown:

Factor	Volatility	MCTR	MCAR	Residual Exposure			Portfolio Correlation	Active Portfolio Correlation	Cont. to TR (Residual)	Cont. to AR (Residual)
				Portfolio	Benchmark	Active				
US Leverage	2.70%	1.02%	0.14%	0.36	0.00	0.36	0.38	0.05	0.36%	0.05%
US Momentum	6.36%	-1.92%	-0.10%	0.24	0.00	0.24	-0.30	-0.02	-0.47%	-0.03%
JP Size	4.17%	0.62%	0.55%	0.28	0.00	0.28	0.15	0.13	0.17%	0.15%
JP Interest Rate Sensitivity	1.59%	-0.25%	-0.03%	0.16	0.00	0.16	-0.16	-0.02	-0.04%	0.00%
US Trading Activity	2.36%	0.75%	0.20%	0.16	0.00	0.16	0.32	0.08	0.12%	0.03%
JP Foreign Sensitivity	1.93%	0.07%	0.13%	0.17	0.00	0.17	0.04	0.07	0.01%	0.02%
US Volatility	8.94%	6.12%	0.93%	0.15	0.00	0.15	0.69	0.10	0.89%	0.14%
US Earnings Variation	2.24%	0.26%	0.06%	0.13	0.00	0.13	0.12	0.03	0.03%	0.01%
FI Value	1.77%	0.31%	0.01%	0.09	0.00	0.09	0.18	0.01	0.03%	0.00%
UK Trading Activity	5.54%	2.28%	0.49%	0.06	0.00	0.06	0.41	0.09	0.13%	0.03%
JP Value	2.29%	0.36%	-0.12%	0.03	0.00	0.03	0.16	-0.05	0.01%	0.00%
FR Value	1.77%	0.31%	0.01%	0.05	0.00	0.05	0.18	0.01	0.02%	0.00%
FR Market Sensitivity	8.20%	5.54%	0.70%	0.05	0.00	0.05	0.68	0.09	0.25%	0.03%
FI Momentum	5.23%	-1.74%	-0.37%	0.04	0.00	0.04	-0.33	-0.07	-0.06%	-0.01%
FR Leverage	1.51%	0.21%	0.03%	0.04	0.00	0.04	0.14	0.02	0.01%	0.00%
JP Membership in NK225	7.07%	1.89%	0.08%	0.07	0.00	0.07	0.27	0.01	0.13%	0.01%
FR Growth	1.30%	0.58%	0.08%	0.03	0.00	0.03	0.44	0.06	0.02%	0.00%
FR Size	9.26%	4.62%	0.64%	0.02	0.00	0.02	0.50	0.07	0.11%	0.02%
FI Leverage	1.51%	0.21%	0.03%	0.02	0.00	0.02	0.14	0.02	0.00%	0.00%
UK Size	5.99%	2.21%	0.31%	0.02	0.00	0.02	0.37	0.05	0.05%	0.01%
FR Variability	2.94%	0.81%	0.09%	0.02	0.00	0.02	0.27	0.03	0.01%	0.00%
FI Size	9.26%	4.62%	0.64%	0.01	0.00	0.01	0.50	0.07	0.05%	0.01%
UK Yield	3.29%	0.24%	0.01%	0.01	0.00	0.01	0.07	0.00	0.00%	0.00%
FI Foreign Exposure	1.47%	0.57%	0.08%	0.01	0.00	0.01	0.39	0.06	0.00%	0.00%
UK Leverage	3.20%	-0.07%	0.05%	0.00	0.00	0.00	-0.02	0.02	0.00%	0.00%
UK Momentum	7.68%	-2.73%	-0.60%	0.00	0.00	0.00	-0.36	-0.08	0.01%	0.00%
UK Volatility	7.80%	4.43%	0.47%	0.01	0.00	0.01	0.57	0.06	0.04%	0.00%
FR Yield Risk Index	2.06%	0.69%	0.08%	-0.01	0.00	-0.01	0.34	0.04	0.00%	0.00%
US Size Non-Linearity	3.76%	0.64%	0.13%	-0.01	0.00	-0.01	0.17	0.03	0.00%	0.00%
FI Variability	2.94%	0.81%	0.09%	-0.01	0.00	-0.01	0.27	0.03	-0.01%	0.00%
FR Momentum	5.23%	-1.74%	-0.37%	-0.01	0.00	-0.01	-0.33	-0.07	0.02%	0.00%
FI Market Sensitivity	8.20%	5.54%	0.70%	-0.01	0.00	-0.01	0.68	0.09	-0.08%	-0.01%
UK Foreign Sensitivity	3.51%	0.09%	0.00%	-0.03	0.00	-0.03	0.03	0.00	0.00%	0.00%
FR Foreign Exposure	1.47%	0.57%	0.08%	-0.02	0.00	-0.02	0.39	0.06	-0.01%	0.00%
JP Growth	1.82%	0.06%	-0.03%	-0.03	0.00	-0.03	0.03	-0.02	0.00%	0.00%
FI Yield Risk Index	2.06%	0.69%	0.08%	-0.03	0.00	-0.03	0.34	0.04	-0.02%	0.00%
UK Growth	2.36%	0.51%	0.07%	-0.04	0.00	-0.04	0.22	0.03	-0.02%	0.00%
JP Volatility	5.49%	2.97%	0.18%	-0.08	0.00	-0.08	0.54	0.03	-0.23%	-0.01%
FI Growth	1.30%	0.58%	0.08%	-0.08	0.00	-0.08	0.44	0.06	-0.05%	-0.01%
US Growth	1.89%	0.24%	-0.03%	-0.12	0.00	-0.12	0.13	-0.01	-0.03%	0.00%
US Size	2.69%	0.29%	0.12%	-0.10	0.00	-0.10	0.11	0.05	-0.03%	-0.01%
UK Value	4.26%	1.11%	-0.06%	-0.12	0.00	-0.12	0.26	-0.01	-0.13%	0.01%
JP Trading Activity	3.83%	1.50%	-0.02%	-0.15	0.00	-0.15	0.39	-0.01	-0.23%	0.00%
US Currency Sensitivity	2.14%	0.08%	-0.03%	-0.18	0.00	-0.18	0.04	-0.01	-0.02%	0.01%
US Earnings Yield	3.43%	0.55%	-0.18%	-0.18	0.00	-0.18	0.16	-0.05	-0.10%	0.03%
US Yield	2.25%	-0.19%	-0.17%	-0.20	0.00	-0.20	-0.08	-0.07	0.04%	0.03%
US Value	2.84%	0.56%	-0.12%	-0.23	0.00	-0.23	0.20	-0.04	-0.13%	0.03%
JP Momentum	5.26%	-1.76%	-0.67%	-0.33	0.00	-0.33	-0.33	-0.13	0.59%	0.23%
JP Financial Leverage	2.26%	0.61%	-0.11%	-0.31	0.00	-0.31	0.27	-0.05	-0.19%	0.03%
Total	2.92%	1.28%	0.78%				0.44	0.27	1.28%	0.78%

Currency Risk Contribution Drilldown

The Factor Exposure Breakdown Report provides a drilldown view into the Portfolio Risk Contribution and Active Portfolio Risk Contribution that are displayed in the Currency Risk row of the Risk Decomposition Report. (Refer to the "Residual Exposure Risk Decomposition Report" on page 19.)

The Currency Risk contributions in the Factor Exposure Breakdown Report are additive: in the example below (allowing for rounding errors), the total Cont. to TR (Contribution to Total Risk) (–0.04%) of all currencies in the Factor Exposure Breakdown Report is equal to the Portfolio Risk Contribution of the Currency Risk row in the Risk Decomposition Report.

The risk contribution of each currency is further decomposed into three components: 1) the exposure to the factor, 2) the factor volatility, and 3) the factor correlation with the portfolio. (In contrast to local factors, currency exposures are reported on a non-residual basis, because Market Timing Risk is accounted as a component of Local Market Risk.) For example, the Cont. to TR of the yen (–0.52%) is the product of its Portfolio Exposure (54%), Volatility (11.13%), and Portfolio Correlation (–0.09). Although the yen is the most volatile currency on a standalone basis, it is negatively correlated with the portfolio, and hence the positive exposure reduces portfolio risk.

The marginal contribution to total risk of a currency is the product of its volatility and correlation with the managed portfolio. For instance, the MCTR of the yen (–0.97%) is the product of its Volatility (11.13%) and Portfolio Correlation (–0.09).

BarraOne provides Active Currency columns for an enhanced analysis of the contribution of currencies to tracking error. These columns attribute active risk to currencies on the basis of each currency's return relative to the benchmark currency strategy as given by the net benchmark currency exposures. For instance, consider a portfolio manager with an MSCI Japan mandate and a US dollar base currency. If this manager selects a US stock, then subsequent USD/JPY exchange rate movements will generate tracking error. In the active enhanced currency analysis, this tracking error is attributed to the implicit US dollar exposure generated by the US stock position, and the risk is associated with the performance of the US dollar relative to the benchmark yen strategy.

In active currency analysis, the risk contribution of each currency is decomposed into three components: 1) the active exposure to the currency, 2) the volatility of the currency return relative to the benchmark currency strategy, and 3) the correlation of the currency relative return with the active portfolio. For example, the Active Currency Contrib of the yen (–0.01%) is the product of its Active Exposure (4%), Active Currency Risk (5.77%), and Active Currency Corr (–0.05). Although the yen is the most volatile currency on a standalone basis, the relative return of the yen is the least volatile (5.77%). This is intuitive, since the yen is the largest component (50%) of the benchmark currency strategy.

The active currency marginal contribution to tracking error is the product of the active currency risk and the currency correlation with the active portfolio. For instance, the Active Currency MCTE of the yen (–0.31%) is the product of the Active Currency Risk (5.77%) and the Active Currency Correlation (–0.05).

An example Factor Exposure Breakdown Report currency risk contribution drilldown is given by:

Factor	Volatility	Exposure			MCTR	Cont. to TR	Portfolio Correlation	Active Currency Risk	Active Currency Correlation	Active Currency MCTE	Active Currency Contribution
		Portfolio	Benchmark	Active							
US Dollar	0.00%	0.21	0.22	-0.01	0.00%	0.00%	0.00	6.13%	0.04	0.27%	0.00%
British Pound Sterling	8.41%	0.10	0.08	0.02	1.44%	0.15%	0.17	9.27%	0.09	0.85%	0.02%
Euro	9.13%	0.15	0.20	-0.05	2.28%	0.34%	0.25	8.64%	0.01	0.12%	-0.01%
Japanese Yen	11.13%	0.54	0.50	0.04	-0.97%	-0.52%	-0.09	5.77%	-0.05	-0.31%	-0.01%
Total	6.41%				-0.04%	-0.04%	-0.01	0.57%	-0.01	0.00%	0.00%

Note: The Total row in the table does not appear in the Factor Exposure Breakdown Report, but it is displayed here only for purposes of the discussion above. Compare the numbers in the Total row with the corresponding columns in the Currency Risk row of the "Residual Exposure Risk Decomposition Report" on page 19. Note also that for currency factors, exposures and residual exposures are always equal.

These are the additional columns for the Factor Exposure Breakdown Report:

Portfolio Correlation

$$\text{Portfolio Correlation}=\frac{(\text{MCTR})}{(\text{Volatility})}$$

Active Currency Risk

$$\text{Active Currency Risk} = \sqrt{\left(X_k - X^B\right)F(X_k - X^B)'}$$

where:

X_k = the factor exposure vector with unit exposure to currency k and 0 exposure to all other factors

X^B = the currency component of the benchmark factor exposure vector, i.e., all non-currency exposures set to 0

Note: Zero for all non-currency factors.

Active Currency Correlation

$$\text{Active Currency Corr}=\frac{\begin{pmatrix}\text{Active}\\ \text{Currency}\\ \text{MCTE}\end{pmatrix}}{\begin{pmatrix}\text{Active}\\ \text{Currency}\\ \text{Risk}\end{pmatrix}}$$

Note: Zero for all non-currency factors.

Active Currency MCTE

$$\text{Active Currency MCTE}_k = \text{MCAR}_k - \text{CMCAR}^B$$

where:

$$\text{CMCAR}^B = \sum_k X_k^B MCAR_k$$

X_k^B = the exposure of the benchmark portfolio to currency factor k

Note: Zero for all non-currency factors.

Active Currency Contribution

$$\text{Active Currency Contribution} = \left(\begin{array}{c}\text{Active}\\ \text{Exposure}\end{array}\right) \times \left(\begin{array}{c}\text{Active}\\ \text{Currency}\\ \text{MCTE}\end{array}\right) \times \left(\frac{1}{100}\right)$$

Note: Zero for all non-currency factors.

Marginal Contribution to Residual Risk Reporting

In the MCRR version of the Risk Decomposition Report (see "Marginal Contribution to Residual Risk Reporting" on page 22, the Total Risk is decomposed into Mkt Timing Risk and Residual Risk columns, and each column is further decomposed among rows of factor groups and Selection Risk.

Optional columns are available in the Factor Exposure Breakdown Report to facilitate reporting using this MCRR approach, which is applicable when the user would like to drill into the both the Market Timing Risk Contribution and Residual Risk Contribution on the basis of the market timing return and the residual return components of each source of risk. Columns added to the Factor Exposure Breakdown Report facilitate residual-return-based factor group risk contribution drilldown reporting.

Non-Currency Factor Group (Industries, Styles, etc.) Risk Contribution Drilldowns — Managed Portfolio

The Factor Exposure Breakdown Report provides a drilldown view into the Portfolio Risk Contribution, Portfolio Mkt Timing Risk Contribution, and Portfolio Residual Risk Contribution of the Common Factor Risk row of the Risk Decomposition Report. (Refer to "Risk Decomposition Report (Residual Return Based) — Managed Portfolio" on page 23.) An example industries risk contribution drilldown for the managed portfolio is displayed below.

The Factor risk contributions in the Factor Exposure Breakdown Report are additive: in the example below (allowing for rounding errors), the sum of the Cont. to TR (20.69%) for all industries in the Factor Exposure Breakdown Report is equal to the Portfolio Risk Contribution of the Industry Risk Source in the Risk Decomposition Report; the sum of the Mkt Timing Risk Contribution (18.43%) for all industries in the Factor Exposure Breakdown Report is equal to the Portfolio Mkt Timing Risk Contribution of the Industry Risk Source; the sum of the Residual Contribution (2.26%) for all industries in the Factor Exposure Breakdown Report is equal to the Portfolio Residual Risk Contribution of the Industry Risk Source.

This decomposition is respected at the factor level. For instance, the Cont. to TR of JP Automobiles and Parts (4.99%) is the sum of the security's Mkt Timing Risk Contribution (4.42%) and Residual Contribution (0.57%).

The Cont. to TR, Mkt Timing Risk Contribution, and Residual Contribution of each factor is further decomposed into three components: 1) the factor portfolio exposure, 2) the volatility of the factor total, market timing, or residual components of return with respect to the market portfolio, and 3) the factor correlation of the component with the managed portfolio. For instance, the factor Residual Contribution of JP Automobiles and Parts (0.57%) is the product of the security's Portfolio Exposure (25.87%), Residual Volatility (18.49%), and Residual Correlation (0.12).

The component Marginal Contribution to Total Risk of a factor is the product of the factor component volatility and the factor component correlation with the managed portfolio. For instance, the Residual MCTR of JP Automobiles and Parts (2.22%) is the product of the factor's Residual Volatility (18.49%) and Residual Correlation (0.12).

An example Factor Exposure Breakdown Report industries risk contribution drilldown for the managed portfolio is given by:

Factor	Volatility	Exposure			MCTR	Cont. to TR	Portfolio Correlation	Local Beta (Mkt)	Mkt Timing Volatility	Mkt Timing Correlation	Mkt Timing MCTR	Mkt Timing Risk Contribution	Residual Volatility	Residual Correlation	Residual MCTR	Residual Contribution
		Portfolio	Benchmark	Active												
JP Automobiles And Parts	26.16%	25.87%	0.00%	25.87%	19.30%	4.99%	0.74	0.61	18.51%	0.92	17.08%	4.42%	18.49%	0.12	2.22%	0.57%
US Motor Vehicles and Parts	37.90%	5.60%	0.00%	5.60%	28.08%	1.57%	0.74	0.84	25.39%	0.92	23.44%	1.31%	28.13%	0.16	4.64%	0.26%
FR Banking	26.13%	4.39%	0.00%	4.39%	19.57%	0.86%	0.75	0.61	18.56%	0.92	17.13%	0.75%	18.40%	0.13	2.44%	0.11%
UK Banks	38.52%	10.26%	8.13%	2.13%	25.28%	2.59%	0.66	0.77	23.49%	0.92	21.69%	2.22%	30.52%	0.12	3.60%	0.37%
JP Consumer and Business Loans	30.30%	1.36%	0.00%	1.36%	19.29%	0.26%	0.64	0.63	19.25%	0.92	17.77%	0.24%	23.41%	0.07	1.52%	0.02%
US Financial Services	29.38%	6.54%	5.55%	0.99%	21.59%	1.41%	0.73	0.64	19.54%	0.92	18.04%	1.18%	21.95%	0.16	3.55%	0.23%
US Consumer Durables	32.20%	0.47%	0.89%	-0.41%	23.99%	0.11%	0.75	0.73	22.23%	0.92	20.53%	0.10%	23.29%	0.15	3.46%	0.02%
US Media	35.91%	0.83%	1.55%	-0.73%	26.62%	0.22%	0.74	0.81	24.76%	0.92	22.86%	0.19%	26.00%	0.14	3.76%	0.03%
US Medical Products	25.77%	1.18%	2.22%	-1.04%	18.01%	0.21%	0.70	0.55	16.60%	0.92	15.33%	0.18%	19.71%	0.14	2.68%	0.03%
JP Insurance	27.88%	1.33%	2.50%	-1.17%	16.89%	0.23%	0.61	0.55	16.85%	0.92	15.55%	0.21%	22.22%	0.06	1.34%	0.02%
JP Consumer Services	20.94%	2.13%	4.01%	-1.87%	14.04%	0.30%	0.67	0.47	14.23%	0.92	13.14%	0.28%	15.36%	0.06	0.90%	0.02%
US Heavy Electrical Equipment	36.58%	6.39%	11.99%	-5.60%	28.62%	1.83%	0.78	0.87	26.51%	0.92	24.47%	1.56%	25.21%	0.16	4.15%	0.27%
JP Games	25.19%	6.94%	13.02%	-6.08%	14.81%	1.03%	0.59	0.52	15.85%	0.92	14.64%	1.02%	19.58%	0.01	0.18%	0.01%
FI Technology Hardware	28.25%	10.44%	19.60%	-9.16%	19.56%	2.04%	0.69	0.65	19.90%	0.92	18.37%	1.92%	20.05%	0.06	1.19%	0.12%
JP Office and Home Electronics	25.53%	16.27%	30.54%	-14.27%	18.59%	3.02%	0.73	0.62	18.95%	0.92	17.49%	2.85%	17.10%	0.06	1.10%	0.18%
Total	22.96%				20.69%	20.69%	0.90	0.66	19.96%	0.92	18.43%	18.43%	11.35%	0.20	2.26%	2.26%

Note: The Total row in the table does not appear in the Factor Exposure Breakdown Report, but it is displayed here only for purposes of the discussion above. Compare the values in the Total row corresponding to the equivalent columns in the Industry row of the "Risk Decomposition Report (Residual Return Based) — Managed Portfolio" on page 23.

These are the additional columns for the Factor Exposure Breakdown Report:

Portfolio Correlation

$$\text{Portfolio Correlation} = \frac{(\text{MCTR})}{(\text{Volatility})}$$

Local Beta (Mkt)

$$\text{Local Beta (Mkt)} = \frac{X_I F X^{M'}}{\sigma_{LM}^2}$$

where:

X_I has exposure 1 to the given factor and exposure 0 to all other factors

$X^{M'}$ = the vector of market portfolio exposures to non-currency factors

σ_{LM} = the local market risk of the market portfolio

Mkt Timing Volatility

$$\text{Mkt Timing Volatility} = \left|\begin{matrix}\text{Local} \\ \text{Beta (Mkt)}\end{matrix}\right| \times \sigma_{LM}$$

where:

| | denotes absolute value

Mkt Timing Correlation

$$\text{Mkt Timing Correlation} = \frac{\begin{pmatrix}\text{Mkt} \\ \text{Timing} \\ \text{MCTR}\end{pmatrix}}{\begin{pmatrix}\text{Mkt} \\ \text{Timing} \\ \text{Volatility}\end{pmatrix}}$$

Mkt Timing MCTR

$$\text{Mkt Timing MCTR} = \begin{pmatrix}\text{Local} \\ \text{Beta (Mkt)}\end{pmatrix} \times LMCTR^{M}$$

At the factor group level, Mkt Timing MCTR is defined as the sum product of each constituent factor's Mkt Timing MCTR and the portfolio exposure to that factor.

The auxiliary quantity $LMCTR^{M}$ is given by:

$$LMCTR^{M} = \frac{X^{M} F X^{P'} + w^{M} \Delta w^{P'}}{\sigma_{RP}}$$

where:

X^{M} = the vector of market portfolio exposures to non-currency factors

$X^{P'}$ = the vector of managed portfolio exposures to all factors, including currency

w^{M} = the effective weight vector of the market portfolio

$w^{P'}$ = the effective weight vector of the managed portfolio

σ_{RP} = the total risk of the managed portfolio

Mkt Timing Risk Contribution

$$\text{Mkt Timing Risk Contribution} = \begin{pmatrix}\text{Portfolio} \\ \text{Exposure}\end{pmatrix} \times \begin{pmatrix}\text{Mkt} \\ \text{Timing} \\ \text{MCTR}\end{pmatrix}$$

Residual Volatility

$$\text{Residual Volatility} = \sqrt{(\text{Volatility})^2 - \begin{pmatrix}\text{Mkt}\\\text{Timing}\\\text{Volatility}\end{pmatrix}^2}$$

Residual Correlation

$$\text{Residual Correlation} = \frac{\begin{pmatrix}\text{Residual}\\\text{MCTR}\end{pmatrix}}{\begin{pmatrix}\text{Residual}\\\text{Volatility}\end{pmatrix}}$$

Residual MCTR

$$\text{Residual MCTR} = (\text{MCTR}) - \begin{pmatrix}\text{Mkt}\\\text{Timing}\\\text{MCTR}\end{pmatrix}$$

At the factor group level, Residual MCTR is defined as the sum product of each constituent factor's Residual MCTR and the portfolio exposure to that factor.

Residual Contribution

$$\text{Residual Contribution} = \begin{pmatrix}\text{Portfolio}\\\text{Exposure}\end{pmatrix} \times \begin{pmatrix}\text{Residual}\\\text{MCTR}\end{pmatrix}$$

Non-Currency Factor Group (Industries, Styles, etc.) Risk Contribution Drilldowns — Active Portfolio

The Factor Exposure Breakdown Report provides a drilldown view into the Active Portfolio Risk Contribution, Active Portfolio Mkt Timing Risk Contribution, and Active Portfolio Residual Risk Contribution of the Common Factor Risk row of the Risk Decomposition Report. (Refer to the "Risk Decomposition Report (Residual Return Based) — Active Portfolio" on page 26.) An example industries risk contribution drilldown for the active portfolio is displayed below.

The Factor risk contributions in the Factor Exposure Breakdown Report are additive: in the example below (allowing for rounding errors), the Cont. to AR (1.67%) for all industries in the Factor Exposure Breakdown Report is equal to the Active Portfolio Risk Contribution of the Industry Risk Source in the Risk Decomposition Report; the sum of the Active Mkt Timing Risk Contribution (–0.02%) for all industries in the Factor Exposure Breakdown Report is equal to the Active Mkt Timing Risk Contribution of the Industry Risk Source; the sum of the Active Residual Contribution (1.69%) for all industries in the Factor Exposure Breakdown Report is equal to the Active Residual Risk Contribution of the Industry Risk Source.

This decomposition is respected at the factor level. For instance, the Cont. to AR of JP Automobiles and Parts (1.44%) is the sum of the security's Active Mkt Timing Risk Contribution (–1.00%) and Active Residual Contribution (2.44%).

The Cont. to AR, Active Market Timing Risk Contribution, and Active Residual Contribution of each factor is further decomposed into three components: 1) the factor active exposure, 2) the volatility of the factor total, market timing, or residual components of return with respect to the market portfolio, and 3) the correlation of the component with the active portfolio. For instance, the Active Residual Contribution of the JP Automobiles and Parts (2.44%) is the product of the factor's Active Exposure (25.87%), Residual Volatility (18.49%) and Active Residual Correlation (0.51).

The component MCAR (Marginal Contribution to Active Risk) of a factor is the product of the factor component Volatility and the factor component Correlation with the active portfolio. For instance, the Residual MCAR of JP Automobiles and Parts (9.43%) is the product of the security's Residual Volatility (18.49%) and Active Residual Correlation (0.51).

An example Factor Exposure Breakdown Report industries risk contribution drilldown for the active portfolio is given by:

Factor	Volatility	Exposure			MCAR	Cont. to AR	Active Portfolio Correlation	Local Beta (Mkt)	Mkt Timing Volatility	Residual Volatility	Mkt Timing Active Correlation	Mkt Timing MCAR	Active Mkt Timing Risk Contribution	Active Resiual Correlation	Residual MCAR	Active Residual Contribution
		Portfolio	Benchmark	Active												
JP Automobiles And Parts	26.16%	25.87%	0.00%	25.87%	5.56%	1.44%	0.21	0.61	18.51%	18.49%	-0.21	-3.88%	-1.00%	0.51	9.43%	2.44%
US Motor Vehicles and Parts	37.90%	5.60%	0.00%	5.60%	7.03%	0.39%	0.19	0.84	25.39%	28.13%	-0.21	-5.32%	-0.30%	0.44	12.36%	0.69%
FR Banking	26.13%	4.39%	0.00%	4.39%	3.51%	0.15%	0.13	0.61	18.56%	18.40%	-0.21	-3.89%	-0.17%	0.40	7.40%	0.32%
UK Banks	38.52%	10.26%	8.13%	2.13%	5.04%	0.11%	0.13	0.77	23.49%	30.52%	-0.21	-4.92%	-0.10%	0.33	9.97%	0.21%
JP Consumer and Business	30.30%	1.36%	0.00%	1.36%	1.51%	0.02%	0.05	0.63	19.25%	23.41%	-0.21	-4.03%	-0.05%	0.24	5.55%	0.08%
US Financial Services	29.38%	6.54%	5.55%	0.99%	3.84%	0.04%	0.13	0.64	19.54%	21.95%	-0.21	-4.09%	-0.04%	0.36	7.94%	0.08%
US Consumer Durables	32.20%	0.47%	0.89%	-0.41%	3.65%	-0.02%	0.11	0.73	22.23%	23.29%	-0.21	-4.66%	0.02%	0.36	8.30%	-0.03%
US Media	35.91%	0.83%	1.55%	-0.73%	3.55%	-0.03%	0.10	0.81	24.76%	26.00%	-0.21	-5.19%	0.04%	0.34	8.74%	-0.06%
US Medical Products	25.77%	1.18%	2.22%	-1.04%	1.77%	-0.02%	0.07	0.55	16.60%	19.71%	-0.21	-3.48%	0.04%	0.27	5.25%	-0.05%
JP Insurance	27.88%	1.33%	2.50%	-1.17%	0.91%	-0.01%	0.03	0.55	16.85%	22.22%	-0.21	-3.53%	0.04%	0.20	4.44%	-0.05%
JP Consumer Services	20.94%	2.13%	4.01%	-1.87%	0.84%	-0.02%	0.04	0.47	14.23%	15.36%	-0.21	-2.98%	0.06%	0.25	3.82%	-0.07%
US Heavy Electrical Equipme	36.58%	6.39%	11.99%	-5.60%	3.56%	-0.20%	0.10	0.87	26.51%	25.21%	-0.21	-5.55%	0.31%	0.36	9.11%	-0.51%
JP Games	25.19%	6.94%	13.02%	-6.08%	-1.27%	0.08%	-0.05	0.52	15.85%	19.58%	-0.21	-3.32%	0.20%	0.10	2.05%	-0.12%
FI Technology Hardware	28.25%	10.44%	19.60%	-9.16%	0.59%	-0.05%	0.02	0.65	19.90%	20.05%	-0.21	-4.17%	0.38%	0.24	4.76%	-0.44%
JP Office and Home Electror	25.53%	16.27%	30.54%	-14.27%	1.51%	-0.22%	0.06	0.62	18.95%	17.10%	-0.21	-3.97%	0.57%	0.32	5.49%	-0.78%
Total	4.19%				1.67%	1.67%	0.40	0.00	0.10%	4.19%	-0.21	-0.02%	-0.02%	0.40	1.69%	1.69%

Note: The Total row in the table does not appear in the Factor Exposure Breakdown Report, but it is displayed here only for purposes of the discussion above. Compare the values in the Total row corresponding to the equivalent columns in the Industry row of the "Risk Decomposition Report (Residual Return Based) — Active Portfolio" on page 26

These are the additional columns for the Factor Exposure Breakdown Report:

Active Portfolio Correlation

$$\text{Active Portfolio Correlation}=\frac{(\text{MCAR})}{(\text{Volatility})}$$

Cont. to AR

$$\text{Cont. to AR}=\begin{pmatrix}\text{Eff Active}\\ \text{Weight (\%)}\end{pmatrix}\times(\text{MCTE})$$

Local Beta (Mkt)

$$\text{Local Beta (Mkt)}=\frac{X_I F X^{M'}}{\sigma_{LM}^2}$$

where:

X_I has exposure 1 to the given factor and exposure 0 to all other factors

$X^{M'}$ = the vector of market portfolio exposures to non-currency factors

σ_{LM} = the local market risk of the market portfolio

Mkt Timing Volatility

$$\text{Mkt Timing Volatility}=\left|\begin{matrix}\text{Local Beta}\\ \text{(Mkt)}\end{matrix}\right|\times\sigma_{LM}$$

where:

σ_{LM} = the local market risk of the market portfolio

| | denotes absolute value

Residual Volatility

$$\text{Residual Volatility}=\sqrt{(\text{Volatility})^2-\begin{pmatrix}\text{Mkt}\\ \text{Timing}\\ \text{Volatility}\end{pmatrix}^2}$$

Mkt Timing Active Correlation

$$\text{Mkt Timing Active Correlation}=\frac{\begin{pmatrix}\text{Mkt}\\ \text{Timing}\\ \text{MCAR}\end{pmatrix}}{\begin{pmatrix}\text{Mkt}\\ \text{Timing}\\ \text{Volatility}\end{pmatrix}}$$

Mkt Timing MCAR

$$\text{Mkt Timing MCAR} = \begin{pmatrix} \text{Local Beta} \\ \text{(Mkt)} \end{pmatrix} \times LMCAR^{M}$$

At the factor group level, Mkt Timing MCAR is defined as the sum product of each constituent factor's Mkt Timing MCAR and the active exposure to that factor.

The auxiliary quantity $LMCAR^{M}$ is given by:

$$LMCAR^{M} = \frac{X^{M} F X^{A'} + w^{M} \Delta w^{A'}}{\sigma_{RA}}$$

where:

X^{M} = the vector of market portfolio exposures to non-currency factors

$X^{A'}$ = the vector of all factor active portfolio exposures, including currency factors

w^{M} = the effective weight vector of the market portfolio

$w^{A'}$ = the effective weight vector of the active portfolio

σ_{RA} = the total risk of the active portfolio

Active Mkt Timing Risk Contribution

$$\text{Active Mkt Timing Risk Contribution} = \begin{pmatrix} \text{Active} \\ \text{Exposure} \end{pmatrix} \times \begin{pmatrix} \text{Mkt} \\ \text{Timing} \\ \text{MCAR} \end{pmatrix}$$

Active Residual Correlation

$$\text{Active Residual Correlation} = \frac{\begin{pmatrix} \text{Residual} \\ \text{MCAR} \end{pmatrix}}{\begin{pmatrix} \text{Residual} \\ \text{Volatility} \end{pmatrix}}$$

Residual MCAR

$$\text{Residual MCAR} = (\text{MCAR}) - \begin{pmatrix} \text{Mkt} \\ \text{Timing} \\ \text{MCAR} \end{pmatrix}$$

At the factor group level, Residual MCAR is defined as the sum product of each constituent factor's Residual MCAR and the active exposure to that factor.

Active Residual Contribution

$$\text{Active Residual Contribution} = \begin{pmatrix} \text{Active} \\ \text{Exposure} \end{pmatrix} \times \begin{pmatrix} \text{Residual} \\ \text{MCAR} \end{pmatrix}$$

Allocation-Selection Report

Overview

While BarraOne computes risk using the Barra Integrated Model (BIM), which has a fixed structure, its reporting of that risk can be tailored to each client's investment process. For example, the Allocation-Selection report presents the active total risk of a fund in terms of two common investment decisions: a top-down allocation decision and a bottom-up security selection decision. BarraOne provides two methods of analyzing the allocation-selection decision: variance and x-sigma-rho.

Variance Allocation-Selection

This section highlights the key features of, and intuition behind, the Variance Allocation-Selection Report.

Background

The application of a two-stage investment process is well established in the industry, with many firms employing analysts and portfolio managers to make stock selection decisions within an area of expertise (*e.g.,* industry/sector, country/region), in the context of a previously established allocation of capital to those groups of assets. Brinson and Fachler[1] established a framework for the analysis of performance within such an allocation-selection framework. The BarraOne Allocation-Selection report leverages those insights in order to decompose the risk of a fund along similar lines.

Let us start from Brinson and Fachler's decomposition of active return into portions due to allocation and selection decisions, along with a third portion coming from the interaction between those two types of decisions:

$$\mathrm{R}_{\text{active}} = \underbrace{\sum_n \left(w_P^n - w_B^n\right)\left(r_B^n - r_B\right)}_{\text{Return from allocation decision}} + \underbrace{\sum_n w_B^n \left(r_P^n - r_B^n\right)}_{\text{Return from selection decision}} + \underbrace{\sum_n \left(w_P^n - w_B^n\right)\left(r_P^n - r_B^n\right)}_{\text{Return from interaction}}$$

where:

r_P^{n} = return of group *n* in the managed portfolio

r_B^{n} = return of group *n* in the benchmark

r_{B} = return of the benchmark

1 Brinson, Gary P., and Nimrod Fachler, "Measuring Non-US Equity Portfolio Performance," Journal of Portfolio Management, Spring 1985, pp. 73-76.

w_P^{n} = weight of group *n* in the managed portfolio

w_B^{n} = weight of group *n* in the benchmark

The interaction term can be combined with the selection term, arriving at:

$$R_{\text{active}} = \underbrace{\sum_n \left(w_P^n - w_B^n\right)\left(r_B^n - r_B\right)}_{\text{Return from allocation decision}} + \underbrace{\sum_n w_P^n \left(r_P^n - r_B^n\right)}_{\text{Return from selection decision}}$$

By extending this breakdown of active return, each asset's active weight in the portfolio can be decomposed into a portion resulting from allocation decisions and a portion resulting from selection decisions, as follows:

$$a_i^n \begin{cases} \left(w_P^n - w_B^n\right)\dfrac{w_{B,i}}{w_B^n} \equiv \left(\dfrac{w_P^n}{w_B^n} - 1\right) w_{B,i} & \text{if } w_B^n \neq 0 \\ w_{P,i} & \text{if } w_B^n = 0 \end{cases} \quad \text{for all } i \in n$$

where:

a_i^{n} = weight of asset *i* in allocation group *n*

$w_{B,i}$ = weight of asset *i* in the benchmark

$w_{P,i}$ = weight of asset *i* in the managed portfolio

$$s_i^n \begin{cases} \left(w_{P,i} - \dfrac{w_P^n}{w_B^n} w_{B,i}\right) & \text{if } w_B^n \neq 0 \\ 0 & \text{if } w_B^n = 0 \end{cases} \quad \text{for all } i \in n$$

Note that if you sum a_i^{n} and s_i^{n}, the result is $w_{P,i}$ - $w_{B,i}$, namely, the asset's active weight.

Decomposing each asset's active weight into allocation and selection components enables the decomposition of the managed portfolio, with its active total risk exposures, into allocation and selection subportfolios for each group (country, sector, *etc.*). Each of these subportfolios will have its active total risk exposures defined by the active weights for its assets and the risk exposures of those assets.

Allocation Risk

Allocation risk for each group of assets is calculated as:

$$\sqrt{\sigma^2_{\text{allocation group}}}$$

Percent Contribution to Allocation Risk (%CR to Allocation Risk)

Each group's percent contribution to allocation risk is calculated as:

$$\frac{(\text{marginal contribution of the group}) \times (\text{weight of the group})}{\text{total allocation risk}}$$

Allocation Risk (%)

Each group's Allocation Risk (%) is calculated as:

$$\frac{\text{variance of the group}}{\text{total allocation variance}}$$

Using the Variance Allocation-Selection Report

In order to use the report, a managed portfolio with an assigned benchmark must first be loaded. Next, a grouping scheme needs to be applied. The grouping scheme should correspond to the allocation decision driving the investment process. Here are a couple of examples.

The first case is a managed portfolio that reflects an active stock selection decision within one of its sectors, but no active allocation decisions. As shown in the table, Volvo is overweight 2.5%, and General Electric is underweight -2.5% within the Industrials sector, leaving the sector as a whole benchmark neutral.

Table 18: Sample Positions Report

Grouping: GICS Sector	Asset ID	Asset Name	Active Weight(%)
by: distinct			**0.00%**
Industrials			0.00%
	928856202	VOLVO AB SER. A	2.50%
	369604103	GENERAL ELECTRIC CO	-2.50%
	D69671218	SIEMENS	0.00%
Consumer Staples			0.00%
	931142103	WAL MART STORES INC	0.00%
	H57312466	NESTLE R	0.00%
Energy			0.00%
	P78331116	PETROBAS ON	0.00%
	G7690A100	ROYAL DUTCH SHELL A	0.00%
Financials			0.00%
	J44497105	MITSUBISHI UFJ FINANCIAL GROUP	0.00%
	F43638141	SOCIETE GENERALE	0.00%

In the Allocation-Selection report below, it is shown that, since the security selection decision is the only source of active total risk, all of the portfolio's active total risk is isolated within the Selection Risk column. A comparison with the traditional Risk Decomposition report (second table below), makes clear that the 67 bps. shown as selection risk includes all sources of risk in the traditional decomposition, *i.e.,* common factor, selection, and currency.

Table 19: Sample Allocation-Selection Report — Selection Only (Variance)

Group	Allocation Risk	Selection Risk	A-S Interaction	Weight(%)	Active Weight(%)
Industrials	0.00	0.00	0.00	25.00%	0.00%
Consumer Staples	0.00	0.00	0.00	25.00%	0.00%
Energy	0.00	0.00	0.00	25.00%	0.00%
Financials	0.00	0.00	0.00	25.00%	0.00%
Interaction	**N/A**	**N/A**	**0.00**	**N/A**	**N/A**
Common Factor Risk	**0.00**	**0.39**	**0.00**	**N/A**	**N/A**
Selection Risk	**0.00**	**0.51**	**0.00**	**N/A**	**N/A**
Total Risk	**0.00**	**0.67**	**0.00**	**100.00%**	**0.00%**

Table 20: Sample Risk Decomposition Report

Risk Source	Portfolio Risk	Active Risk
Local Market Risk	13.70	0.65
Common Factor Risk	12.94	0.39
Industry	12.32	0.36
Style	3.25	0.17
Factor Interaction	N/A	N/A
Selection Risk	4.49	0.51
Currency Risk	6.61	0.23
Currency/Market Interaction	N/A	N/A
Total Risk	15.87	0.67

In the next example, the managed portfolio is modified slightly to include both allocation and selection decisions. Notice the introduction of a new sector, Telecom Services, in the managed portfolio. The benchmark has no weight in this sector, so this represents a pure allocation decision. Since this sector is overweight, another sector needs to be underweight. This is accomplished by underweighting the Industrials sector by 5%, representing the second allocation decision. This underweighting is accomplished by increasing the previous underweight in General Electric, while Volvo continues to be overweight. These are security selection decisions.

Table 21: Sample Positions Report

Grouping: GICS Sector	Asset ID	Asset Name	Active Weight(%)
by: distinct			**0.00%**
Telecom Services			5.00%
	Y14965100	CHINA MOBILE LTD	5.00%
Industrials			-5.00%
	928856202	VOLVO AB SER. A	2.50%
	369604103	GENERAL ELECTRIC CO	-7.50%
	D69671218	SIEMENS	0.00%
Consumer Staples			0.00%
	931142103	WAL MART STORES INC	0.00%
	H57312466	NESTLE R	0.00%
Energy			0.00%
	P78331116	PETROBAS ON	0.00%
	G7690A100	ROYAL DUTCH SHELL A	0.00%
Financials			0.00%
	J44497105	MITSUBISHI UFJ FINANCIAL GROUP	0.00%
	F43638141	SOCIETE GENERALE	0.00%

To the see the implications of these allocation and selection decisions, let us again turn to the Allocation-Selection report.

Table 22: Sample Allocation-Selection Report — Both (Variance)

Group	Allocation Risk	Selection Risk	A-S Interaction	Active Weight(%)	Active Risk
Telecom Services	2.131	0.000	0.000	5.000%	2.131
Industrials	0.953	1.081	-0.592	-5.000%	1.219
Consumer Staples	0.000	0.000	0.000	0.000%	0.000
Energy	0.000	0.000	0.000	0.000%	0.000
Financials	0.000	0.000	0.000	0.000%	0.000
Interaction	**N/A**	**N/A**	**0.587**	**N/A**	**N/A**
Common Factor Risk	**1.486**	**0.720**	**-0.228**	**N/A**	**1.581**
Selection Risk	**1.504**	**0.773**	**0.141**	**N/A**	**1.732**
Total Risk	**2.101**	**1.081**	**-0.005**	**0.000%**	**2.362**

This shows the risk from the allocation decision to invest in the Telecom Services sector. Because this group is not in the benchmark, it is purely an allocation decision and, thus, no risk arises in the Selection column. However, when we look at the Industrials sector, we have allocation risk arising from our decision to underweight the group, selection risk arising from the overweight of Volvo and underweight of GE, as well as risk from the interaction between the two types of decisions.

As shown in the first example, the risks from the allocation and selection decisions, as well from the interaction between the two, can be further decomposed into common factor and selection components. Look at the rows at the bottom of the report. Common factor risk is that captured by the fundamental factors, while selection (or asset-specific) risk is the idiosyncratic risk not captured by the risk factors. This distinction enables a detailed analysis of the sources of risk within each component of the investment decision. Finally, the last row of the report displays the active total risk from the allocation and selection decisions, as well as the interaction of those two.

This section described the Variance Allocation-Selection Report. Utilizing the standard Brinson-Fachler definition of allocation and selection, BarraOne decomposes asset weights into allocation and selection weights, and utilizing those weights and the risk exposures of the assets, computes the active total risk coming from allocation and selection decisions.

X-Sigma-Rho Allocation-Selection

The goal of any attribution analysis is to measure the impact of active management decisions. The attribution model should therefore reflect the investment process. In the X-Sigma-Rho approach, the risk contribution of any part (*e.g.*, a group of factors such as industries, a single factor, or an asset-level decomposition) is the product of the exposure, the standalone volatility, and the correlation. In marginal contribution analysis, the contribution is the product of the exposure and the marginal contribution. The latter is the product of the standalone volatility and the correlation.

The next portion of this section organizes the available columns as follows:

Weight Columns

- Weight (%)
- Benchmark Weight (%)
- Active Weight (%)
- Effective Weight (%)
- Effective Benchmark Weight (%)
- Effective Active Weight (%)

Allocation Columns

- Allocation Relative Sector Volatility
- Allocation Relative Sector VaR (%)
- Allocation MCAR
- Allocation Relative Sector Correlation
- Allocation Risk Contribution
- Ex Currency Allocation Columns

Selection Columns

- Selection Active Sector Volatility
- Selection Active Sector VaR (%)
- Selection MCAR
- Selection Active Sector Correlation
- Selection Risk Contribution
- Ex Currency Selection Columns

Interaction Columns

- Interaction Risk Contribution
- Interaction Risk Contribution (ex. Currency)

Active Risk Columns

- Active Risk
- Active Variance
- Marginal Contribution to Active Total Risk (MC to Active Risk)
- Percent Contribution to Active Total Risk (%CR to Active Risk)
- Portfolio Active Total Risk
- Other Active Risk Columns

Formula Key

The formulas used to describe the attributes available for display in the columns of the X-Sigma-Rho Allocation-Selection Report use the following symbols.

$\mathbf{w}_A$ = active holdings vector

$\mathbf{w}'_A$ = active holdings vector (transposed)

$\mathbf{w}_B$ = benchmark holdings vector

$\mathbf{w}_B^{(i)}$ = benchmark sector holdings vector for sector i

$\mathbf{w}_P^{(i)}$ = portfolio sector holdings vector for sector i

$\mathbf{V}$ = variance-covariance matrix + specific risk

Γ_i^A = allocation MCAR

Γ_i^S = selection MCAR

$r_{B,i}$ = benchmark sector return for sector i

$r_{P,i}$ = portfolio sector return for sector i

$w_{B,i}$ = benchmark sector weight for sector i

$w_{P,i}$ = portfolio sector weight for sector i

R_A = active return

R_B = benchmark return

σ = standard deviation

ρ = rho (correlation)

T = holding period

CL = confidence level

NORMSINV = inverse of standard normal cumulative distribution ($\mu = 0,\ \sigma = 1$)

Weight (%)

Weight of the allocation group in the managed portfolio.

$$w_{P,i} = \sum_{k \in i} w_{P,k} \text{ : portfolio sector weight for sector } i$$

$$\mathbf{w}_P^{(i)} = \begin{cases} w_{P,k} / w_{P,i} & \text{if } k \in i \\ 0 & \text{otherwise} \end{cases} \text{ : portfolio holdings vector for sector } i$$

Benchmark Weight (%)

Weight of the allocation group in the benchmark.

$$w_{B,i} = \sum_{k \in i} w_{B,k} \text{ : benchmark sector weight for sector } i$$

$$\mathbf{w}_B^{(i)} = \begin{cases} w_{B,k} / w_{B,i} & \text{if } k \in i \\ 0 & \text{otherwise} \end{cases} \text{ : benchmark holdings vector for sector } i$$

Active Weight (%)

Active weight of the allocation group.

$$w_{A,i} = w_{P,i} - w_{B,i} \text{ : active sector weight for sector } i$$

Effective Weight (%)

Effective weight of the allocation group. Same as "Weight (%)" on page 222, except $h_{P,k}$ is effective holdings: *(contract size*notional value*holdings) / market value of managed portfolio*.

Effective Benchmark Weight (%)

Effective weight of the allocation group in the benchmark. Same as "Benchmark Weight (%)" on page 222, except $h_{B,k}$ is effective holdings: *(contract size*notional value*holdings) / market value of benchmark*.

Effective Active Weight (%)

Effective active weight of the allocation group. Same as "Active Weight (%)" on page 222, except substituting *effective* weight and *effective* benchmark weight.

Allocation Relative Sector Volatility

Risk (% standard deviation) of the allocation decision for the group.

$$\sigma(r_{B,i} - R_B) = \sqrt{(\mathbf{w}_B^{(i)} - \mathbf{w}_B)'\mathbf{V}(\mathbf{w}_B^{(i)} - \mathbf{w}_B)}$$

Allocation Relative Sector VaR (%)

Parametric VaR (%).

$$\sigma(r_{B,i} - R_B) \cdot NORMSINV(CL) \cdot \sqrt{T}$$

Allocation MCAR

Marginal contribution to portfolio active total risk.

$$\Gamma_i^A = \sigma(r_{B,i} - R_B)\rho(r_{B,i} - R_B, R_A)$$

Allocation Relative Sector Correlation

Correlation of the allocation group risk to portfolio active total risk.

$$\rho(r_{B,i} - R_B, R_A) = (\mathbf{w}_B^{(i)} - \mathbf{w}_B)'\mathbf{V}\mathbf{w}_A \Big/ \sigma(r_{B,i} - R_B)\sigma(R_A)$$

Allocation Risk Contribution

Product of risk and the correlation of the allocation decision, giving a contribution that sums across groups to total allocation risk.

$$\sigma\ (r_{B,i} - R_B)\Gamma_i^A$$

Allocation Relative Sector Volatility ∗ Allocation Relative Sector Correlation ∗ Active Weight

Ex Currency Allocation Columns

These columns are analytically identical to similarly named columns with currency risk, except the exposures of each asset are their local exposures without currency risk.

- Allocation Relative Sector Volatility (ex. Currency)
- Allocation Relative Sector Correlation (ex. Currency)
- Allocation Risk Contribution (ex. Currency)
- Allocation MCAR (ex. Currency)

Selection Active Sector Volatility

Risk (% standard deviation) of the asset selection choices.

$$\sigma(r_{P,i} - r_{B,i}) = \sqrt{(\mathbf{w}_P^{(i)} - \mathbf{w}_B^{(i)})' \mathbf{V} (\mathbf{w}_P^{(i)} - \mathbf{w}_B^{(i)})} = \sqrt{\mathbf{w}_A^{(i)\prime} \mathbf{V} \mathbf{w}_A^{(i)}}$$

Selection Active Sector VaR (%)

Parametric VaR (%)

$$\sigma(r_{P,i} - R_{B,i}) \cdot NORMSINV(CL) \cdot \sqrt{T}$$

Selection MCAR

Marginal contribution to portfolio active total risk.

$$\Gamma_i^S = \sigma(r_{P,i} - r_{B,i}) \rho(r_{P,i} - r_{B,i}, R_A)$$

Selection Active Sector Correlation

Correlation of the selection risk to portfolio active total risk.

Selection Risk Contribution

Contribution of the group selection risk to active total risk.

$$w_{P,i} \Gamma_i^S$$

The interaction contribution term is displayed:

$$w_{B,i} \Gamma_i^S$$

Selection Active Sector Volatility * Selection Active Sector Correlation * Weight

Aggregation

Σ Group Selection Risk Contributions = Portfolio Selection Risk Contribution

Ex Currency Selection Columns

These columns are analytically identical to similarly named columns with currency risk, except the exposures of each asset are their local exposures without currency risk.

- Selection Active Sector Volatility (ex. Currency)
- Selection Active Sector Correlation (ex. Currency)

- Selection Risk Contribution (ex. Currency)
- Selection MCAR (ex. Currency)

Interaction Risk Contribution

Contribution of the interaction term to active total risk.

$$(w_{P,i} - w_{B,i})\Gamma_i^S$$

Interaction Risk Contribution (ex. Currency)

This analytically identical to Interaction Risk Contribution, except the exposures of each asset are their local exposures without currency risk.

Active Risk

Total risk (% standard deviation) due to the manager's deviation from the benchmark.

$$\sigma(R_A) = \sqrt{\mathbf{w}'_A \mathbf{V} \mathbf{w}_A}$$

Note that

$$\sigma(R_A) = \sum_i (w_{P,i} - w_{B,i})\Gamma_i^A + \sum_i w_{P,i}\Gamma_i^S$$

which is the sum of Allocation Risk Contribution and Selection Risk Contribution.

Active Variance

Risk (variance) due to the manager's deviation from the benchmark.

$$\sigma^2(R_A) = \mathbf{w}'_A \mathbf{V} \mathbf{w}_A$$

Aggregation

Σ Group Allocation Risk Contributions = Portfolio Allocation Risk Contribution

Marginal Contribution to Active Total Risk (MC to Active Risk)

Marginal contribution of the group to active total risk. See “Marginal Contribution to Active Total Risk (MC to Active Total Risk)” on page 78.

Percent Contribution to Active Total Risk (%CR to Active Risk)

The percent contribution of the group to active total risk. See "Percent Contribution to Active Total Risk (%CR to Active Total Risk)" on page 87.

Portfolio Active Total Risk

Portfolio Allocation Risk Contribution + Portfolio Selection Risk Contribution

Other Active Risk Columns

These columns are analytically identical to similarly named columns used in the BarraOne Positions Report for x-sigma-rho risk analysis.

- Active Local Market Risk
- Active Local Market Risk Contribution
- Active Local Market MCTE
- Active Currency Risk
- Active Currency Risk Contribution
- Active Currency MCTE

Using the X-Sigma-Rho Allocation-Selection Report

In order to use the report, a managed portfolio with an assigned benchmark must first be loaded. Next, a grouping scheme needs to be applied. The grouping scheme should correspond to the allocation decision driving the investment process. Here are a couple of examples.

The first case is a managed portfolio that reflects an active stock selection decision within one of its sectors, but no active allocation decisions. As shown in the table, Volvo is overweight 2.5%, and General Electric is underweight –2.5% within the Industrials sector, leaving the sector as a whole benchmark neutral.

Table 23: Sample Positions Report

Grouping: GICS Sector	Asset ID	Asset Name	Active Weight(%)
by: distinct			**0.00%**
Industrials			0.00%
	928856202	VOLVO AB SER. A	2.50%
	369604103	GENERAL ELECTRIC CO	-2.50%
	D69671218	SIEMENS	0.00%
Consumer Staples			0.00%
	931142103	WAL MART STORES INC	0.00%
	H57312466	NESTLE R	0.00%
Energy			0.00%
	P78331116	PETROBAS ON	0.00%
	G7690A100	ROYAL DUTCH SHELL A	0.00%
Financials			0.00%
	J44497105	MITSUBISHI UFJ FINANCIAL GROUP	0.00%
	F43638141	SOCIETE GENERALE	0.00%

In the Allocation-Selection report below, it is shown that, since the security selection decision is the only source of active total risk, all of the portfolio's active total risk is isolated within the Selection Active Sector Volatility column. A comparison with the traditional Risk Decomposition report (second table below), makes clear that the selection risk shown below includes all sources of risk in the traditional decomposition, *i.e.,* common factor, selection, and currency.

Table 24: Sample Allocation-Selection Report — Selection Only (X-Sigma-Rho)

Group	Allocation Relative Sector Volatility	Allocation Relative Sector Correlation	Allocation MCAR	Allocation Risk Contribution	Selection Active Sector Volatility	Selection Active Sector Correlation	Selection MCAR	Selection Risk Contribution	Weight(%)	Active Weight(%)
Consumer Staples	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	20.0000%	0.0000%
Energy	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	20.0000%	0.0000%
Financials	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	20.0000%	0.0000%
Industrials	0.000	0.0000	0.0000	0.0000	3.0461	1.0000	3.0461	1.2184	40.0000%	0.0000%
Active Total Risk	0.0000	N/A	N/A	0.0000	1.2184	N/A	N/A	1.2184	100.0000%	0.0000%

Table 25: Sample Risk Decomposition Report

Risk Source	Portfolio Risk	Active Risk
Local Market Risk	13.70	0.65
Common Factor Risk	12.94	0.39
Industry	12.32	0.36
Style	3.25	0.17
Factor Interaction	N/A	N/A
Selection Risk	4.49	0.51
Currency Risk	6.61	0.23
Currency/Market Interaction	N/A	N/A
Total Risk	15.87	0.67

In the next example, the managed portfolio is modified slightly to include both allocation and selection decisions. Notice the introduction of a new sector, Telecom Services, in the managed portfolio. The benchmark has no weight in this sector, so this represents a pure allocation decision. Since this sector is overweight, another sector needs to be underweight. This is accomplished by underweighting the Industrials sector by 5%, representing the second allocation decision. This underweighting is accomplished by increasing the previous underweight in General Electric, while Volvo continues to be overweight. These are security selection decisions.

Table 26: Sample Positions Report

Grouping: GICS Sector	Asset ID	Asset Name	Active Weight(%)
by: distinct			**0.00%**
Telecom Services			5.00%
	Y14965100	CHINA MOBILE LTD	5.00%
Industrials			-5.00%
	928856202	VOLVO AB SER. A	2.50%
	369604103	GENERAL ELECTRIC CO	-7.50%
	D69671218	SIEMENS	0.00%
Consumer Staples			0.00%
	931142103	WAL MART STORES INC	0.00%
	H57312466	NESTLE R	0.00%
Energy			0.00%
	P78331116	PETROBAS ON	0.00%
	G7690A100	ROYAL DUTCH SHELL A	0.00%
Financials			0.00%
	J44497105	MITSUBISHI UFJ FINANCIAL GROUP	0.00%
	F43638141	SOCIETE GENERALE	0.00%

To the see the implications of these allocation and selection decisions, let us again turn to the Allocation-Selection report.

Table 27: Sample Allocation-Selection Report — Both (X-Sigma-Rho)

Group	Allocation Relative Sector Volatility	Allocation Relative Sector Correlation	Allocation MCAR	Allocation Risk Contribution	Selection Active Sector Volatility	Selection Active Sector Correlation	Selection MCAR	Selection Risk Contribution	Weight(%)	Active Weight(%)
Consumer Staples	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	20.0000%	0.0000%
Energy	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	20.0000%	0.0000%
Financials	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	20.0000%	0.0000%
Industrials	17.7514	-0.3063	-5.4364	0.2718	7.2829	0.6760	4.9229	1.7230	35.0000%	-5.0000%
Telecom Services	31.0586	0.2638	8.1935	0.4097	45.1497	0.4750	21.4439	1.0722	5.0000%	5.0000%
Active Total Risk	0.0000	N/A	N/A	0.6815	3.4767	N/A	N/A	2.7952	100.0000%	0.0000%

This shows the risk from the allocation decision to invest in the Telecom Services sector.

⊳ **Note:** In a Variance Allocation-Selection Report, if the benchmark does not have a particular sector, then that sector's position weight is zero (0). In an X-Sigma-Rho Allocation-Selection Report, however, selection weight = *the sector-relative weight in the managed portfolio – the sector-relative weight in the benchmark portfolio*. Hence, even if the benchmark does not have a particular sector, if the managed portfolio does have that sector, then the selection weight will be non-zero.

When we look at the Industrials sector, we have allocation risk arising from our decision to underweight the group, selection risk arising from the overweight of Volvo and underweight of GE, as well as risk from the interaction between the two types of decisions.

As shown in the first example, the risks from the allocation and selection decisions, as well from the interaction between the two, can be further decomposed into common factor and selection components. Look at the rows at the bottom of the report. Common factor risk is that captured by the fundamental factors, while selection (or asset-specific) risk is the idiosyncratic risk not captured by the risk factors. This distinction enables a detailed analysis of the sources of risk within each component of the investment decision. Finally, the last row of the report displays the active total risk from the allocation and selection decisions, as well as the interaction of those two.

This section described the X-Sigma-Rho Allocation-Selection report. Utilizing the standard Brinson-Fachler definition of allocation and selection, BarraOne decomposes asset weights into allocation and selection weights, and utilizing those weights and the risk exposures of the assets, computes the active total risk coming from allocation and selection decisions.

Multiple Portfolio Comparison Report

Overview

Multiple Portfolio Comparison provides relative risk values and correlation matrices that identify portfolios with similar risk characteristics and measure whether they serve to concentrate or diversify other strategies in the analysis. You can easily change the components of your analysis at any time and assess alternative combinations of portfolio strategies. The correlation and relative risk matrices are based on Barra's factor covariance matrix.

With BarraOne's Multiple Portfolio Comparison feature (MPC), which enables you to view summary statistics and correlations for multiple portfolios, you can compare up to 200 portfolios in terms of their factor exposures, correlation, relative risk, and a range of other characteristics.

With the MPC tool, you can:

- Assess plan diversification by viewing asset class correlation
- Identify manager strategy overlap by checking manager correlation
- Monitor managers' risk and total tracking error

This makes it easy to analyze the correlations of multiple managers, as well as the aggregate statistics for your managed portfolios. Each portfolio can have its own benchmark, and you can compare them all to a single overall market portfolio.

Summary Report

The Summary report provides an overview of the current portfolio's status. The MPC Summary report makes it easy to report summary risk statistics for all your managers. The report makes all pertinent statistics accessible in a single report, including the risk of the portfolio, the risk of the benchmark, and the portfolio's total tracking error.

Portfolio	Market Value	Benchmark	Total Risk	Benchmark Total Risk	Tracking Error	Beta (Bmk)	Value-At-Risk($)
US Energy Equipment	697,955,749	Russell 3000	31.84	11.90	27.83	1.34	365,554,703
US Biotechnology	745,198,462	Russell 3000	29.90	11.90	25.00	1.45	366,455,207
Global Equity	4,774,580,337	MSCI World	23.83	11.53	19.92	1.14	1,871,585,365
Private Real Estate	1,350,875,069	MSCI Real Estate	14.79	12.92	8.97	0.91	328,727,673
EUR Credit	1,344,328,360	MSCI Euro Credit	8.93	8.90	5.49	0.81	197,502,764
US Growth	5,554,647,046	S&P Growth	12.27	11.53	2.85	1.04	1,121,328,735
US Value	5,667,949,856	S&P Value	11.45	11.74	2.83	0.95	1,067,364,885
US Credit	1,547,668,708	Merrill Lynch Corporate	6.90	4.70	2.75	1.41	175,720,890
US Gov	2,314,808,050	Merrill Lynch Government	4.01	4.22	0.21	0.95	152,815,924
EUR Gov	2,284,354,818	Merrill Lynch Euro Gov	8.77	8.81	0.12	0.99	329,359,687
Cash Equivalents	1,000,000,000	Cash	0.00	0.00	0.00	0.00	0

Figure 7: Sample MPC Summary Report

The coefficient of determination (active), also called R-squared, measures the percent contribution to active total risk due to market systematic risk. When a long-only portfolio has a market beta close to 1, its active coefficient of determination will be close to zero.

Factor Exposure Breakdown Report

The Factor Exposure Breakdown report, when both a benchmark and a market are selected, displays active factor exposures. The portfolio's active exposure is calculated by adjusting the portfolio's active exposure by the systematic component:

$$X_{\text{Active}} = X_{\text{P}} - X_{\text{B}}$$

where:

X_{Active} = active exposure

$X_{P,B}$ = portfolio, benchmark exposure

The Factor Exposure Breakdown Report displays exposures to styles, industries, and sectors. When looking at the report, you can use a rule of thumb to discern which active bets can be considered significant.

Table 28: Interpreting Active Exposures

Active Exposure Type	Significant Value
Styles	≥ |0.2|
Sectors	≥ |3%|
Industries	≥ |3%|

Correlation Report and Relative Risk Report

The Correlation Report and Relative Risk Report offer insights on the interaction of portfolios with each other, with the aggregate portfolio, and with all other portfolios.

The Correlation Report enables you to view the correlations between the different asset classes in your plan. Low correlation between asset classes indicates diversification, which results in lower risk.

Portfolio	Equities	Fixed Income	Alternatives	Cash
Equities	1.00			
Fixed Income	0.06	1.00		
Alternatives	0.59	0.03	1.00	
Cash	0.00	0.00	0.00	1.00
Aggregate of Others	0.49	0.06	0.58	0.00

Figure 8: Sample MPC Correlation Report

The Correlation Report also lets you check correlations between managers before making a hiring decision to ensure minimum overlap. The manager correlation report enables you to validate that your managers are diversifying (or concentrating).

Portfolio	US Value	US Growth	Global Equity	US Gov	US Credit	EUR Gov	EUR Credit	Private Real Estate	US Biotech	US Energy Equip.	Cash Equiv.
US Value	1.00										
US Growth	0.85	1.00									
Global Equity	0.41	0.36	1.00								
US Gov	-0.22	-0.27	-0.08	1.00							
US Credit	-0.02	-0.06	0.01	0.87	1.00						
EUR Gov	0.06	-0.04	0.18	0.36	0.31	1.00					
EUR Credit	0.14	0.08	0.25	0.21	0.17	0.81	1.00				
Private Real Estate	0.62	0.58	0.30	-0.12	0.03	0.09	0.15	1.00			
US Biotechnology	0.40	0.57	0.20	-0.14	-0.01	-0.01	0.05	0.44	1.00		
US Energy Equipment	0.45	0.39	0.24	-0.13	-0.02	0.08	0.10	0.36	0.44	1.00	
Cash Equivalents	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
Aggregate of Others	0.71	0.66	0.43	-0.13	0.05	0.18	0.29	0.58	0.45	0.44	0.00

Figure 9: Sample MPC Correlation Report

The “Portfolio Total” correlation is computed as an *ex ante* correlation of two portfolios using the portfolios’ exposures to the Barra risk model.

$$\rho_{A,B} = \frac{Cov_{A,B}}{\sigma_A \sigma_B}$$

where:

$$Cov_{A,B} = X_A F X_B^T + w_A \varepsilon w_B^T$$

$$\sigma_A = \sqrt{X_A F X_A^T + \varepsilon_A^2}$$

$$\sigma_B = \sqrt{X_B F X_B^T + \varepsilon_B^2}$$

It describes the similarity between the portfolios. The stronger the relationship between the portfolios, the closer to one the correlation will be. A positive correlation signals that the two portfolios follow a similar investment style and will compete with each other to make similar transactions in the market. The final effect will be to increase the fund’s risk. A negative correlation signals that the portfolio managers consistently make opposite investment decisions, reducing the fund’s risk.

“Benchmark Total” is the correlation of the benchmark assigned to portfolio A with the benchmark assigned to portfolio B.

If the correlation type is "Active Total," the report shows the correlation of the active exposures of the portfolio.

$$\rho_{A,B}^{active} = \frac{Cov_{A,B}^{active}}{\sigma_A^{active}\sigma_B^{active}}$$

where:

$$Cov_{A,B}^{active} = X_A^{active} F X_B^{T,\ active} + w_A^{active} \varepsilon w_B^{T,\ active}$$

$$X_A^{active} = X_A - X_{benchmark}$$

For other "Active" correlation types, the correlation is between factor blocks of the active exposures of the portfolio.

If the report includes the correlation of one portfolio against an "Aggregate of Others," it indicates if the portfolio reduces or adds to the risk of a fund. When the correlation is positive, the portfolio is increasing the fund's risk; when the correlation is negative, the portfolio has a diversifying effect on the fund's risk.

The Relative Risk Report compares portfolios along the familiar measure of active total risk.

$$\sigma = \sqrt{X_{\substack{\text{relative}\\ \text{exposures}}} F X^T_{\substack{relative\\ risk}} + w_{active} \varepsilon w^T_{active}}$$

where:

$$X_{\substack{\text{relative}\\ \text{exposures}}} = X_A - X_B$$

The higher the relative risk, the more different are the investment style and asset selection decisions for the two portfolios. Correlation measures the strength of the relationship between the portfolios being compared and is limited to values between −1 and +1. A negative correlation means the portfolio is reducing risk. A positive correlation means the portfolio concentrates risk.

You can view relative risk and correlations between individual portfolios, between a single portfolio and all others in the plan, and between a single portfolio and the entire plan.

Applying Multiple Portfolio Comparison Elsewhere

Multiple Portfolio Comparison is useful for other applications, as well. For example, you can compare several managers within a firm against an internal benchmark and find any deviation from the mandate. You can also compare external portfolios against each other while searching for the most efficient combination of investment styles and risk.

You can also use Multiple Portfolio Comparison to compare the results of different backtests. The portfolio manager can load the portfolios resulting from the different strategies each month, and observe how different investment decisions affect the risk decomposition of the portfolios.

Conclusion

Multiple Portfolio Comparison can help you in making better investment decisions. The centralized location of the reports together with the in-depth risk analysis make it a helpful tool for comparing different investment opportunities.

Stress Testing Report

Introduction to Stress Testing

Stress testing has gained prominence among regulators and practitioners as an important measure that complements traditional risk measures, such as variance, tracking error, and VaR. Regulators, including the Basel committee and EU Commission (UCITS), require that practitioners incorporate stress testing into their regular risk management practices.

To understand the Stress Testing module, it is helpful to look at the regulatory developments that mandate periodic stress tests on investment products. The EU Commission's UCITS directives, for example, extend the range of permissible investments, such as complex derivatives and hedge funds (of funds), but they require more investor protection in the form of an extensive system of risk controls. Risk controls are based on VaR and stress testing for market risk, and counterparty risk management analytics for credit risk measurement. With respect to stress testing, the UCITS directives require monthly (or more frequent) stress scenarios be applied to collective investment schemes. These stress tests are composed of shocks to the risk factors relevant to the assets held in a given fund. Similarly, the Bank of International Settlements (BIS) document, Framework for Supervising Information about Derivatives and Trading Activities, states that stress scenarios need to cover "a range of factors that can create extraordinary losses or gains in trading portfolios" and that the tests should "provide insights into the impact of such event on positions."

Stress testing, however, is a generic term used to describe various techniques (quantitative and/or qualitative) used by institutions to gauge their vulnerability to exceptional but plausible events. There are two components to a stress-testing model:

- The set of market risk factors, including interest rates and exchange rates.
- A valuation model, to compute asset values as a function of underlying market factors.

Stress testing involves choosing scenarios (risk factor shocks) and passing those scenarios to the valuation model to understand the effect of the hypothetical scenario at a given point.

Overview

BarraOne lets you stress test your portfolios to see how they might be affected by various market scenarios. You choose the scenarios (market shocks) you want to apply, and BarraOne revalues the portfolio to calculate the profit and loss impact of the simulated shocks. This section describes the BarraOne Stress Testing reports.

BarraOne supports the following types of scenarios:

- User-defined sensitivity analysis. Users may choose selected market data or spreads and specify the magnitude and direction of the shock. Stressing a portfolio with isolated market data enables users to determine the sensitivity of a fund to specific market changes. For example: isolated parallel yield curve shifts, a change in equity index volatilities, or a change in FX volatilities.

- Historical scenarios. BarraOne provides a set of predefined scenarios, such as 1987 Black Monday, 9-11 terrorist attack, etc. We use a four-step process to create the historical scenarios:
  - Define the historical event
  - Determine the relevant parameter: risk factor, absolute change, time window (1 day, 1 week, etc.)
  - Compute the maximum realization of individual risk factors
  - Define the stress scenario by combining the various risk factors
- User-defined hypothetical scenarios. Users can customize the stress test and tailor it to suit the portfolios that are being tested. Users may have expectations for future market conditions, or prefer to define scenarios that are not correlated with historical events. For example, interest rates up 100 bp, and equity market in the U.S. and EU falling 10%.

In calculating the profit and loss effect of stress scenarios, there are a number of methods commonly employed. BarraOne provides the following two methods of stress scenarios:

Uncorrelated Scenario Method

Risk factor shocks that simultaneously affect the portfolio. When the portfolio is revalued, the selected risk factors will be shocked, while all others are held constant at current market conditions. Uncorrelated shocks may be applied in isolation (a single factor shock, or sensitivity analysis), or as a bundle of shocks. The latter is particularly suitable for defining market scenarios that include impacts to multiple markets and risk factors (such as equity prices, interest rates, and FX rates).

Conditional Scenario Method (Correlated Shocks)

This methodology combines user-specified shocks with the inherent relationships that exist in the BIM covariance matrix. Investors want to evaluate the impact of a stress test on a portfolio given some market movements (such as oil or interest rates), even though the portfolio is not directly exposed to specific market factors.

- BarraOne computes the likely movement of market factors given a core market shock (oil, for example): +15% using a conditional expectation.
- BarraOne uses the correlation embedded in the BIM covariance matrix to compute the likely co-movement of interest rates, equity markets, and FX markets conditional on crude oil (commodity) returns of +15%.
- The advantage of the approach is that the stress test results are comparable to the risk exposures generated by the system.
- The application enables the user to toggle between a stress test in uncorrelated and correlated methodology.

Correlated Shape Shocks

The correlated shock methodology also extends to Interest Rate shape shocks. In uncorrelated mode, when a user defines an Interest Rate shape shock, *e.g.,* a shock to the 10Y node, BarraOne assumes that the shock to the other vertices is zero. Thus, an uncorrelated shock defined on the 10Y vertex will not affect shorter term securities.

In correlated mode, BarraOne uses the STB covariances to compute correlated shocks to an entire term structure based on shocks defined on specific nodes. In other words, users may define shape shocks and use the correlation methodology to extend the shocks to vertices for which shocks are not defined.

This feature enables the user the option of shocking specific vertices and having the shocks on the other vertices computed based on their correlations. For example, if the user defines shocks to the 1Y and 10Y vertices, BarraOne will compute shocks to the other vertices (2Y, 3Y, 4Y, etc.) based on their correlations with the 1Y and 10Y vertices.

Notes:

- To force a vertex shock of 0, the user must enter “0.0” as the shock.
- The user must shock at least one vertex that is part of BIM. Shocks to other vertices (e.g., 1M, 3M) will be applied only to those vertices and will not be used in the correlation calculation. Correlated (BIM) vertices include the following:
  - 1Y, 2Y, 3Y, 5Y, 10Y, 20Y, 30Y in any market
  - 15Y and 25Y for Treasury curves in developed markets

Stress Testing Details

The following sections give a more detailed description of the BarraOne methodology for implementing the abovementioned stress testing techniques.

Types of Shocks

Shocks are classified into the following market categories: Equity, Interest Rate, Credit Spreads, Detailed Spreads, Foreign Exchange, and Commodity. The following table captures the shocks by the above-mentioned markets and the instruments that are impacted:

Table 1: Stress

Types of Shocks					
Choose shock (risk) type	**Choose market**	**Choose an object**	**Change**	**How to change**	**What Instruments may be affected**
Equity	Country (choose one country from a list of countries, *e.g.,* USA)	Equity Index (choose an Index from the list of all available indexes for the selected Country, *e.g.,* DIJA)	Index Value	percentage change, *e.g.,* -3%	Equities, Equity Indexes (Composites), Equity Index Futures, Equity Options, Equity Index Options, Convertible Bonds
	Note that ADRs are sensitive to Country of Quotation, rather than the local market.	Individual stock/Index Implied Volatilities, based on the User/Vendor-provided option and convertible bond prices	Index Volatility	percentage change, *e.g.,* +10%	Equity Options, Equity Index Options, Convertible Bonds
			Implied Volatility for the Options and Convertibles, where the Price was provided		Equity Options, Equity Index Options, Convertible Bonds **Note:** Euro shocks affect only mutual funds
Interest Rate	Currency (choose one currency from a list of currencies, *e.g.,* EUR), and then choose the type of Market Data to shock (Shift, Shape, Volatility). Note that an individual EMU country shock applies only to sovereign bonds in the EMU country.	Curve Type (choose from a list of Treasury, LIBOR, Muni, Real, OIS (if applicable). Note that for government bonds denominated in EUR, the local government Treasury term structure is stressed, rather than the EMU term structure.	Basis points or percentage of change in Shift, Shape, or Volatility of selected Curve Type for selected Currency.	For a Shape Market Data change, enter the basis point or percentage change at each vertex.	Interest rate instruments; foreign exchange instruments; bonds and bond derivatives; IPBs; overnight index swaps; US muni bonds and muni floaters; convertible bonds; structured assets; MBS

Table 1: Stress

Types of Shocks					
Choose shock (risk) type	**Choose market**	**Choose an object**	**Change**	**How to change**	**What Instruments may be affected**
Credit Spreads	Currency (choose one currency from a list of currencies, *e.g.,* EUR).	Bond Spread or CDS Spread.	Spreads for the selected Spread + Currency + Issuer Type + Rating range combination.	(absolute) change USD Corporate AAA Bond Spread +10 bp; (relative) change USD Corporate AAA Bond Spread +2%	Same Issuer Type bonds and bond derivatives; Convertible Bonds
		Issuer Type (Government, Corporate, Agency) and Rating range e.g., Corporate AA+ to AA–).	Implied Spreads for the selected Currency + Issuer Type + Rating combination for the bonds, where the Price was provided by User.	(absolute) change USD Corporate AAA Bond Spread +10 bp; (relative) change USD Corporate AAA Bond Spread +2%	Same Issuer Type bonds and bond derivatives; convertible bonds
			CDS Spreads.	absolute change, *e.g.,* +100 bp; relative change, *e.g.,* +10%	CDS, CDS Baskets
Factor Spreads	Currency (choose one currency from a list of currencies, *e.g.,* EUR). An “EM” currency is available, which will list individual emerging market countries as Sectors.	Select a combination of Sector, Subsector, and Rating	Spreads factor for the combination of currency, sector, subsector and rating. Shocks are additive, so if a user specifies 50bp shocks to both Rating=A and Rating=All for Industry=HLTH, then the net shock to A-rated HLTH bonds will be 100bp.	Enter the amount of change in basis points or percentage. For negative change, type the minus sign, such as –10.	BarraOne finds the matching factors in your portfolio and then shifts the option-adjusted spread of the assets by the stress value. Correlated shocks are supported.

Table 1: Stress

Types of Shocks					
Choose shock (risk) type	**Choose market**	**Choose an object**	**Change**	**How to change**	**What Instruments may be affected**
Detailed Spreads	N/A	Attributes may be either System attributes or user attributes of either Enumerated Type or Text. If Text, the Association of the attribute must be either Asset Id or Miscellaneous.	If a grouping scheme exists for the attribute, select a filter (grouping scheme) from the first Filter dropdown menu, and then choose the value of the attribute to shock from the second Filter dropdown menu. If no grouping scheme exists for the attribute, then in the field provided enter the exact case-sensitive text string for the value of the attribute to be shocked.	Enter the amount of change in basis points or percentage. For negative change, type the minus sign, such as –10.	BarraOne finds the matching assets in your portfolio and then shifts the option-adjusted spread of the assets by the stress value.

Table 1: Stress

Types of Shocks

Choose shock (risk) type	Choose market	Choose an object	Change	How to change	What Instruments may be affected
Foreign Exchange	N/A	Foreign-to-Domestic currency pair, *e.g.,* EUR/USD (assuming EUR-to-local-Currency rate is constant, change all local EMU rates as if EUR/USD changed). **Note:** FX rate shock is defined as Foreign/Domestic ratio, *e.g.,* EUR/USD rate shock of –10% means Euro (numerator of ratio) depreciates 10% vs. U.S. dollar, *i.e.,* 100/100 becomes 90/100. Cross-currency shocks based on specified shocks, e.g., if EUR/USD is shocked –10%, and GBP/USD is shocked +20%, then EUR/GBP is shocked as follows: (1–10%)/(1+20%)–1 = –25%.	Spot FX Rate FX Rate Volatility	Relative % change, *e.g.,* –3% Relative percentage change, *e.g.,* +10%	FX Forward/Future, FX Option, FX Future Option, all Cash Instruments (Equities, Bonds, Convertibles, MBS, Derivatives) having Currency = shocked Currency, Convertibles, having Equity Currency = shocked Currency
Commodity	N/A	Choose a Commodity, e.g., Gold)	Spot Price Volatility Price Curve	Relative percentage change, *e.g.,* -3% Relative percentage change, *e.g.,* +10% For a Price Curve Market Data change, enter the percentage change at each vertex.	Commodity, Commodity Future, Commodity Index Future, Commodity Future Option

Note: A volatility shock for an equity-, commodity-, or FX-based option affects one of the following, depending upon availability, in order of priority:

- user-supplied implied volatility term structure attribute for the option (N/A for Asian and barrier options)
- user-supplied implied volatility from the schedule in the option terms and conditions
- user-supplied static implied volatility in the option terms and conditions
- implied volatility of the underlying asset, which is computed using BIM

Mutual Funds and Hedge Funds

Barra does not have access to the constituents (*i.e.,* the individual securities) of a mutual fund or hedge fund. Rather, Barra has a set of factor exposures from which a "style analysis" is performed. These funds are exposed to various factors throughout the BarraOne models; that is, the exposures are not limited to one market. The exposure of each fund to its factors is estimated by regression of the fund returns against Barra factor returns. This distinction means that a special methodology is required to evaluate funds in stress testing.

The price change in a stress testing market scenario for a hedge fund or a mutual fund in an uncorrelated scenario is the sum of the following:

- Equity-related price change
- Interest rate-related price change
- Credit spread-related price change
- Foreign exchange-related price change

Equity

For each local market country equity price shock to which a fund is exposed, BarraOne first computes the beta of the local market country to the selected index portfolio. Then, BarraOne computes the shocked price as follows:

$$\text{Initial Price} \times \sum_{n=1}^{N} \left[\beta_n \times \text{Shocked Market Return}_n \right]$$

where $N =$ number of equity markets

Interest Rate

For each interest rate shift or shape shock to which a fund is exposed, BarraOne converts the curve rate changes, defined at KRD vertices, to the corresponding STB factor returns (*e.g.,* a U.S. Treasury curve shock is converted to US_GOV STB factors). BarraOne then computes the shocked price as follows:

$$-\text{Initial Price} \times \sum_{m=1}^{M} \left[\text{Shocked Factor Return}_m \times \text{Factor Exposure}_m \right]$$

where $M =$ number of factor exposures

Note that this value is negative, because positive STB returns (in which the curve moves up) correspond to a negative price change.

Credit Spread

For each credit spread shock (Bonds Spread shocks only, not CDS spread shocks) to which a fund is exposed, BarraOne computes the shocked price as follows:

$$\text{Initial Price} \times \sum_{k=1}^{K}\left[\text{Spread Duration}_k \times \text{Shocked Spread}_k\right]$$

where $K =$ number of credit spreads

Foreign Exchange

For foreign exchange rate shocks to which a fund is exposed, BarraOne calculates the shocked price as follows, where the FX rates are with respect to the fund's Price Currency:

$$\text{Initial Price} \times \sum_{p=1}^{P}\left[\left(\frac{\text{Shocked FX Rate}_p}{\text{Initial FX Rate}_p} - 1\right) \times \text{Factor Exposure}_p\right]$$

where $P =$ number of currencies

Total Fund Shocked Market Value

Finally, the total fund shocked market value is calculated as follows:

$$\text{Initial Price} \times \left\{ \begin{array}{l} \sum_{n=1}^{N}\left[\beta_n \times \text{Shocked Market Return}_n\right] \\ -\sum_{m=1}^{M}\left[\text{Shocked Factor Return}_m \times \text{Factor Exposure}_m\right] \\ +\sum_{k=1}^{K}\left[\text{Spread Duration}_k \times \text{Shocked Spread}_k\right] \\ +\sum_{p=1}^{P}\left[\left(\frac{\text{Shocked FX Rate}_p}{\text{Initial FX Rate}_p} - 1\right) \times \text{Factor Exposure}_p\right] \end{array} \right\}$$

where:

$N =$ number of equity markets

$M =$ number of factor exposures

$K =$ number of credit spreads

$P =$ number of currencies

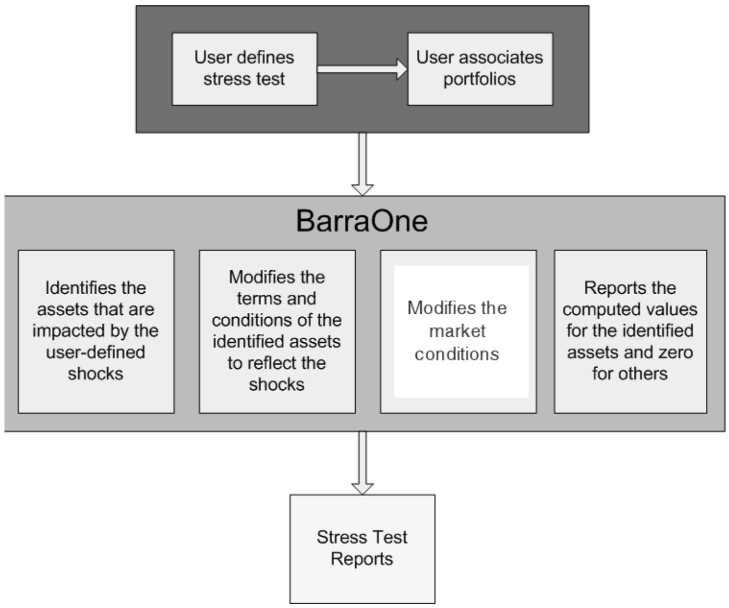
Correlated Shocks Methodology for Funds

In a correlated scenario, a fund's P&L is computed in the same way that it is computed for an equity instruments, namely, solving the matrix system for user-defined shocks and risk factors. So, there are no step-by-step decomposition computations as above.

Uncorrelated Shocks

The previous sections describe the various assets and the shocks that have an effect on the valuation of each asset. Uncorrelated shocks capture the impact of only the user-defined shocks. By default, all stress tests run in uncorrelated mode.

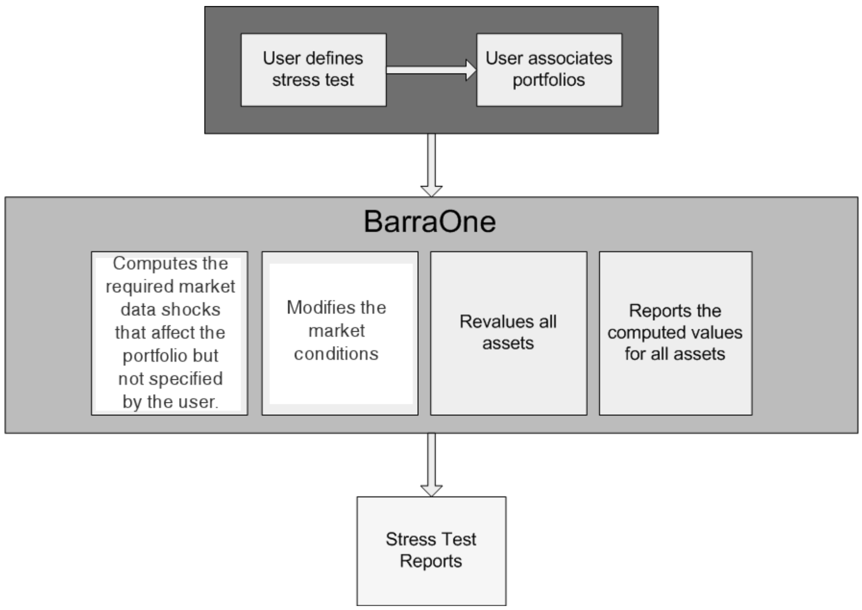
The workflow for uncorrelated shocks is as follows:



Correlated Shocks

A stress test implemented in uncorrelated mode assumes that the user has specified the stress test to the detail that is required and makes no attempt to compute the shocks not specified by the user that have an effect on the portfolio. Many users would like to take advantage of the inherent relationships that exist in the covariance matrix and compute the Profit/Loss under a stress scenario should the existing relationships continue to hold.

The workflow for correlated shocks is as follows:



In order to compute the Profit/Loss under a stress test, we use the "Conditional expectation methodology." Suppose we are interested in forecasting the changes in returns of Y based on return shock S (such as the S&P 500 drops 5%, or 10 year interest rates rise 25 bp).

Suppose:

- n is the number of user-defined shocks
- m is the number of targets to be analyzed
- S is an n x 1 vector for user-defined shocks
- Y is an m x 1 vector for changes in returns of the targets to be analyzed
- Σ_{SS} is the n x n covariance matrix for components in S
- Σ_{SY} is the covariance matrix for covariance between components in S and Y

Then:

- $E(Y \mid S) = E(Y) + \Sigma_{SY}^{T} \Sigma_{SS}^{-1} (S - E(S))$

For our purpose, we assume:

- $E(S) = 0$ and $E(Y) = 0$

In a single shock case (*i.e., n* = 1), $\Sigma_{SY}^{T} \Sigma_{SS}^{-1}$ will give the beta (β) of Y to S.

- Y and S can be the return of assets/portfolios or factors (or mix).
- For our purpose, if we think of assets, portfolios, and factors as random variables, we can construct the covariance matrix for them based on our BIM factor covariance matrix and selection risk.

Types of Reports

Two types of reports are supported in BarraOne:

- Multiple portfolio↔Multiple stress test comparison
- Asset-level Profit/Loss post-stress test

The following tables display sample reports from the application.

Portfolio	Initial Market Value	2000 Tech Bubble		2001 Sept 11	
		Final Market Value	P&L	Final Market Value	P&L
MMIM	2,777,312,416,630	2,524,039,381,246	-9.1%	2,608,881,740,073	-6.1%
MSEAFE_AD	13,842,377,207,297	13,286,978,277,510	-4.0%	13,047,229,082,472	-5.7%
SAP500D	13,268,140,958,932	11,897,683,734,824	-10.3%	12,334,661,820,006	-7.0%

Figure 10:Multiple Portfolio Report

Asset Name	Initial Market Value	2000 Tech Bubble		2001 Sept 11
		Final Market Value	P&L	
Total	**467,891,224.76**	**436,033,458.78**	**-6.81%**	
ALTRIA GROUP INC	79,295,137.35	73,817,790.65	-6.91%	
AMERICAN FINL GROUP INC OHIO	2,014,087.46	1,864,483.80	-7.43%	
APPLERA APPL BIO	1,120,408.20	1,007,984.70	-10.03%	
AQUA AMERICA INC	1,176,639.75	1,068,221.95	-9.21%	
ARCHSTONE COMM	11,516,203.44	10,283,073.41	-10.71%	
AT&T CORP 8.500000% 20311115	3,876,160.00	3,844,691.41	-0.81%	
AUTONATION INC	3,461,480.00	3,173,902.61	-8.31%	
BRINKS CO	682,768.45	617,915.69	-9.50%	
CITIGROUP INC	2,655,615.04	2,381,374.38	-10.33%	
CITIGROUP INC 5% 20140915	2,943,826.67	2,930,984.57	-0.44%	
CONOCOPHILLIPS	11,760,810.00	10,261,720.59	-12.75%	
CREDIT SUISSE (USA) INC 6.125000% 20111115	3,196,656.67	3,202,713.52	0.19%	

Figure 11: Single Portfolio Detailed Report

Grouping: GICS Sector	Initial Market Value	2000 Tech Bubble		2001 Sept 11
		Final Market Value	P&L	Final Market Value
by: distinct	**467,891,225**	**436,033,459**	**-7%**	**448,678,636**
Consumer Discretionary	23,781,824	21,231,613	-11%	21,997,177
Consumer Staples	110,848,059	102,531,347	-8%	105,440,207
Energy	15,887,851	13,750,699	-13%	14,536,379
Financials	110,593,504	102,313,355	-7%	105,419,147
Health Care	3,096,581	2,831,966	-9%	2,896,125
Industrials	43,860,689	40,437,958	-8%	41,709,976
Materials	12,916,014	11,719,932	-9%	12,124,630
N/A	67,529,802	67,103,024	-1%	68,575,877
Telecommunication Services	17,670,574	17,632,676	0%	17,866,609
Utilities	61,706,326	56,480,888	-8%	58,112,509

Figure 12: Single Portfolio Grouped by GICS® Sector Report

Grouping: Currency	Initial Market Value	2000 Tech Bubble		2001 Sept 11
		Final Market Value	P&L	Final Market Value
by: distinct	**13,842,377,207,297**	**13,286,978,277,510**	**-4.0%**	**13,047,229,082,472**
AUD	838,819,834,203	812,830,486,939	-3.1%	682,479,316,289
CHF	946,661,792,011	905,365,981,941	-4.4%	898,757,817,584
DKK	120,730,741,487	113,597,790,967	-5.9%	114,024,560,647
EUR	4,887,620,199,968	4,602,608,889,598	-5.8%	4,632,086,614,344
GBP	3,183,069,340,275	3,043,223,003,159	-4.4%	3,056,650,867,259
HKD	235,731,228,027	229,225,500,411	-2.8%	259,078,526,108
JPY	2,958,463,935,323	2,953,824,435,199	-0.2%	2,775,491,513,039
NOK	130,663,803,070	117,288,841,008	-10.2%	122,350,408,763
NZD	21,717,135,600	20,322,557,629	-6.4%	18,721,532,949
SEK	377,811,154,260	356,585,670,773	-5.6%	357,149,217,160
SGD	141,088,043,073	132,105,119,886	-0.064	130,438,708,330

Figure 13: Single Portfolio Grouped by Currency Report

Column Definitions

$ P&L

Asset $ P&L = Asset Final Market Value – Asset Initial Market Value

Asset $ P&L for futures = Asset Final Market Value

Portfolio $ P&L = Portfolio Final Market Value – Portfolio Initial Market Value

% P&L

Asset % P&L = Asset $ P&L / | Asset Initial Effective Market Value |

Portfolio % P&L = Portfolio $ P&L / | Σ (Asset Effective Market Value in Lookthrough mode) |

⊳ **Notes:**

- Lookthrough is not available for Bond Futures and Commodity Futures, so they affect the portfolio % P&L denominator.
- Lookthrough is available for Equity Index Futures. In Lookthrough mode, an EIF has Effective Market Value = 0, so it does not affect the portfolio % P&L denominator.

P&L Contribution

Asset P&L Contribution = Asset $ P&L / Portfolio Initial Market Value

Portfolio P&L Contribution = Portfolio $ P&L / Portfolio Initial Market Value

⊳ **Note:** Portfolio % P&L and P&L Contribution may differ if the portfolio consists of Bond Futures or Commodity Futures, since the % P&L denominator considers the Effective Market Value of the futures, while P&L Contribution denominator does not.

Cashflow Reports

Two reports support portfolio and asset-level cashflow analysis:

- Immunization
- Security Cashflow

These reports are available interactively and can be included in export sets and batch reports.

Immunization Report

This report is used for immunization and asset liability matching, in which a portfolio cashflow is compared against a liability benchmark to determine any possible shortfall. This report is typically used in insurance and plan sponsor use cases. Cashflows are displayed in nominal and discounted terms for Coupon, Principal, Total, Benchmark, and Net.

	Coupon		Principal		Total Cashflow		Benchmark Cashflow		Net Cashflow	
Date header	Nominal	Discounted	Nominal	Discounted	Nominal	Discounted	Nominal	Discounted	Nominal	Discounted
Total	**1,075,390.00**	**911,092.43**	**1,509,657.59**	**1,104,859.00**	**2,585,047.59**	**2,015,951.43**	**1,738,763.44**	**6,583,447.44**	**846,284.14**	**-4,567,496.01**
2012/12/31	82,247.81	81,595.21	122,157.59	122,094.37	204,405.40	203,689.57	48,720.04	48,226.06	155,685.36	155,463.51
2013/12/31	104,723.44	101,773.99	32,500.00	31,260.13	137,223.44	133,034.12	193,903.56	188,674.77	-56,680.12	-55,640.64
2014/12/31	101,689.06	97,080.51	32,500.00	30,245.54	134,189.06	127,326.05	237,980.38	226,994.25	-103,791.32	-99,668.20
2015/12/31	98,654.69	91,908.72	32,500.00	29,049.07	131,154.69	120,957.79	224,229.63	208,957.91	-93,074.94	-88,000.12
2016/12/31	95,620.31	86,466.44	32,500.00	27,715.50	128,120.31	114,181.94	202,206.81	187,401.68	-74,086.50	-73,219.74
2017/12/31	88,335.94	77,262.68	132,500.00	113,742.17	220,835.94	191,004.85	179,267.32	194,902.36	41,568.62	-3,897.51
2018/12/31	81,951.56	68,938.13	12,500.00	9,882.86	94,451.56	78,820.99	129,471.90	109,787.19	-35,020.34	-30,966.20
2019/12/31	80,717.19	65,046.14	12,500.00	9,357.34	93,217.19	74,403.48	119,837.24	117,922.61	-26,620.05	-43,519.13
2020/12/31	80,100.00	61,685.44	100,000.00	72,126.29	180,100.00	133,811.73	109,664.96	140,891.22	70,435.04	-7,079.49
2021/12/31	70,350.00	52,078.98	100,000.00	72,103.47	170,350.00	124,182.45	107,456.93	112,641.31	62,893.07	11,541.14
2022/12/31	61,600.00	43,558.70	100,000.00	78,440.66	161,600.00	121,999.36	57,698.83	49,861.95	103,901.17	72,137.41
2023/12/31	46,200.00	31,341.58	400,000.00	271,514.68	446,200.00	302,856.26	22,938.38	40,883.37	423,261.62	261,972.89
2024/12/31	30,800.00	19,926.56	0.00	0.00	30,800.00	19,926.56	23,052.10	71,180.59	7,747.90	-51,254.03
2025/12/31	27,025.00	16,918.75	200,000.00	123,587.55	227,025.00	140,506.30	22,991.01	137,044.57	204,033.99	3,461.73
2026/12/31	11,375.00	6,930.88	100,000.00	54,238.46	111,375.00	61,169.34	19,916.99	4,730,509.78	91,458.01	-4,669,340.44
2027/12/31	7,000.00	4,373.91	0.00	0.00	7,000.00	4,373.91	19,643.73	9,075.83	-12,643.73	-4,701.93
2028/12/31	7,000.00	4,205.83	100,000.00	59,500.91	107,000.00	63,706.74	19,783.64	8,492.01	87,216.36	55,214.73

Nominal cashflows in this report are the actual, non-discounted, future cashflows that are scheduled to occur in the calendar month or calendar year indicated by the month-end or year-end date in the left column. Discounted cashflows in this report are discounted at a rate dependent upon the instrument type (LIBOR for most instruments, treasury rates for government bonds, and reference rates for cashflow bonds and cash flow assets).

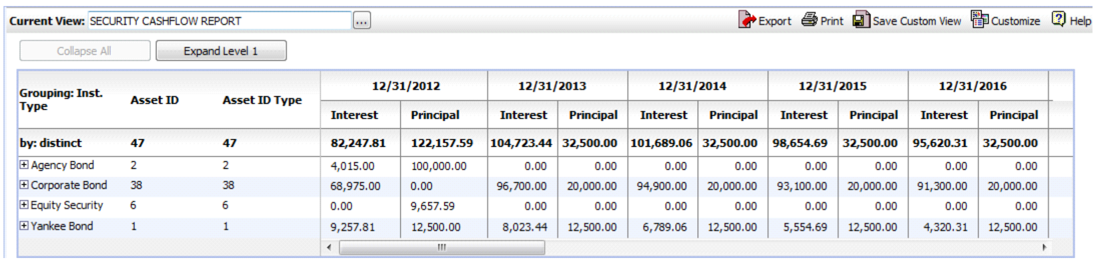
▷ **Note:** If the Analysis Date is on the same date as a cashflow, that cashflow will not appear in the report, because the Analysis Date is assumed to be after market close, and the cashflow is assumed to have occurred during the market day. In essence, then, the report represents cashflows as of Analysis Date +1.

Mandatory sink schedules are observed, but any optionality (including puts, calls, and optional sinks) is assumed not to be exercised. MBS cashflows are adjusted based upon the BarraOne prepayment model. Cashflows are not assumed to be reinvested.

The Total row in this report is a simple sum of the details rows in the report.

Security Cashflow Report

This report is used primarily for cash management to anticipate cashflows from individual securities and security groups. It is typically used by fixed income portfolio managers to determine short term reinvestment plans and cashflow distribution.


Current View: SECURITY CASHFLOW REPORT

Export Print Save Custom View Customize Help

Collapse All Expand Level 1

Grouping: Inst. Type	Asset ID	Asset ID Type	12/31/2012		12/31/2013		12/31/2014		12/31/2015		12/31/2016	
			Interest	Principal	Interest	Principal	Interest	Principal	Interest	Principal	Interest	Principal
by: distinct	47	47	82,247.81	122,157.59	104,723.44	32,500.00	101,689.06	32,500.00	98,654.69	32,500.00	95,620.31	32,500.00
Agency Bond	2	2	4,015.00	100,000.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corporate Bond	38	38	68,975.00	0.00	96,700.00	20,000.00	94,900.00	20,000.00	93,100.00	20,000.00	91,300.00	20,000.00
Equity Security	6	6	0.00	9,657.59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yankee Bond	1	1	9,257.81	12,500.00	8,023.44	12,500.00	6,789.06	12,500.00	5,554.69	12,500.00	4,320.31	12,500.00

All cashflows are in nominal (undiscounted) terms, identical to the values in the Nominal column of the Immunization Report. That is, the cashflows in this report are the actual, non-discounted, future cashflows that are scheduled to occur in the calendar month or calendar year indicated by the month-end or year-end date in the top row.

> **Note:** If the evaluation date is on the same date as a cashflow, that cashflow will not appear in the report, because the evaluation date is assumed to be after market close, and the cashflow is assumed to have occurred during the market day. In essence, then, the report represents cashflows as of Analysis Date +1.

Mandatory sink schedules are observed, but any optionality (including puts, calls, and optional sinks) is assumed not to be exercised. MBS cashflows are adjusted based upon the BarraOne prepayment model. Cashflows are not assumed to be reinvested.

The Total row in this report is a simple sum of the detail rows in the report.

Instrument Types

Coupon and principal cashflows are computed for the following instrument types:

- Bonds (agency, corporate, treasury, municipal, inflation-protected)
- Cashflow Bonds
- Cash Flow Assets
- Commercial Paper
- Convertible Bonds

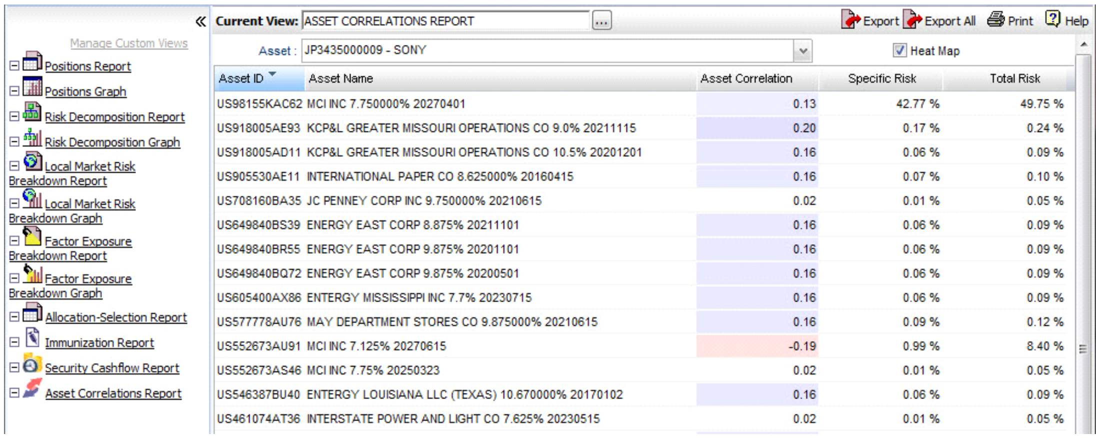
- Credit Default Swaps (CDS, CDS baskets- funded and unfunded, Credit Linked Notes)
- Floating Rate Notes, Variable Rate Notes
- Interest Rate Swaps (IR Swaps, Inflation Swaps, Zero Coupon Swaps, Overnight Index Swaps)
- Intex assets (CMO, ABS, CMBS)
- MBS (generics and ARMs)
- Term Deposits

Important: All other instrument types, including Duration Proxies and currency, are assumed to have a cashflow equal to present value as of the Analysis Date. That is, all other assets will show a cashflow based on the assumption that all positions are liquidated at their market value on the analysis Date.

Note: Only holdings as of the analysis date are used. Any holdings added or subtracted subsequent to the analysis date are not considered as part of the calculation.

Asset Correlations Report

The Asset Correlations Report under **Analysis** tab > **Reports** shows the correlation of a selected asset's return (%) with the return (%) of each of the other assets in the selected portfolio, as well as the Specific Risk and Total Risk of each asset.



Asset-Liability Management Reporting

The ALM (Asset-Liability Management) tab supports liability-driven investing.

There are three types of reporting:

- Risk Reports
- Stress Test Reports
- Duration Reports
- What-If Reports

Risk Reports

Risk Summary

The risk summary report displays Total Risk and Contribution to Effective Duration based upon the Surplus Portfolio ($P_{A\text{-}L}$), in addition to the Market Values of the Asset Portfolio (P_A) and the Liabilities Portfolio (P_L). Funding Ratio is *Assets Mkt Val / Liability Mkt Val*.

Asset Portfolio Contribution to Risk

This report and graph display selected columns from the Positions Report for the Asset Portfolio (P_A) grouped by the selected Grouping Attribute and Scheme.

Risk Factor Breakdown

This is a Risk Factor Breakdown report that combines the Asset Portfolio (P_A), Liabilities Portfolio (P_L), and Surplus Portfolio ($P_{A\text{-}L}$) into a single report.

Stress Test Reports

A stress test cashflow report calculates the effect of each selected stress test scenario on cashflows for the Asset Portfolio (P_A) and Liabilities Portfolio (P_L), and then it calculates a funding ratio and funding change for each scenario.

Duration Reports

These reports are similar to Positions Reports with KRD columns for the Asset Portfolio (P_A), Liabilities Portfolio (P_L), and Surplus Portfolio ($P_A - P_L$).

What-If Reports

All what-if scenarios create dynamic portfolios that the user can employ to test various aspects of their asset-liability management process.

Hedging

The Hedging scenario applies a dynamic modification, or delta, to the current Hedge Portfolio (if any) that the user has selected for the current Profile. The Hedging scenario results in a dynamic hedging delta portfolio that is added in-memory to the static user-defined Hedge portfolio.

Funding Ratio

A Funding ratio scenario enables users to shock the funding ratio and see the effect on risk. The user provides the change to the Assets Portfolio and Liability Portfolio, and BarraOne computes the risk of the resulting Surplus Portfolio. The user defines a funding ratio change in terms of Asset Base Value and/or Liability Base Value. The user defines the change as a percentage change in the market value of the asset/liability portfolio. BarraOne recomputes the reports with the new base value of the asset/liability portfolio.

The funding ratio shock is applied by setting new market value and scaling each position according to its weight.

For example:

PA = +5% and PL = -5% is computed as follows:

New Asset Portfolio Market Value = 1.05 * Asset Portfolio Market Value

New Liability Portfolio Market Value = 0.95 * Liability Portfolio Market Value

Coverage Ratio (CR) = Funding Ratio = 100 * (Matching Liabilities + Return Portfolio) / Liabilities = 100 * Assets / Liabilities

Asset Allocation

The Asset Allocation scenario enables users who have organized their Assets Portfolio into a tree to change the weight of each node in the tree to test different allocation decisions. For instance, Pension Fund boards perform monthly asset class allocation reviews. To prepare allocation recommendations, the Analyst and Risk Manager can evaluate different scenarios of allocation change.

Longevity Shock

A Longevity Shock scenario takes an input portfolio and a “Longevity Shock” and returns a result portfolio with the shock applied. The resulting portfolio will have different holdings and different synthetic instruments representing shocked cashflows, which can then be used for report generation, including the Stress Test reports.

A Longevity Shock scenario enables users to apply a multiplier to the Liability Portfolio at various vertices and recompute risk, market value, funding ratio, etc.

While there may be any number of positions in a Liability Portfolio, a Liability Portfolio in a Longevity Shock What-If Scenario may consist of only two Instrument Types: Cash Flow Assets, and Inflation-Indexed Liabilities (IIL). All other Instrument Types are ignored in the analysis.

A Longevity Shock is modeled by applying user-specified shocks (changes) on the Liability Portfolio cashflow in predefined time buckets (i.e., vertices).

The input is the Liability Portfolio positions, plus 0-1Y, 1Y-2Y, etc. buckets with corresponding cashflow coefficients. The user defines the shocks as Year/Value pairs, for example: 2014 - CF1, 2020 - CF2, etc.

All portfolio cashflows falling into a bucket are shocked by the corresponding coefficient. The shock to the portfolio is in percentage terms.

BarraOne changes (i.e., calibrates) the portfolio asset's parameters (i.e., IIL notional/holdings, cashflow asset's cashflows) to satisfy the user-specified shocks. The assets in the "shocked" portfolio will not stay the same as in original portfolio, nor will only their holdings change.

The result output from this operation is new "shocked" portfolio positions, but only the portfolio as a whole is used or represented in Longevity Shock-related reports. The user will not be able to “look through” the shocked Liability Portfolio and see the position results, because the positions parameters will be changed, thus making them incomparable with the original Liability Portfolio positions.

BarraOne computes new reports with the new shocked cashflow, which affects the Liability Portfolio market value and the base value of the Surplus Portfolio.

Chapter 3

Asset Analytics

This chapter is dedicated to the technical treatment of specific financial instruments in BarraOne.

Overview

In order to estimate risk, the ability to "mark-to-market" all instruments in the portfolio and benchmark is required, thus the need for appropriate valuation models. In addition, exposures for all instruments to the factors in the integrated covariance matrix need to be calculated.

For equities, the mark-to-market is based upon supplied market prices. Simulated equity market prices are based upon current factor exposure and scenarios of factor returns. For fixed income instruments, the valuation model and exposure calculations are discussed in the *Barra Risk Model Handbook*.

The following tables provide an overview of the complete instrument coverage in BarraOne. This chapter focuses primarily on the valuation and risk analytics for selected derivative instruments.

Table 10: Interest Rate Instruments

Instrument (Market)	Data Source	Option Types	Pricing Method	Pricing Model
EuroDollar Future	Importable Bloomberg	N/A	Cost of Carry	N/A
Brazil Interest Rate Future	Barra-supplied	N/A	Cost of Carry	N/A
Eurodollar Future Option	Importable Bloomberg	European	Closed Form	Black (1976)
		European Asian	Approximation	Asian
Swap (Vanilla and Basis)	Importable	N/A	Discounted Cash Flow	N/A
Currency Swap	Importable	N/A	Discounted Cash Flow	N/A
Zero Coupon Swap	Importable	N/A	Discounted Cash Flow	N/A
Overnight Index Swap (AUD, CAD, EUR, NZD, SEK, GBP, USD, CHF, DKK, and JPY currencies)	Importable	N/A	Discounted Cash Flow	N/A
Inflation Swap (EMU, U.K., Canada, U.S., Sweden, Australia, New Zealand, South Africa, Japan, Brazil)	Importable	N/A	Discounted Cash Flow (with Barra-provided real term structure)	N/A
Cap/Floor	Importable	N/A	Closed Form (Modeled as a series of European-style put/call options)	Black (1976)
Total Return Swap (Equity and Fixed Income)	Importable	NA	Discounted Cash Flow	Replicating portfolio

Table 10: Interest Rate Instruments (Continued)

Instrument (Market)	Data Source	Option Types	Pricing Method	Pricing Model
Swaption	Importable	European	Closed Form	Hull-White or Black
		Bermudan Cancelable Swap	Crank-Nicholson (PDE)	Hull-White or Black
FRA (Forward Rate Agreement)	Importable	N/A	Cost of Carry	N/A

Table 11: Fixed Income Instruments

Instrument (Market)	Data Source	Option Types	Pricing Method	Pricing Model
Duration Proxy	Importable	N/A	N/A	N/A
Agency Bond (U.S.) Agency Zero (U.S.) Corporate Bond (U.S. and Global) Eurobond (Global) Government Note/Bond* (Global) Treasury	Barra-supplied Importable Bloomberg	American European	For regular issues: Discounted Cash Flow For callable and putable issues: Crank-Nicholson (PDE) * Australia, Austria, Belgium, Brazil, Canada, Colombia, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Netherlands, New Zealand, Norway, Peru, Poland, Portugal, South Africa, Spain, Sweden, Switzerland, U.K.	Hull-White
Bond Forward Cashflow Bond Commercial Deposit Composite	Importable	N/A	For regular issues: Discounted Cash Flow For callable and putable issues: Crank-Nicholson (PDE)	Hull-White
Optionable (Callable and Putable) Bonds	Importable Bloomberg	European American Bermudan	Crank-Nicholson (PDE)	Hull-White
Convertible Bond (U.S. and Global)	Barra-supplied Importable Bloomberg	American European Bermudan	Trinomial Tree	N/A

Table 11: Fixed Income Instruments (Continued)

Instrument (Market)	Data Source	Option Types	Pricing Method	Pricing Model
Floating Rate Note (U.S. and Global) Variable Rate Note	Barra-supplied Importable Bloomberg	American European Bermudan	Discounted Cash Flow for Vanilla FRNs Crank-Nicholson (PDE) for FRNs with calls, puts, and/or lifetime rate caps and floors QRPC simulation for FRNs with periodic caps/ floors	Hull-White
Inflation-Protected Bond (EMU, U.K., Canada, U.S., Sweden, Australia, New Zealand, South Africa, Japan, Brazil)	Barra-supplied Importable Bloomberg	American European	Discounted Cash Flow (with Barra-provided real term structure)	N/A
Municipal Bond (U.S.)	Importable	American European	Discounted Cash Flow (with Barra-provided municipal term structure) Crank-Nicholson (PDE) if pre-refundable	N/A
Municipal Floating Rate Note (U.S.)	Importable	N/A	Discounted Cash Flow for Vanilla Muni FRNs Crank-Nicholson (PDE) for Muni FRNs with calls, puts, and/or lifetime rate caps and floors QRPC simulation for Muni FRNs with periodic caps/ floors	Hull-White
MBS (U.S.)	Barra-supplied	N/A	Simulation of interest rate scenarios. Cash flow computed with Barra Implied Prepayment model.	Hull-White
Danish MBS (Denmark)	Barra-supplied	N/A	Discounted Cash Flow. Cash flow computed with Barra Implied Prepayment model.	N/A

Table 11: Fixed Income Instruments (Continued)

Instrument (Market)	Data Source	Option Types	Pricing Method	Pricing Model
TBA MBS	Barra-supplied Importable	N/A	N/A	N/A
Adjustable Rate Mortgage (ARM)	Barra-supplied Importable	N/A	Simulation of interest rate scenarios. Cash flow computed with Barra Implied Prepayment model.	Hull-White Note: User prices required
Securitized Products (U.S., EMU, U.K.): • USD-denominated RMBS (Agency CMO/ REMIC, Whole Loan CMO/REMIC) • USD-denominated ABS (Home Equity, Manufactured Housing, Credit Card, Auto, Equipment, Student Loans) • USD-denominated CMBS • EUR-denominated RMBS, ABS, CMBS • GBP-denominated ABS, CBO, CLO, CMBS	Intex-supplied	N/A	Simulation of interest rate scenarios. Cash flow computed with Barra Implied Prepayment model using user-supplied cashflow assumptions.	Hull-White
Term Deposit	Barra-supplied Importable	N/A	Discounted Cash Flow	N/A
Treasury Future (Australia, Canada, U.K., Euro, Germany, Japan, Korea, Spain, Sweden, Switzerland, South Africa, U.S.)	Barra-supplied Importable	N/A	Numerical Integration (accounting for the quality option)	Hull-White
Treasury Future Option	Importable	European American	Crank-Nicholson (PDE)	Hull-White
Repo	Importable	N/A	Closed Form	Discounted Present Value
Cashflow Asset	Importable	N/A	Discounted Cash Flow	N/A
Inflation-Linked Liability	Importable	N/A	Discounted Cash Flow	N/A

Table 11: Fixed Income Instruments (Continued)

Instrument (Market)	Data Source	Option Types	Pricing Method	Pricing Model
Syndicated Loan	Barra-supplied Importable	American	Discounted Cash Flow for Vanilla FRNs Crank-Nicholson (PDE) for FRNs with calls, puts, and/or lifetime rate caps and floors	Hull-White
Credit Default Swap Credit Default Swap Basket Credit Linked Note	Importable	N/A	Discounted Cash Flow	Deterministic Intensity Reduced Form Model
CDS Option	Importable	European	Closed Form	Black (1976)
CDS Tranche	Importable	N/A	Discounted Cash Flow	Deterministic Intensity Reduced Form Model
Nth-to-Default	Importable	N/A	Discounted Cash Flow	Deterministic Intensity Reduced Form Model

Table 12: Foreign Exchange Instruments

Instrument	Data Source	Option Types	Pricing Method	Pricing Model
Currency	Barra-supplied Importable	N/A	Market Price	N/A
FX Forward	Importable	N/A	Interest Rate Parity	N/A
FX Future	Importable Bloomberg	N/A	Cost of Carry	N/A
FX Option	Importable Bloomberg	European	Closed Form	Garman-Kohlhagen
		American Bermudan	Trinomial Tree	N/A
		European Barrier European Double Barrier	Trinomial Tree	Merton (1973) Reiner and Rubinstein (1991) Rich (1994)
		European Asian	Approximation	Asian
FX Future Option	Importable	European	Closed Form	Black (1976)
		American	Trinomial Tree	N/A

Table 13: Equity Instruments

Instrument	Data Source	Option Types	Pricing Method	Pricing Model
Private Equity	Importable	N/A	N/A	N/A
Equity Rule-Based Proxy	Importable	N/A	N/A	N/A
Equity Claim	Importable	N/A	Cost of Carry	N/A
Contract for Difference (CFD)	Importable	N/A	Cost of Carry	N/A
Equity Security	Barra-supplied Importable	N/A	Market Price	N/A
Equity Index Exchange-traded Fund	Barra-supplied Importable	N/A	Market Price	N/A
Equity Basket	Importable	N/A	Market Price	N/A
Equity Forward	Importable	N/A	N/A	N/A
Equity Future	Importable	N/A	Cost of Carry	N/A
Equity Index Future	Barra-supplied Importable	N/A	Cost of Carry	N/A
Equity Option	Importable Bloomberg	European	Closed Form	Black-Scholes Black-Scholes Generalized Black-Scholes Continuous Dividend
		American Bermudan	Trinomial Tree	N/A
		European Barrier European Double Barrier	Trinomial Tree	Merton (1973) Reiner and Rubinstein (1991) Rich (1994)
		European Asian	Approximation	Asian
Equity Index Future Option	Importable	European	Closed Form	Black (1976)
		American	Trinomial Tree	N/A
		European Asian	Approximation	Asian
Variance Future Volatility Swap Variance Swap Forward Volatility Agreement	Barra-supplied Importable	N/A	Discounted Cash Flow	N/A
Volatility Option	Barra-supplied Importable	European	Closed Form	Black (1976)
		American	Trinomial Tree	N/A

Table 14: Miscellaneous Instruments

Instrument	Data Source	Option Types	Pricing Method	Pricing Model
Certificate/Tracker • Standard • Reverse • Discount • Bonus • Reverse Bonus • Outperformance • Twin-Win • Airbag • Capital Protected • Reverse Convertible • Barrier Range Reverse Convertible	Importable	Vanilla	Closed Form	Black-Scholes
		Barrier	Trinomial Tree	N/A
Commodity	Barra-supplied	N/A	N/A	N/A
Commodity Future	Importable	N/A	Cost of Carry	N/A
Commodity Index Future	Importable	N/A	Cost of Carry	N/A
Commodity Future Option	Importable	European	Closed Form	Black (1976)
		American	Trinomial Tree	N/A
		European Asian	Approximation	Asian
Composite Index	Barra-supplied Importable	N/A	N/A	N/A
Custom Exposure Asset	Importable	N/A	N/A	N/A
Hedge Fund	Importable	N/A	N/A	N/A
Mutual Fund/Unit Trust	Barra-supplied	N/A	Market Price	N/A
Property/Real Estate	Barra-supplied	N/A	N/A	N/A
Private Real Estate	Importable	N/A	N/A	N/A
StructureTool Asset	Importable	N/A	Monte Carlo Simulation	Various, but typically: • lognormal price/rate for equity and FX underliers • Hull-White single factor for interest rate underliers
Unit Exposure Asset	Barra-supplied	N/A	N/A	N/A

Interest Rate Instruments

This section describes the techniques BarraOne uses to handle the following instruments:

- EuroDollar Future
- Brazil Interest Rate Future
- EuroDollar Future Option
- Swap
- Cap/Floor
- Total Return Swap
- Swaption
- FRA (Forward Rate Agreement)

EuroDollar Future

A EuroDollar futures contract is an agreement between a buyer, a seller, and an established futures exchange or its clearinghouse in which the buyer/seller agrees to take/make “delivery” of a specified amount of a notional deposit transaction at a specified price at a specified time. These contracts are cash settled, without actual delivery of a deposit. A futures contract is subject to daily marking to market.

Valuation Methodology

The valuation methodology for a future position in BarraOne is the same for all future assets. BarraOne treats a future instrument as a position opened on a particular future exchange. By default, its market value is zero.

The face value of an EuroDollar future is calculated and displayed as follows:

Face Value of an EuroDollar Future

$$\text{Face Value} = (1 - r \cdot f) \cdot \text{Contract Size}$$

where:

r	=	annualized forward interest rate (*e.g.,* 3M U.S. LIBOR forward rate)
f	=	length of deposit period in years (*e.g.,* a deposit period of 3M is 0.25)

Face Value of an EuroDollar Future

Contract Size = size of the deposit (*e.g.,* 100,000 USD)

Necessary Market Data: LIBOR Zero interest rate curve (BarraOne supports only LIBOR-based EuroDollar futures). The user price is not required.

Pricing methodology: Cost of Carry

The price of an EuroDollar future is displayed using the market convention:

$100\,(1-r)$

Exposure Analysis

An EuroDollar future is exposed to term structure and swap factors.

The effective duration for all interest rate instruments is computed numerically by shifting interest rates up and down by 25 basis points and revaluing the face value of the instrument under the two scenarios.

The same methodology is used for other term structure exposures, such as Shift, Twist, and Butterfly, by applying the respective shape to the term structure.

Refer to "Interest Rate Factor Exposures" on page 283 for more information. For a complete discussion of exposures to term structure risk, refer to the *Barra Risk Model Handbook*.

An EuroDollar future has zero specific risk.

Face value is used in risk aggregation as the effective value of an EuroDollar future.

Brazil Interest Rate Future

BarraOne supports Brazil's One-Day Interbank Deposit Futures and Long-Term Interbank Deposit Futures.

Valuation Methodology

The valuation methodology for a future position in BarraOne is the same for all future assets. BarraOne treats a future instrument as a position opened on a particular future exchange. By default, its market value is zero.

The face value of a Brazil interest rate future is calculated and displayed as follows:

Face Value of an Brazil Interest Rate Future

$$\text{Face Value} = \frac{100{,}000}{\left(\frac{i}{100}+1\right)^{\frac{n}{252}}}$$

where:

i	=	traded interest rate (interpolated from the Brazil zero swap rate curve); spot rate for overnight contracts, 6-month forward rate for long-term contracts
n	=	for overnight contracts: the number of accrual days between the analysis day and the day preceding expiration date, based on a BUS/252 day count convention
	=	for long-term contracts: the number of accrual days between expiration of the contract and expiration of the underlying asset, based on a BUS/252 daycount convention, *i.e.,* the number of business days in the six months following contract expiration
Contract Size	=	size of the deposit (100,000 BRA)

Necessary Market Data: Brazil interbank zero rate swap rate curve.

Pricing methodology: Cost of Carry

Exposure Analysis

An Brazil interest rate future is exposed to term structure and swap factors.

The effective duration for all interest rate instruments is computed numerically by shifting interest rates up and down by 25 basis points and revaluing the face value of the instrument under the two scenarios.

The same methodology is used for other term structure exposures, such as Shift, Twist, and Butterfly, by applying the respective shape to the term structure.

Refer to "Interest Rate Factor Exposures" on page 283 for more information. For a complete discussion of exposures to term structure risk, refer to the *Barra Risk Model Handbook*.

An Brazil interest rate future has zero specific risk.

Face value is used in risk aggregation as the effective value of an Brazil interest rate future.

EuroDollar Future Option

The holder of an EuroDollar future option has the right to buy (call) or sell (put) the underlying EuroDollar futures contract at a specified price. An exercised call option acquires a long position in the futures contract. An exercised put option acquires a short position in the futures contract. The resulting long and short positions are subject to daily marking to market.

The call option payoff in terms of prices can be written as follows:

EuroDollar Future Call Option Payoff

$$\begin{aligned}
&Payoff\left(Call_{Price}\right) \\
&= \max\left[0,\ IRFutureFaceValue - StrikeFaceValue\right] \\
&= \max\left[0,\ \left(1 - R_{Tm(Market)} \times Accrual_m\right) - \left(1 - R_{Tm(Strike)} \times Accrual_m\right)\right] \\
&= \max\left[0,\ \left(R_{Tm(Strike)} \times Accrual_m - R_{Tm(Market)} \times Accrual_m\right)\right] \\
&= Payoff\left(Put_{Rate}\right)
\end{aligned}$$

Finally, the option on the EuroDollar future can be presented as a put option on the simple LIBOR rate.

Supported Option Types

BarraOne supports puts and calls on the following types of EuroDollar future options:

- European
- Asian (European)

Valuation Methodology

Necessary market data: LIBOR interest rate curve

Model value: Option value from the option model

European Asian

Pricing methodology: Approximation

Pricing model: “Asian Model” on page 430

European

Pricing methodology: Closed form

Pricing model: "Black Model (1976)" on page 422

If the market price of the option is provided by the user, BarraOne will calibrate the volatility of the underlying future. When the option price is not supplied by the user, the option price is computed using the user-supplied implied volatility of the option, if available. If neither the user-supplied option price nor the user-supplied implied volatility of the option is available, then BarraOne will derive the option price from the Black (1976) model, using Barra-provided sigma from the Hull-White model to approximate the price volatility of the underlying future.

The following formula depicts an approximation of the method Barra uses to convert Hull-White sigma to Black volatility:

Conversion of Hull-White Sigma to Black Volatility (approximation)

$$\sigma_F = \frac{1}{F}\left|\frac{\partial F}{\partial x}\right|\sigma_x$$

where:

σ_F	=	approximated Black model volatility of the underlying future contract
F	=	price of the underlying future contract
$\left\|\frac{\partial F}{\partial x}\right\|$	=	sensitivity of the underlying future contract to unit term structure shift
σ_x	=	Hull-White volatility

Numeraire Exposure

The underlying asset for a EuroDollar future option is the future price defined in "Face Value of an EuroDollar Future" on page 265. The numeraire exposure of the option is the option premium.

Note: When a EuroDollar future option is well out-of-the-money, the application will display extremely large values for Total Risk and MCTR, due to the sensitivity of our risk model. These values are accurate, but because the market value of such assets is close to zero (0), these values will not be materially reflected in calculations at the portfolio level.

Swap

BarraOne supports the vanilla, currency, zero coupon, and inflation forms of interest rate swaps.

Vanilla Swap

A vanilla interest rate swap is a contract between two parties in which one party (the party long the swap) agrees to pay a fixed interest rate, and the other party (the party short the swap) agrees to pay a floating interest rate in the same currency.

The amount of money that changes hands at each payment date is based upon an underlying principal amount referred to as the notional amount. The notional amount itself never changes hands; the notional amount is merely the amount upon which the interest payments (one fixed rate and one floating rate) are based.

At each payment date, the net interest payment is paid from one party to the other. Based upon the levels of the floating rate and the fixed rate, two interest payments are computed, and then the difference is paid to whichever side has the lower interest payment. This is equivalent to each side paying the other the full amount of the respective interest payments, except less cash changes hands. Of course, in the unlikely event that both interest payments are identical (meaning the fixed rate equals the floating rate on payment date), then no cash changes hands.

Valuation Methodology

Pricing methodology: Discounted Cash Flow

To value an interest rate swap, including forward starting swaps, BarraOne determines the fair value of each side (or leg) of the transaction. The cash flows of the fixed leg are determined by the coupon rate set at the time of the agreement. The cash flows of the floating leg are determined by LIBOR. The value is the difference between the fair value of the fixed leg and the fair value of the floating leg.

For forward starting swaps, the pricing methodology, pricing model and necessary market data is the same as a plain vanilla swap. The model value is the price difference between the two legs of the transaction.

Exposure Analysis

The swap's risk factor exposures are manifestly equal to the portfolio exposures. Because the swap market value is near zero (exactly zero at inception), it is convenient not to divide by the market value when quoting exposures, but rather to use just the derivative of value with respect to a market factor, and scale this by notional amount in portfolio calculations.

Following this convention, the exposure per unit of notional to factor x is:

$$e^{x}_{swap} = \frac{\dfrac{\partial P_{float}}{\partial x} - \dfrac{\partial P_{fixed}}{\partial x}}{V_{swap}}$$

Numerically, we expect the effective duration of a swap of term T to be very close to $(p - D)$, where p is the time to next reset of the floating leg, and D is duration of a par-priced fixed rate bond with maturity T. This quantity will most likely be negative, reflecting the fact that the fixed payer is short the fixed-rate bond.

The effective duration for all interest rate instruments is computed numerically by shifting interest rates up and down by 25 basis points and revaluing the instrument under the two scenarios.Thus, it measures the sensitivity of the overall swap (the combination of both the long and the short legs).

The dollar duration similarly measures the sensitivity of the overall swap.

The same methodology is used for other term structure exposures, such as Shift, Twist, and Butterfly, by applying the respective shape to the term structure.

Refer to "Interest Rate Factor Exposures" on page 283 for more information. For a complete discussion of exposures to term structure risk, refer to the *Barra Risk Model Handbook*.

In addition to STB exposures, swaps are also exposed to the swap spread and currency factors. As for any other security, the currency exposure is the currency value of the swap. The swap spread exposure is the effective duration of the swap.

There is no specific risk for swaps.

Yield, nominal duration, modified duration, average life, and other cashflow-related statistics are not meaningful for describing swaps.

Currency Swap

A currency swap is very similar to a vanilla swap, except that different currencies and different discount factor curves are used for each leg, because the payments are made in different currencies. Also, unlike vanilla swaps (in which no principal changes hands between the two parties), in a currency swap there are provisions that affect principal exchange.

Currency swaps may be specified as having either no principal exchange, principal exchange only at maturity, or principal exchange at start and maturity of contract. The formulas shown in this section apply to the case of no principal exchange, but they are easily modified for cases involving principal exchange.

Valuation Methodology

Pricing Methodology: Discounted Cash Flow

Leg of Currency Swap

$$P_{Fixed} = \sum_{i=1}^{n} NPA \times R \times AF_{i-1,i} \times DF_i$$

where:

P_{Fixed}	=	present value of cash flows
NPA	=	notional principal amount
R	=	coupon rate
i	=	summation counter
n	=	number of coupons payable between valuation date and maturity date
$AF_{i-1,i}$	=	accrual factor between dates *i-1* and *i*, based upon the specified accrual method
DF_i	=	zero coupon discount factor at date *i*

Model value: The net present value in reporting currency of all legs.

Exposure Analysis

A currency swap has two sets of interest rate exposures: one set for the pay leg and one set for the receive leg.

$$E_P = \frac{\partial \text{ Swap Value}}{\partial \text{ Pay Leg}}$$

$$E_R = \frac{\partial \text{ Swap Value}}{\partial \text{ Receive Leg}}$$

FX swap effective duration is calculated as the aggregated duration of both legs. The formula is as follows:

> FX swap effective duration = ([receive leg duration] * [receive leg market value] + [pay leg duration] * [pay leg market value]) / (Swap market value)

Currency exposures are computed using the same method used for an FX Forward (refer to "FX Forward" on page 348).

The specific risk of the instrument is zero.

Inflation Swap

An inflation swap is much like a vanilla interest rate swap, except one side pays LIBOR, and the other side pays the ratio of the specified Consumer Price Index (CPI) rate on the quote date to the value of the same CPI rate at the inception of the trade (or at some fixed date). Inflation swaps are supported only in markets for which Barra supplies the real term structure. The valuation methodology, numeraire exposure, and risk exposure are the same as for an interest rate swap.

Notes:

- BarraOne uses an inflation curve that is a proxy for CPI. This proxy curve is calculated as the difference between the Treasury and Real curves. This curve is used when users select "Inflation" as the Reference Rate in the terms and conditions of the swap, in which case BarraOne values the floating leg based on projected inflation.

  If the accrual type is set to "At Maturity," BarraOne calculates accrued inflation from the start date to the analysis date, and then BarraOne adds projected inflation from the analysis date to the maturity date based on the current inflation curve. For example, for a 30-year pay-at-maturity swap starting today, BarraOne values the floating leg as paying *expected inflation at maturity / inflation at start date*, so if the current inflation level is 100, and expected inflation in 30 years is 165, then the floating leg is assumed to pay 165% x *Notional* at maturity.

  The coupon frequency determines compounding, e.g., if coupon frequency is set to 1Y, BarraOne will calculate forward one-year inflation rates for 30 years. If coupon frequency is set to 6M, BarraOne will calculate forward six-month inflation rates for 60 periods (i.e., two periods per year for 30 years).

- The last historical reset rate that is generated by BarraOne for the inflation leg of an inflation swap is used to determine the coupon payment at the end of the coupon period only until the settlement date; from the settlement date until the end of the coupon payment period, BarraOne calculates the rate from market data:

  To illustrate how BarraOne calculates the historical reset rate, let us denote the time between the beginning and end of the coupon payment period with t, the time between the beginning and the settlement date with $t1$, and the time between the settlement date and the end with $t2$. For $t1$, BarraOne uses the reset rate from the historical index levels ($r1$), although this is just an approximation. For $t2$, BarraOne uses a forecast rate ($r2$), which is explicitly taken as the forward rate for $t2$. Since BarraOne uses annualized continuously compounding, for the resulting rate (R) for the coupon payment period, BarraOne starts with the formula $exp(t1*r1) * exp(t2*r2) = exp(t*R)$ and solves for R with $R = (t1*r1 + t2*r2)/t$.

User Prices

Users may import a price for an inflation swap. This enables users to match the BarraOne inflation swap market value with their own valuation.The user-imported price must be expressed as a currency amount in the price currency of the inflation swap, and it will be used as the swap's market value. The imported price is then used by the application as indicated below:

- BarraOne will calibrate a spread to the swap curve and return the inflation swap durations based on the imported user price.
- In stress test simulations, the calibrated spread based on the imported price is used for repricing the inflation swap based upon the simulated market conditions. The inflation swap will not be sensitive to spread shocks.
- In historical value-at-risk simulations, the user imported price for the inflation swap is used as the initial market value, while the calibrated spread is kept constant in all simulations.
- In Monte Carlo value-at-risk simulations, the imported price and calibrated spread are used for the base scenario, and the calibrated spread is kept constant in all simulations.

⊳ **Note:** User-imported prices are ignored for interest rate swaps other than inflation swaps (*i.e.,* interest rate swaps with a Reference Rate set to Inflation).

Zero Coupon Swap

An zero coupon swap (or accrual swap) is much like a vanilla interest rate swap, except the fixed rate leg pays only one coupon at maturity. It has an accrual rate at which it accrues interest throughout the life of the swap. The valuation methodology, numeraire exposure, and risk exposure are the same as those of an interest rate swap.

Overnight Index Swap

An overnight index swap is much like a vanilla interest rate swap, except the floating rate leg is tied to a published index of a daily overnight rate reference. The valuation methodology, numeraire exposure, and risk exposure are the same as those of an interest rate swap.

Cap/Floor

An interest rate cap is an agreement that gives the buyer the right to fix the maximum rate of interest on a notional short- or medium-term loan at a specific strike rate for a specified period. On the settlement date, the seller of the cap pays the buyer any amount above the strike.

An interest rate floor is an agreement that gives the buyer the right to fix the minimum rate of interest on a notional short- or medium-term investment at a specific strike rate for a specified period. On the settlement date, the seller of the floor pays the buyer any amount below the strike.

Valuation Methodology

Pricing methodology: Cap/floor options are treated as a series of European-style interest rate put/ call options.

Pricing model: “Black Model (1976)” on page 422

Necessary market data:

- Zero rates
- Hull-White or Black volatility

A cap/floor can be decomposed into a series of individual interest rate put/call options (caplets, floorlets).

Interest Rate Caps

The total cap can be treated as a sum of the individual caplets. Let P be the notional amount; let F be the present implied forward rate for the start of this caplet period; let K be the cap rate; let T be the time from the valuation date until the start of the caplet; let τ be the length of the caplet period (from T to $T+\tau$); and let $F_{T,T+\tau}$ be the actual forward rate for the caplet at time T.

The cash flow for the caplet period is $P\tau\, max(F_{T,T+\tau}-K, 0)$ at time $T+\tau$. Thus, the payout for the caplet looks much like the payout from a European option terminating at time T, and a commonly used valuation model treats it as such.

Delta, gamma, and vega are calculated as shown in "Black-Scholes Generalized Model Options" on page 447, but they are modified as follows: Delta is in units of currency per 100% change in the implied forward rate. To convert this to currency per basis point, simply divide by 10,000. To convert gamma to units of currency per bp^2, divide gamma by $10{,}000^2$. Vega is in units of currency per 100% change and can be converted to currency per 1% change by dividing by 100.

Theta is the option price sensitivity to change in time. It is calculated by moving the analysis date one day into the future and revaluing, and it is reported as a change in price, rather than as a derivative.

Interest Rate Floors

A rate floor is simply modeled as a European put on the forward rate.

Note that the price as quoted in basis points by the dealer is not the same as the basis points obtained from the options on Eurodollar futures. This is because the underlying LIBOR deposit for each Eurodollar option is .25 years. The price in dollars is then 126 bps × \$1 million × .25 = \$3,150, which is equivalent to the dealer price (31.5 bps × \$1 million = \$3,150).

Model value: The present values of the caplets/floorlets from the Black model are summed to give the overall value of the cap/floor.

Total Return Swap

A total return swap is an over-the-counter agreement between counterparties, in which one party makes payments based upon a specified rate (either fixed, or floating plus a margin), and the other party makes payments based upon the total return (including income and capital gains) of an underlying asset.

Total return swaps are often used to hedge a portfolio (much like a futures contract). They are also used to gain exposure to a market more cheaply than buying the underlying asset outright, to avoid capital gains taxes, or for asset allocation purposes.

Supported Total Return Swaps

BarraOne supports equity and fixed income total return swaps. For an equity total return swap, the underlying asset may be either an equity index or a single equity. For a fixed income total return swap, the underlying asset is a fixed income index (such as the Lehman Aggregate) or a single bond.

- BarraOne supports total return swaps where the total return leg is paid either periodically or at maturity.
- The application does not support swaps where the notional amount is variable; only constant notional swaps are supported.
- Additionally, total return swaps are not supported where an up-front exchange is made for the total return of an asset; in this instance, the user is advised to load a position in the underlying asset to reasonably replicate the risk associated with a swap of this type.

Valuation Methodology

Necessary market data:

- LIBOR
- Price of the underlying asset on the payment date

Pricing methodology:

- Discounted Cash Flow

Pricing methodology:

- Replicating Portfolio

The market value of the swap is the value of the replicating portfolio.

Exposure Analysis

Conceptually, a total return swap can be replicated by holding a composite portfolio consisting of a short position in a LIBOR FRN and a long position in the underlying asset. Each leg is assumed to be equal to the notional amount of the contract. The intuition behind this approach is as follows:

> The investor decides to borrow the notional amount and then invest it all for a fixed period of time into a market index. At the end, the investor liquidates index position and pays out the borrowed notional plus interest on it.

> To be able to borrow the notional amount in the beginning of the swap, the investor has to pay an adjustable coupon, usually with a certain margin. The cost of borrowing is assumed to be associated with money market rates. That is why most TRS have a LIBOR + margin pay leg.

The position in the floating leg of the replicating portfolio remains constant (–1 to indicate a short position).

In the case where the total return leg is paid at each reset, the replicating portfolio position in the underlying asset will change with each reset. The position in the underlying asset will equal (*notional amount*)/(*underlying asset return*). The readjustment of the replicating portfolio accounts for the cash flow based on the underlying asset return.

A slightly different replicating portfolio is used in the case where the total return leg is paid only at swap termination. In this case, the position in the underlying asset remains constant throughout the life of the swap contract. The underlying asset position does not change at each reset date, as it does in the previous case.

The risk of the swap is the risk of the replicating portfolio.

Underlying Asset (Total Return) Leg

The underlying asset return for one payment period is computed as follows:

$Notional \times (Px_{(T1)} / Px_{(T0)} - 1)$

where:

$Px_{(T)}$ represents the underlying asset price at time T.

The return is unconditional and can be positive or negative.

Floating Leg

The floating coupon can reference any index rate supported for an interest rate swap.

The margin can be positive or negative.

Swaption

An interest rate swaption is the option to enter, at option expiration, into a standard vanilla forward-starting interest rate swap either to pay fixed and receive floating (a payer's swaption or swaption buyer) or to pay floating and receive fixed (a receiver's swaption or swaption payer).

Supported Swaption Types

- European
- Bermudan
- Cancelable Swap

  Note: A cancelable swap is modeled as an interest rate swap plus a swaption to go into the opposite swap on the specified date. The swap does not expire on that date.

Valuation Methodology

Necessary market data:

- Zero rate

European pricing model: "Hull-White Model" on page 425 (analytical formula)

Bermudan and cancelable swap pricing model: "Hull-White Model" on page 425 (simulation)

Black versus Hull-White

Users may import a three-dimensional surface (cube) of implied volatility for swaptions as a user attribute. The three dimensions are: moneyness, swap term, and swaption maturity. The moneyness of the swaption is determined using Barra's interest rate curve and is used to extract the appropriate Black volatility from the cube. The swaption is then valued using the "Black Model (1976)" on page 422.

Without a user-imported volatility surface cube, and without a user-provided price, BarraOne uses the Hull-White model to value swaptions. If the user provides a price, BarraOne calibrates a Hull-White volatility to that price. If the calibration fails, then BarraOne attempts to calibrate a Black volatility; if that fails, as well, then BarraOne falls back to the default Hull-White model volatility.

In historical VaR and Monte Carlo VaR simulations, BarraOne uses the volatility cube for the initial valuation, but BarraOne does not model the volatility in simulations. In other words, in HVaR decomposition, the Volatility VaR is always 0; in MCVaR, the volatility is held constant.

If the user supplies a swaption implied volatility surface (cube):

1. BarraOne calculates a Black price based on the Black model and the Black volatility from the volatility cube.
2. BarraOne tries to calibrate a Hull-White volatility from the Black price. There are two possible scenarios:

   (a) Calibration succeeds:

   - The implied volatility displayed in BarraOne is the calibrated Hull-White volatility. BarraOne will then try to calibrate the Black volatility from the Hull-White model, and the Calibration flag is set to "Success" or "Fail," depending upon the result.

- The risk values (KRDs, Greeks, Spread Durations. etc.) displayed in BarraOne are calculated using the Hull-White model with the calibrated Hull-White volatility.
- In MCVaR, the calibrated Hull-White volatility is kept constant in each simulated scenario, and the Hull-White model is used.
- Stress test:
    - In an uncorrelated interest rate shape shock, the calibrated Hull-White volatility and the Hull-White model are used for the base valuation; the calibrated Hull-White volatility is kept constant between the before and after shock valuations; and the Hull-White model is again used for the after shock valuation. This is true for all markets.
    - In an uncorrelated interest rate volatility shock, the calibrated Hull-White volatility and the Hull-White model are used for the base valuation; the calibrated Hull-White volatility is shocked based on the defined scenario; and the Hull-White model is again used for the after shock valuation. This is true for all markets.

(b) Calibration fails:

- The implied volatility displayed in BarraOne is the Black volatility, and the Calibration flag is set to "Fail."
- The risk values (KRDs, Greeks, Spread Durations, etc.) displayed in BarraOne are calculated using the Black model with interpolated Black volatility from the user-provided volatility cube.
- In MCVaR, the Black volatility from the volatility cube is kept constant in each simulated scenario, and the Black model is used.
- In an uncorrelated interest rate shape/volatility shock stress test, the Black volatility and the Black model are used for the base valuation; the Black volatility is kept constant between the before and after shock valuations; and the Black model is again used for the after shock valuation. This is true for all markets.

Exposure Analysis

A swaption is exposed to the swap and term structure factors.

The effective duration for all interest rate instruments is computed numerically by shifting interest rates up and down by 25 basis points and revaluing the instrument under the two scenarios.

The same methodology is used for other term structure exposures, such as Shift, Twist, and Butterfly, by applying the respective shape to the term structure.

Refer to "Interest Rate Factor Exposures" on page 283 for more information. For a complete discussion of exposures to term structure risk, refer to the *Barra Risk Model Handbook*.

FRA (Forward Rate Agreement)

A Forward Rate Agreement is essentially an interest rate forward, or an agreement to fix the effective interest on a future borrowing or deposit in advance of the intended borrowing or deposit date. Thus, FRAs enable counterparties to lock in a forward interest rate.

The buyer of the FRA enters into the contract to protect itself from a future increase in interest rates by locking in a borrowing rate. This occurs when a company believes that interest rates may rise and wants to fix its borrowing cost today.

The seller of the FRA wants to protect itself from a future decline in interest rates by locking in a rate. Investors who want to hedge the return obtained on a future deposit use this strategy.

This instrument is equivalent to a one-payment interest rate swap, where both legs have the same payment frequency.

Valuation Methodology

Necessary market data:

- LIBOR Zero rate

Pricing methodology: Cost of Carry

FRAs derive their value from the spot curve, or implicitly from the forward curve. The payoff is the spot rate at the settlement date minus the implied forward rate. The party long the agreement receives a payment if the spot rate is above the forward rate.

An implied forward rate is the market implied rate from a time in the future to a time farther in the future. Spot rates describe zero-coupon investment rates that start at the current time. From spot rates, forward rates (*i.e.,* rates that start at a future date) can be inferred.

The present value of an FRA is calculated as the present value of the future cash flows using implied forward rates derived from the appropriate discount curve, where the LIBOR forward rate is replaced by the effective rate on the effective date of the FRA.

FRA Model Value

$$Notional\left(R - R_F\right)Te^{-r\left(t_1 - t\right)}$$

where:

Notional	=	notional principal amount of the FRA contract
R	=	market interest rate between t_1 and t_2 at t (calculated by the BarraOne application)
t_2	=	maturity date of the FRA contract
t_1	=	effective date of the FRA contract
t_0	=	contract date
t	=	evaluation date
R_F	=	implied forward rate between t_1 and t_2 at t_0
T	=	time accrual between t_1 and t_2 , *e.g.,* 90/360 = 0.25
e	=	base of the natural logarithm
r	=	default-free interest rate

Numeraire Exposure

The numeraire exposure for an FRA defaults to the notional principal amount.

Fixed Income Instruments

This section describes the techniques BarraOne uses to handle the following instruments:

- Exposure Analysis
- Duration Proxy
- Optionable (Callable or Putable) Bond
- Bond Forward
- Treasury Future
- Bond Option
- Treasury Future Option
- Convertible Bond
- Floating Rate Note (FRN)
- Variable Rate Notes
- Inflation Protected Bond (IPB)
- Mortgage Backed Securities (MBS)
- Municipal Floating Rate Note
- Repo
- Cashflow Bond
- Cashflow Asset
- Inflation Linked Liability
- Securitized Products
- Syndicated Loan
- Credit Default Swap
- Credit Default Swap Basket
- Credit Linked Note
- CDS Option
- CDS Tranche
- Nth-to-Default

Exposure Analysis

The exposures of all fixed income securities in BarraOne consist of interest rate exposures calculated from local shocks to the term structure. Additionally, any non-sovereign fixed income asset is exposed to a spread factor (note that South Africa treasuries that do not belong to the BESA index are also exposed to Swap STBs). Assets in a market for which Barra has a detailed credit model may also be exposed to credit spread factors or to an emerging market factor. Each asset is also exposed to specific risk.

Asset exposures are determined by currency of cashflows, asset type, and possibly issuer, sector, and rating. This section outlines the basic exposure methodology for all fixed income instruments. Details about fixed income exposures can be found in the *Barra Risk Model Handbook*.

Interest Rate Factor Exposures

All fixed income assets are exposed to one or more interest rate factors. The protocol for determining what these factors are is as follows:

- What is the bond's currency of denomination and its ISO code?
- Does the instrument belong to a market that is supported?
- Is the instrument an inflation-protected security or a standard security?
- Is the instrument a US municipal bond?

Nominal Yield Curves

Interest rate factor exposures are the price sensitivities of assets to changes in the term structure of interest rates. For any asset covered by Barra's models, there is an analytical model in which the price of the asset is given as a function of the term structure and other inputs. The market price for ordinary assets (such as bonds) is calibrated to the analytical model by solving for the option-adjusted spread. For other instruments (options, futures, convertible bonds, *etc.*), the calibration constant is implied volatility (options), implied repo rate (bond futures), or implied volatility or option-adjusted spread (convertible bonds).

Exposure of an asset to interest rate and other factors is determined by calibrating the asset valuation model to the price of the asset as follows:

Fixed Income Valuation Model Calibration

$$P_0 = V\left(r(T), s, \cdot\right)$$

where:

P_0	=	price of asset
V	=	valuation model
$r(T)$	=	spot rate curve of the market as a function of term

Fixed Income Valuation Model Calibration (Continued)

s	=	calibration constant (option-adjusted spread, or repo rate for futures)
$\bullet$	=	other model inputs

Once we have a calibrated model, we compute exposures numerically by "shocking" the inputs related to the risk model factors. In particular, interest rate exposures are calculated by shifting the term structure up and down by the factor shape functions, and then estimating the exposures from the computed changes in model value.

For developed markets, interest rate factors for bonds are shift, twist, and butterfly factor shapes or key rate shapes based on sovereign bonds. The factor shapes are obtained by principal component analysis of the covariance matrix of spot rate changes in each local market. The shapes are normalized so they are positive at maximum term and their norm is equal to the number of vertices.

The interest rate and other exposures are described mathematically as follows:

Interest Rate Exposures Derived Mathematically

$$E_i = -\frac{1}{P_0}\frac{\partial V[r(T) + \theta\phi_i(T), s, \cdot]}{\partial \theta}$$

where:

E_i	=	exposure to the i^{th} term structure factor
$\partial V/\partial \theta$	=	the first order derivative of the valuation function V with respect to the perturbation ϕ_i at the base term structure $r(T)$
θ	=	magnitude of perturbation (shock), *e.g.,* 25 basis points
$\phi_i(T)$	=	term structure factor shapes as a function of term: shift, twist, and butterfly (STBs) as shown in Figure 10 on page 285; or key rate tents (KRDs) as shown in Figure 11 on page 286.

The numerical function for approximating exposures amounts to using finite values for the "shock" parameter to shift the term structure:

Interest Rate Exposures Approximated Numerically

$$E_i \approx -\frac{1}{P_0}\frac{V[r(T)+\theta\phi_i(T),s,\cdot]-V[r(T)-\theta\phi_i(T),s,\cdot]}{2\theta}$$

Examples of term structures shocked up and down by STB and key rate shapes are shown in Figure 12 on page 286 and Figure 13 on page 287.

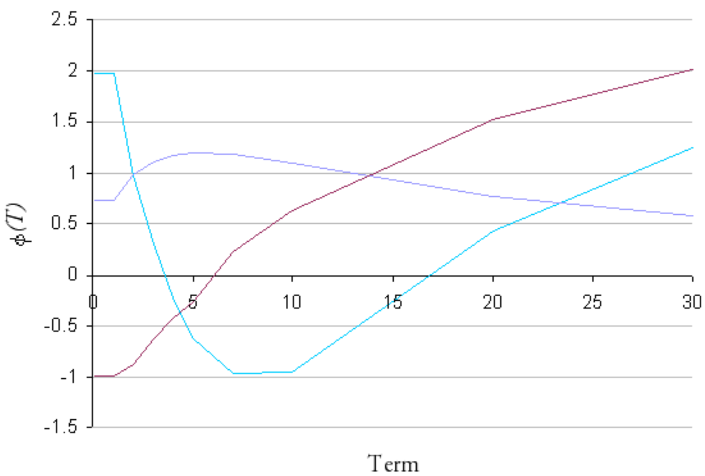


Figure 10: STB Factor Shapes

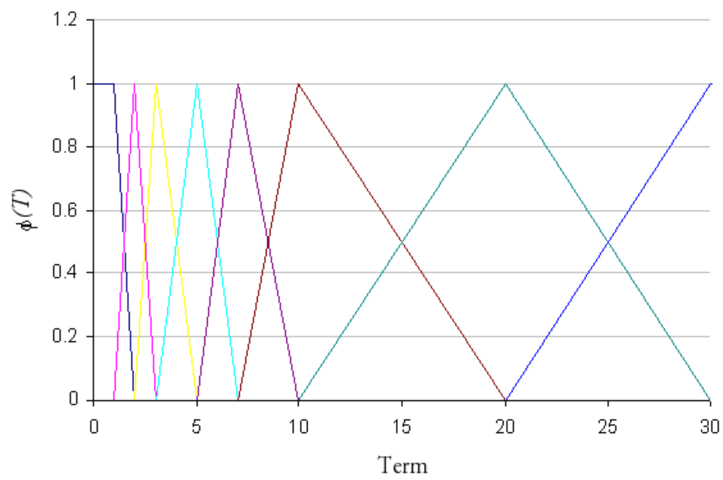


Figure 11: Key Rate Factor Shapes

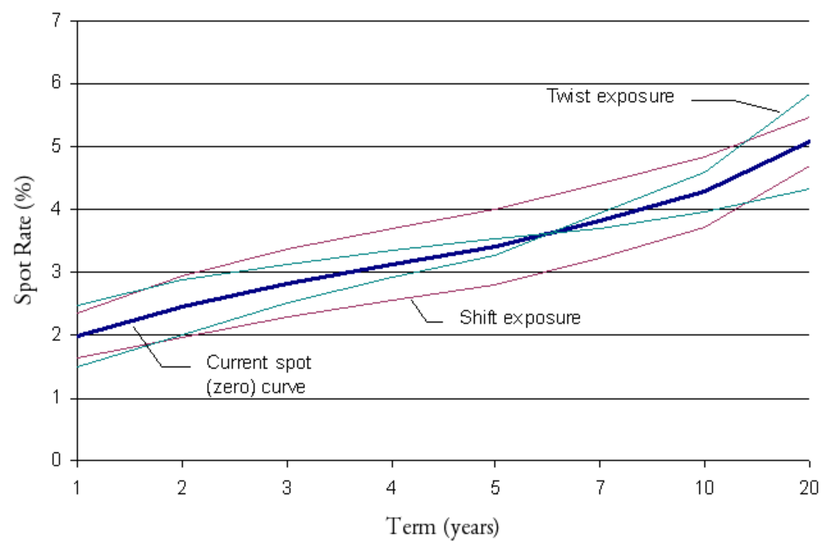


Figure 12: Term structure shifted up and down by the shift and twist factors to get effective duration

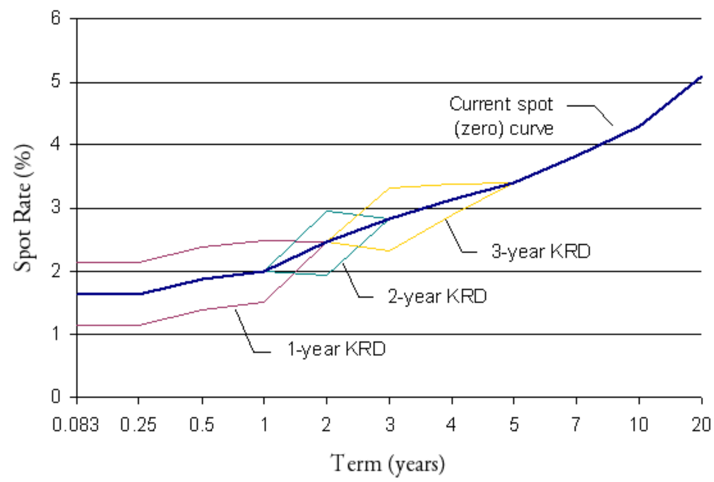


Figure 13: Term structure shifted up and down by the first three key rate factors to get key rate durations

Real Yield Curves

Interest rate factor exposures for inflation-protected bonds are obtained in a way similar to the nominal yield curve factor exposures. See "Inflation Protected Bond (IPB)" on page 317.

Credit Factor Exposures

Details about the Fixed Income Credit Model can be found in Fixed Income Risk Modeling with the Global Industry Classification Standard (GICS®). Credit factor exposures consist of swap spread curves, sector, rating, issuer, and miscellaneous spread factors, most of which are a function of the spread duration.

Spread Duration

$$D_s = -\frac{1}{P_0}\frac{\partial V\left(r(T), s\right)}{\partial s}$$

where:

$\partial V / \partial s$ = the partial derivative of the valuation function V with respect to the calibration constant s

Swap Factor Exposures

The exposure to the swap spread factor is calculated one of the following ways:

- If the bond is not floating off LIBOR, and if the bond is also exposed to another "detailed" credit factor, then the exposure to the swap spread and the credit spread factor is the spread duration D_{spr}.
- If the bond is floating off LIBOR, and if the bond is also exposed to another "detailed" credit factor (this includes emerging market factors), then the exposure to the swap spread is the effective or option-adjusted duration D_{eff}, and the exposure to the credit spread factor is the spread duration D_{spr}.

  For assets denominated in USD, AUD, CAD, CHF, EUR, JPY, or GBP with the appropriate rating and/or sector information, then the exposure to the swap spread is:

  - Swap Spread Shift Exposure = *Effective Swap Shift Exposure*
  - Swap Spread Twist Exposure = *Effective Swap Twist Exposure*
  - Swap Spread Butterfly Exposure = *Effective Swap Butterfly Exposure*

- If the bond is not floating off LIBOR, and if the bond is not exposed to another "detailed" credit factor, then the exposure to the swap spread is:

$$D_{spr} \max\left[1, \left(\frac{\max(OAS, 10\text{bp})}{\max(S, 10\text{bp})}\right)^{\gamma}\right]$$

  where D_{spr} is the spread duration, *OAS* is the bond option-adjusted spread, *S* is the swap spread (*i.e.,* the average difference between swap spot rates and Treasury spot rates), and y is a market-dependent scaling exponent (usually between 0.5 and 1.0).

- If the bond is floating off LIBOR, and if it is not exposed to another spread factor, then the exposure to the swap spread is:

$$D_{eff} + D_{spr}\left[\max\left[1, \left(\frac{\max(OAS, 10\text{bp})}{\max(S, 10\text{bp})}\right)^{\gamma}\right] - 1\right]$$

  For assets denominated in USD, AUD, CAD, CHF, DKK, EUR, JPY, NOK, NZD, GBP, SEK, or ZAR but with no rating or sector information, the exposure to the swap spread is:

  - Swap Spread Shift Exposure = *Effective Swap Shift Exposure* + *Spread Swap Shift Exposure* * *Adjustment Factor*
  - Swap Spread Twist Exposure = *Effective Swap Twist Exposure* + *Spread Swap Twist Exposure* * *Adjustment Factor*
  - Swap Spread Butterfly Exposure = *Effective Swap Butterfly Exposure* + *Spread Swap Butterfly Exposure* * *Adjustment Factor*

  In the formulas above, the Adjustment Factor is calculated as:

$$\left[\max\left[1, \left(\frac{\max(OAS, 10\text{bp})}{\max(S, 10\text{bp})}\right)^{\gamma}\right] - 1\right]$$

where:

- S is the average swap spread over treasury. This is calculated separately for each asset, as the average of the swap spreads at each term structure vertex up to the next vertex after the maturity of the asset.
- OAS is the bond option-adjusted spread over the swap term structure.
- y is a market-dependent scaling exponent (usually between 0.5 and 1.0).

Credit Derivatives

Credit derivatives are by definition exposed to credit risk and should be exposed to the credit factors.

For instance, Credit Default Swaps are exposed to the spread factor corresponding to the currency, sector, and rating of the reference entity. The exposure is equal to:

$$\chi_S^{CDS} = -\frac{1}{P_{CDS}}\frac{\partial P_{CDS}}{\partial S}$$

CDS have no swap spread exposure.

U.S. Dollar Credit Factor Exposures

A U.S. dollar-denominated non-sovereign bond has exposure to a fine-grained credit spread factor: agency spread, corporate spread (sector-by-rating), MBS spread, or muni spread (muni curve), equal to the spread duration.

▷ **Note:** US Agency bonds are not exposed to the US Agency factor unless the bonds are rated AAA. US Municipal bonds are not exposed to the US Muni x Rating factors unless the bonds are rated. Neither bond is exposed to any detailed credit factor; rather (as is usual in such situations), both are exposed to the swap factor, with the exposure scaled by the bond OAS.

Japan Yen Credit Factor Exposures

A yen-denominated bond is exposed to government or non-government current yield equal to the clean bond price minus par. In addition, a yen-denominated government bond possibly has exposure to another factor equal to the spread duration. All yen-denominated corporate bonds are exposed to another factor equal to the spread duration. Additional information can be found in the Japan Fixed Income Factor Model (JPF4).

Euro Credit Factor Exposures

A euro-denominated non-sovereign bond has exposure to a sector-by-rating spread equal to the spread duration.

▷ **Note:**

Most eurozone governments have country-specific Shift, Twist, and Butterfly factors: Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal, Slovakia, and Spain. The euro-denominated bonds of these national governments receive no additional factor exposures.

Some other eurozone governments do not have country-specific Shift, Twist, and Butterfly factors: Cyprus, Estonia, Latvia, Luxembourg, Malta, and Slovenia. The euro-denominated bonds of these national governments are exposed as follows:

1. All-euro Shift/Twist/Butterfly factors (calculated using a weighted average of AAA eurozone government bonds)

2. Euro swap factor

3. Sovereign sector-by-rating factors appropriate for the bond rating (e.g., Sovereign A, Sovereign AA, etc.)

U.K. Sterling Credit Factor Exposures

A sterling-denominated non-sovereign bond has exposure to a sector-by-rating spread equal to the spread duration.

Canada Dollar Credit Factor Exposures

A Canada dollar-denominated non-sovereign bond has exposure to a sector-by-rating spread equal to the spread duration.

Switzerland Franc Credit Factor Exposures

A Switzerland franc-denominated non-sovereign bond has exposure to a sector-by-rating spread equal to the spread duration.

Sweden Kronor Credit Factor Exposures

A Sweden kronor-denominated non-sovereign bond has exposure to a sector-by-rating spread equal to the spread duration.

Emerging Markets Credit Factor Exposures

An emerging market sovereign issued in an external currency has exposure to its respective emerging market spread equal to the spread duration, except for a collateralized Brady bond for which the exposure is equal to the stripped spread duration.

Note: Emerging Market (EM) factors apply to bonds for which the issuer is domiciled in an Emerging Market* and the currency of denomination is any external currency. In particular, note that if an issuer in an Emerging Market country issues a bond in another emerging market, then the EM factor applies. For example, if a Korean company or the Korean government issues a bond with principal and coupon denominated in the Brazilian real, then the bond is exposed to the Brazilian (real-denominated) Shift, Twist, Butterfly, and Swap factors, as well as the EM factor for Korea.

* See https://support.msci.com/docs/DOC-3077 for markets covered by EM factors.

Implied Prepayment

BarraOne includes implied prepayment risk factors in the U.S. fixed income credit model, as the prepayment speed impact can be as great as the impact interest rate movements. All securities exposed to a prepayment cash flow model (MBS are exposed to one additional prepayment speed duration factor.) See also "Prepayment Models" on page 441.

Table 15: Implied Prepayment Factors

Factor Name	Factor ID
Conventional 15 Prepayment	USD_CDT_CONV15_REFI
Conventional 30 Prepayment	USD_CDT_CONV30_REFI
Conventional Balloon Prepayment	USD_CDT_CONVB_REFI
GNMA 15 Prepayment	USD_CDT_GNMA15_REFI
GNMA 30 Prepayment	USD_CDT_GNMA30_REFI

In principal, we calibrate the Barra behavioral prepayment model to fit the market prices of a representative set of U.S. MBS, including TBAs and seasoned generics, and we use the changing calibration constants to specify a risk factor. In practice, the factors are determined by a linearized form of this calibration.

The factor exposure is a prepayment duration, or the partial derivative of MBS value with respect to a small change in the prepayment model speed divided by price. It is a measure of prepayment sensitivity; like other derivatives, it is computed using a two-sided numerical approximation by shocking the prepayment speed parameter up, running the valuation model, and then shocking it down and running the valuation model again.

$$\frac{\Delta P}{P} \cong D_{prepayment}\Delta(\text{PrepaymentSpeed})$$

A portion of a bond's return and return volatility can be attributed to, or explained by, changes in the market participants' mortgage prepayment expectations. These factors help enable portfolio risk management for those portfolio managers who take prepayment bets.

> **Note:** BarraOne does not enable the user to enter a prepayment speed duration value for a fixed income proxy. For a proxy, this value will be set to zero.

Implied Volatility

BarraOne includes an interest rate implied volatility risk factor for the following markets:

- Australia
- Canada
- EMU
- Japan
- Sweden

- Switzerland
- United Kingdom
- United States

These factors affect the portfolio risk for instruments that are exposed to interest rate volatility of the government term structure in the affected markets. Instruments with significant exposure to these factors include:

- Callable/Putable Bond
- Bond Option
- Treasury/Agency Future
- Treasury/Agency Future Option
- Caps/Floor
- Swaption
- MBS
- Floating Rate Note (FRN)
- Variable Rate Note
- Eurodollar Future Option

A regular bond has an exposure of zero (0) to these factors. Due to the approximations used in valuation, there may be small volatility exposures for certain types of assets (such as vanilla FRNs) that should have zero exposure.

Implied volatility is the volatility implied by the market prices of interest rate options. In the Barra fixed income framework, we fit the parameters of the Hull-White interest rate option model that minimize a loss function for several liquid instruments with observable market prices, such as swaptions and caps/floors, though the model will not exactly equal market price for each one. (The implied volatility factors are based upon the log of the volatility of the ten-year yield in each market.)

The factor exposure is a Volatility Duration, or the partial derivative of value with respect to a small change in the option model volatility parameter divided by price. It is a measure of volatility sensitivity; like other derivatives, it is computed using a two-sided numerical approximation by shocking the appropriate model volatility parameter up, running the valuation model, and then shocking it down and running the valuation model again.

$$\frac{\Delta P}{P} \cong D_{volatility} \Delta \sigma$$

A portion of a bond's return and return volatility can be attributed to, or explained by, changes in the market participants' volatility expectations. These factors help enable portfolio risk management for those portfolio managers who take volatility bets.

Refer to *New Implied Volatility Factors in the Barra Integrated Model* for additional information.

Currency Exposures

Fixed income assets (with the exception of futures) have an exposure of 1 to the cash flow currency.

Specific Risk

Note that the column in which this risk characteristic is displayed is labeled "Selection Risk," regardless of the specific implementation of this new model as outlined below.

Fixed Income Issuer Specific Risk Model

For a bond (except a U.S. muni or an emerging market bond), bond derivative, CDS, or CLN issued in a market covered by the issuer-specific risk implementation of the model, if a supported issuer short name and the bond's credit factor (*i.e.,* rating and optional sector) are both available in the T&C, then the bond's specific risk parameter is the specific yield volatility for its issuer and factor combination. Specific yield volatility is the specific risk divided by effective duration; thus, to calculate a bond's specific risk, its specific risk parameter is multiplied by its effective duration (except for floating rate assets, for which it is multiplied by spread duration).

Thus:

Bond Specific Risk = *Bond Effective Duration* x *Issuer and Factor Specific Yield Volatility*

The asset-level, fixed income, issuer- specific risk model provides for accuracy and responsiveness. The behavior of the model is determined by the market, the availability and support of the issuer short name, and the availability in the T&C of the bond's credit factor (*i.e.,* rating and optional sector). The following markets are covered by this implementation of the model:

- AUD
- CAD
- CHF (note that there are currently no supported issuer short names in the CHF market)
- EUR
- GBP
- JPY
- SEK (note that there are currently no supported issuer short names in the SEK market)
- USD

Notes:

- Users may take advantage of this implementation by specifying the issuer short name when importing user bonds in supported markets. A table of supported issuer short names is available on the MSCI Client Support website.
- Not every user-provided combination of issuer short name and factor is supported by this model, although all system bonds in supported markets will have valid combinations.
- Issuer Specific Risk data (*i.e.,* factor and specific risk yield volatility) is delivered weekly. If a gap of one week occurs (*i.e.,* one record is missing), then the previous week's value is used. If the gap is two week or longer (*i.e.,* two or more records are missing), then the Factor Specific Risk implementation of this model is used.

Details about the analytics behind issuer specific risk are available at https://support.msci.com/docs/DOC-3923.

CDS and Derivatives

CDS and CLN (credit linked notes) in covered markets also use the issuer specific risk model. The issuer parameter is selected based on the issuer and factor exposure of the reference entity. Unlike bonds, the risk parameter is scaled by the spread duration of the CDS or CLN.

Floating rate notes (i.e., all fixed income assets with variable coupons) use the issuer/factor specific risk parameter scaled by the spread duration of the asset, rather than by effective duration.

For other types of fixed income derivatives for which the underlying asset is a bond exposed to the credit factor model (e.g., a bond option), the issuer-specific risk model is also applied with the issuer volatility parameter for the underlying and with the effective duration of the derivative.

Factor Specific Risk

For a bond (except a U.S. muni or an emerging market bond), bond derivative, CDS, or CLN issued in any developed market with a credit factor exposure model, if the bond's credit factor (*i.e.,* rating and optional sector) is available in the T&C, but its issuer short name is either not available or not supported, then its specific risk parameter is the specific yield volatility for its factor, only.

Transition Matrix Specific Risk

U.S. municipal bonds and emerging market bonds use the transition matrix specific risk model.

In this model, specific risk is expressed as:

$$\sigma_{spec}^2 = \beta D^2 + \gamma$$

where D is the bond spread duration, and β and γ are rating and issuer-dependent constants that are updated every month.

Heuristic Specific Risk

For all other markets, or when there is no credit factor exposure for the asset (including a bond in developed market for which its rating does not have a corresponding factor), specific risk is calculated using the heuristic (linear) specific risk model. This model has two parameters: one to account for sovereign market risk; one to account for the credit riskiness of the corporate issuer. The heuristic model assumes that the specific risk of the bond is proportional to spread duration.

Expressed as return volatility, this specific risk is:

$$\sigma_i = D_i b_a + D_i c_a s_i$$

where:

σ_i = monthly specific risk of corporate bond i

D_i = spread duration of bond i

b_a = constant spread return risk for government bonds in domestic market a

c_a = constant to account for additional specific spread return volatility of corporate bonds in market a

s_i = OAS of asset i

Linked Specific Risk

Linked specific risk comes into play only at the portfolio level. Specific risk in a factor model framework accounts for non-factor risk, *i.e.,* to components of volatility that cannot be attributed to systematic sources of return (and risk). Please see the Fixed Income Model research notes for more details on specific risk modeling.

In a portfolio context, one needs to account for the fact that if an issuer experiences a credit event, all bonds of this issuer are affected. Therefore, the simplistic assumption that specific risk diversifies on the portfolio level does not hold to the full extent.

Linked Specific Risk accounts for this economic intuition by imposing a correlation of the specific risk of bonds from the same issuer:

$$cov_{i,j}^{Specific} = corr_{i,j}^{Specific} \sigma_i^{Specific} \sigma_j^{Specific}$$

where D is the asset-by-asset specific risk matrix with entries $cov_{i,j}$ for bonds i and j, and $\sigma_i^{Specific}$ is the specific risk forecast for asset i.

Correlation

- The correlation of issuer specific risk between two bonds that share an issuer short name will vary by market:

- For markets with detailed credit factor models, two levels of correlation are used: one for bonds that share their credit factor, and one for bonds that have different credit factors. Bonds that share the same credit factor have a higher specific risk correlation. These parameters vary by market and are set based on historical market conditions. The same factor specific risk correlation is around 0.7 in most markets, while the different factor specific correlation is around 0.4.
- In markets with no detailed credit factors, a single correlation parameter is used. This correlation is fixed at 0.65.
- The correlation between two bonds of the same issuer in different markets is the product of the square roots of the two parameters in each market:

$$\rho_{eff} = \sqrt{\rho_1}\sqrt{\rho_2}$$

  For detailed credit markets, the correlation used with an asset in another market is the one for different factor exposure bonds.

Example

Corporate Issuer M issues three bonds (1,2,3) exposed to two factors (A,B); Corporate Issuer N also issues also three bonds (4,5,6) exposed to two factors (A,C), one of which is shared with the other issuer. Graphically, one can represent the asset-issuer relation as in the table below, where σ_{same} indicates that the two bonds share the same issuer and factor, and where σ_{diff} indicates that the two bonds share the same issuer but different factor. Bonds that do not share an issuer have zero specific risk correlation regardless of the factor exposure.

Asset			1	2	3	4	5	6
	Issuer		M	M	M	N	N	N
		Factor	A	B	B	A	C	C
1	M	A	1	σ_{diff}	σ_{diff}	0	0	0
2	M	B	σ_{diff}	1	σ_{same}	0	0	0
3	M	B	σ_{diff}	σ_{same}	1	0	0	0
4	N	A	0	0	0	1	σ_{diff}	σ_{diff}
5	N	C	0	0	0	σ_{diff}	1	σ_{same}
6	N	C	0	0	0	σ_{diff}	σ_{same}	1

Observe the following report for an illustration of the implementation of linked specific risk in BarraOne.

BARRAID	ISIN	Asset Name	Sector	Currency	LSR Root Id	Selection Risk
000I4K	DE0001134468	GERMANY (GOVERNMENT OF) 6% 20160620	Government	EUR	000I4K	0.34
000IE7	FR0000570780	FRANCE (GOVERNMENT) 8.5% 20121226	Government	EUR	000IE7	0.11
000XZ3	DE0004771662	WORLD BANK INTERNATIONAL BANK FOR RECONSTRUCTION AND DEVELOPMEN	Supranational	EUR	(Issuer Id: 71483)	1.07
0016VQ	BE0000282880	BELGIUM, KINGDOM OF (GOVERNMENT) 8% 20150328	Government	EUR	0016VQ	0.31
002DMD	IT0001086567	ITALY, REPUBLIC OF (GOVERNMENT) 7.25% 20261101	Government	EUR	002DMD	1.04
003GPP	AT0000383864	AUSTRIA, REPUBLIC OF (GOVERNMENT) 6.25% 20270715	Government	EUR	003GPP	1.07
003KS6	DE0001342244	DEUTSCHE FINANCE (NETHERLANDS) BV 0% 20261015	Financial	EUR	(Issuer Id: 75670)	3.07
003KSB	DE0001892057	DEUTSCHE FINANCE (NETHERLANDS) BV 0% 20320120	Financial	EUR	(Issuer Id: 75670)	3.92
003LEP	XS0070184527	WORLD BANK INTERNATIONAL BANK FOR RECONSTRUCTION AND DEVELOPMEN	Supranational	EUR	(Issuer Id: 71483)	1.21
003ML2	XS0071948540	UBS FINANCE (CURACAO) NV 0% 20270129	Financial	EUR	Issuer Id: 75672	1.23
004W7K	DE0002764198	KFW BANKENGRUPPE 5.5% 20180122	Agency	EUR	(Issuer Id: 17324)	1.26
004ZXX	FR0000571366	CAISSE D"AMORTISSEMENT DE LA DETTE SOCIALE 5.25% 20121025	Agency	EUR	(Issuer Id: 71019)	0.64
00504H	FR0000571218	FRANCE (GOVERNMENT) 5.5% 20290425	Government	EUR	00504H	0.91

Notes:

- “LSR Root Id” identifies assets that share the same issuer.
- For bonds that are issued by Governments or Local / Provincials (sector attribute), “Selection Risk” is the asset-level (annualized) specific risk forecast. In terms of the formulas above, it corresponds to $\sigma_i^{Specific}$.
- “Currency” is the currency of denomination of the bond.

Duration Proxy

Duration proxies are intended to provide users with a rules-based approach to proxying rejected fixed income assets, and they offer an alternative to either using link proxies or importing the relevant terms and conditions for assets that are not natively covered in BarraOne. The user provides a simple set of asset characteristics, and then BarraOne creates the asset and computes a set of BIM factor exposures for the asset based on a set of exposure rules defined in the application.

This feature is especially useful when either the user does not have access to the asset terms and conditions, when BarraOne does not have a valuation methodology for the specific asset class, or when the user prefers external valuations. Note that as there is no direct valuation of duration proxies, users must import the asset price using the existing BarraOne Asset Data template. Prices should be loaded as the clean price as a percentage of par value.

Exposure Analysis

Currency Exposure

The duration proxy's currency exposure is a unit exposure to the currency specified by the user.

Exposure Calculations

The duration proxy exposures are computed using the formulas below.

Notation

The following notation is used in the following formulas for duration proxy exposures:

Fixed Income Proxy Rule Exposure Notation

D_R	=	term structure duration of the proxy rule (supplied by the user)
D_S	=	spread duration of the proxy rule (supplied by the user)
i	=	vertex of the key rate
L	=	$\min\left(i \mid T_i \geq M, i = 1,2,\ldots,N\right)$ if $T_N \geq M$ N otherwise
T_i	=	terms of the key spot rate
M	=	stated maturity of the proxy rule
N	=	number of key rates
K_i	=	the i^{th} key rate duration
E	=	shift, twist, or butterfly exposure
B_i	=	shift, twist, or butterfly factor shape vector

Key Rate Durations

The key rate duration is computed from the following formula:

$$K_i = \frac{1}{\sum_{i=1}^{L} T_i} T_i D_R$$

STB Exposures

The following formula is used to compute STB exposures:

$$E = \sum_{i=1}^{N} B_i K_i$$

Term Structure Exposure Mapping

Duration proxies are mapped to the appropriate term structure factors based upon the specified Asset Type, Country, and Currency.

Swap Spread Exposures

For markets where detailed sector-by-rating credit factors or emerging market factors are supported, the swap spread exposure is the effective duration. For markets with only swap spread factors, if a separate Spread Duration is provided, then the swap spread exposure is defined as follows:

Swap Spread Exposure

$$(\alpha - 1)D_s + D_{eff}$$

where:

α	=	scaling factor
D_{eff}	=	effective duration

Swap Spread Scaling Factor

$$\alpha = \max\left(1, \frac{s}{\max\left(10bp, s_{swap}\right)}\right)^{\gamma}$$

where:

s_{swap}	=	swap spread in basis points provided for each local market
γ	=	exponent constant for each local market

If no Spread Duration is provided, then Effective Duration is used, instead.

Credit Spread Exposures and Emerging Market Exposures

For markets with a detailed sector-by-rating model, the Rating, Sector, and Subsector values are used to determine which spread factor is assigned to the proxy asset.

> **Note:** For IPBs, if the sector is “Government,” then the issue is mapped to a government IPB. For any other sector, the issue is mapped to a corporate IPB.

If Spread Duration is provided, then the exposure to the appropriate credit factor exposure or emerging market factor equals the user provided Spread Duration. If no Spread Duration is provided, then Effective Duration is used, instead.

Performance Attribution Returns

Duration proxy returns are determined based on one of the following sources:

- User-Provided Returns: Users may load fixed income proxy returns using the standard asset returns import template.
- BarraOne Computed "Fitted Return": If no user duration proxy returns have been provided, BarraOne computes "fitted returns" based on the following:

$$R_t = \left(\frac{P_t + A_t}{P_{t-1} + A_{t-1}} - 1 \right) \bullet 100$$

where:

R_t = Daily return for day t (%)

P_{t-1} = Clean price on day $t-1$

A_{t-1} = Accrued interest on day $t-1$

P_t = Clean price on day t

A_t = Accrued interest on day t

Optionable (Callable or Putable) Bond

Many bonds contain embedded put options, call options, or combinations of these. These bonds are valued using the "Crank-Nicholson Algorithm with Adaptive Grid" on page 444. BarraOne supports callable and putable bonds with European, American, and Bermudan exercise styles.

Only ordinary calls and puts are handled by BarraOne. BarraOne does not support bonds with embedded options with a variable exercise price (*e.g.,* a call with a floating call price based upon Treasury rates). Special calls or puts (*e.g.,* the "putable on death" puts of some MTNs, or "make whole" calls) are non-economic, in the sense that their value is not measurable based upon economic variables, such as interest rates. The option component for a bond with an embedded option of one of these types is ignored.

Bond Forward

Exposures

Bond Forwards inherit the exposures of the underlying bond, including currency risk.

Specific Risk

Bond Forwards inherit the specific risk of the underlying bond.

Outputs

BarraOne computes the same outputs as for bonds.

Valuation

BarraOne uses the underlying bond T&C and the bond forward T&C to compute the fair forward price and compare it with the contract forward price to determine the value (similar to how equity forward values are computed).

The Market Value at time t of a forward is:

$$\left(F_t - F_0\right) \cdot e^{-r \cdot T}$$

where:

r = the discount rate to time T (LIBOR for corporate underliers, Treasury for government underliers)

F_0 = the delivery price (fair forward price on the start date)

F_t = the fair forward price as of the analysis date

The fair forward price of a bond is:

$$F = \left(B - PV(I)\right) \cdot e^{r \cdot T}$$

where:

B = the bond's market value (dirty price) on the analysis date

I = the net income the bond pays between the valuation date and the end date of the forward (i.e., nominal cash flows during the period)

$PV(I)$ = the present value of that income (i.e., discounted cash flow)

We can simplify the Market Value calculation to:

$$MTM(Forward) = B - PV(I) - F_0 \cdot e^{-r \cdot T}$$

If the user supplies the MTM, BarraOne enables the calibration of a spread to add to the discount rate and then report that as the Implied Financing Rate.

$$User\ MTM(Forward) = B - PV(I) - F_0 \cdot e^{-(r+s) \cdot T}$$

Simulation

Bond Forwards have the same treatment as bonds. In stress test and VaR simulation are sensitive to the same shocks.

Treasury Future

A bond futures contract is an agreement whereby the short position agrees to deliver specified bonds to the long position at a set price within a certain time window. For a list of bond futures contracts supported by BarraOne, refer to the asset coverage description on the BarraOne client support site at https://support.msci.com/community/barraone.

The futures contract typically is traded on an exchange, and the underlying bond is standardized, meaning that it is a fictional bond. There is a collection of deliverable bonds, as determined by the futures exchange, that may be delivered by the short side of the contract in exchange for payment by the long side.

The prices of real bonds that can be delivered into the contract are translated into units of the standardized bond through a system of price factors (*i.e.*, conversion factors) calculated according to contract-specific rules determined by the exchange. Generally, one of the deliverable bonds has the highest financing rate implied by the futures price. This bond is called the cheapest-to-deliver bond (CTD).

The settlement value of a bond futures contract is linked to the prices of a set of underlying bonds. Less commonly, a bond futures contract is cash settled, with the settlement price determined in terms of the yields of the underlying bonds.

Valuation Methodology

Necessary market data:

- Treasury zero rate
- Deliverable bond list

Pricing methodology: Numerical Integration, accounting for the quality (delivery) option

Pricing model: "Hull-White Model" on page 425

Like all futures contracts, a bond futures contract's price represents only the level on which daily profit and loss is computed for daily settlement. It does not represent any amount of capital paid by the long to the short party. Therefore, bond futures contracts have no market value in BarraOne.

The price of a futures contract is its expected value at delivery date with respect to the risk-neutral probability measure. A complication for note and bond futures contracts is that they are settled by physical delivery, and there are generally many securities that are eligible for delivery from a pool of similar future contracts. At any given time, one of the bonds in the deliverable basket is the "cheapest to deliver," but the identity of this bond can change prior to settlement.

Futures contracts are analyzed in the same interest rate modeling framework as bonds and most other fixed income derivatives. In any model, the current futures price F_t is determined by the risk-neutral expectations formula

$F_t = E\,[F_T]$

where F_T is the settlement value. That is, the current futures price is equal to its average value at settlement, weighted according to the probability of each outcome in the risk-neutral setting. The settlement time T may be the start or the end of the delivery month. The choice is made based upon whether the cost-of-carry on the current CTD is negative or positive.

The one-factor "Hull-White Model" on page 425 determines the set of possible interest rate scenarios at contract settlement. For each scenario, the settlement rules of the contract are applied to determine the scenario value F_T. For the typical physically settled contract, F_T is found by determining which bond is cheapest to deliver. Usually, the same bond will not be cheapest to deliver in all scenarios, giving rise to negative convexity in the futures contract. For cash-settled contracts with settlement value based upon bond yields, the relevant yield formula is applied.

The futures price is used to calculate the effective market value, which is *futures price X notional amount*. Effective market value is used to compute effective weight, which is then used to aggregate asset risk exposures at the portfolio level.

The calculated futures price typically will not match the market price of a contract. BarraOne calibrates the model to the market price by finding the repo rate for deliverable bonds that matches the model and market prices. This repo rate is then used in subsequent calculations.

Note that prices for Australian Treasury Futures are quoted on a 100–yield basis. To calculate the Effective Market Value from the price *P*, the following formula may be used:

$$\text{Effective Market Value} = 1000 \times \left[\frac{c\left(1 - v^n\right)}{i} + 100v^n \right]$$

where:

$$i = \frac{100 - P\%}{200}$$

$$v = \frac{1}{1+i}$$

$$c = \frac{\text{nominal coupon rate}}{2} \quad \text{(note that nominal coupon is currently 6\% for Australian Treasury Futures)}$$

n = number of coupon payments (e.g., 20 for a 10-year future)

Exposure Analysis

The exposure of a bond futures contract equals the contract's size (*e.g.*, \$100,000 for a U.S. Bond futures contract) times the contract's fair value.

The risk exposures of a bond future are its exposure to the underlying term structure and duration. The duration of a bond futures contract is not strictly defined, because there is no market value to use as the denominator for computing the percentage impact given a shift in interest rates. However, the sensitivity of a bond futures contract to changes in interest rates is meaningful. Therefore, BarraOne reports the derivative of the fair value calculation with respect to a change in interest rates. The fair value is expressed as a percentage of the contract size.

Bond futures in the U.S., U.K., EMU and Japan markets are also exposed to implied volatility. Refer to "Implied Volatility" on page 291.

Bond futures do not have currency risk, for the same reasons that equity index futures do not have currency risk. For an explanation of the methodology, see "Currency Exposures of Equity Index Futures" on page 369.

Bond Option

A bond option is an agreement to buy or sell an underlying physical bond at an agreed price in the future. BarraOne supports European- and American style exercise.

Valuation Methodology

Necessary market data:

- Volatility of interest rates

The valuation of a bond option requires the volatility of interest rates (the sigma value in the Hull-White model used to model interest rate movements), which is provided by BarraOne. If the user specifies the price of the option in the market data, then BarraOne will calibrate the implied volatility.

Pricing methodology: "Crank-Nicholson Algorithm with Adaptive Grid" on page 444

Pricing model: "Hull-White Model" on page 425

Treasury Future Option

An option on a bond futures contract gives the holder the right to buy (call) or sell (put) the underlying futures contract. Upon exercise, a position is created in the underlying futures contract.

Note: When a treasury future option is well out-of-the-money, the application will display extremely large values for Total Risk and MCTR, due to the sensitivity of our risk model. These values are accurate, but because the market value of such assets is close to zero (0), these values will not be materially reflected in calculations at the portfolio level.

Supported Option Types

BarraOne supports puts and calls on European and American bond future options.

Valuation Methodology

Necessary market data:

- Treasury zero rate
- Underlying future price

Model value: Option value from the option model

Pricing methodology: Closed form

Pricing model: "Black Model (1976)" on page 422

If the market price of the option is provided by the user, BarraOne will calibrate the volatility of the underlying future. When the option price is not supplied, BarraOne will derive the option price from the Black (1976) model, using Barra-provided sigma from the Hull-White model to approximate the price volatility of the underlying future. The following formula depicts an approximation of the method Barra uses to convert Hull-White sigma to Black volatility:

Conversion of Hull-White Sigma to Black Volatility (approximation)

$$\sigma_F = \frac{1}{F}\left|\frac{\partial F}{\partial x}\right|\sigma_x$$

where:

σ_F	=	approximated Black model volatility of the underlying future contract
F	=	price of the underlying future contract
$\left\lvert\frac{\partial F}{\partial x}\right\rvert$	=	sensitivity of the underlying future contract to unit term structure shift
σ_x	=	Hull-White volatility

Convertible Bond

A convertible bond is a bond that may be converted by the holder into the issuing company's stock at certain times in the future. When the stock price increases (*i.e.,* the conversion option is in the money), the bond behaves more like an equity. When the stock price decreases, the bond behaves more like a bond. Convertible bonds are therefore exposed to both equity and fixed income risk factors.

For convertible bonds, the exercise style of the option to convert the bond into stock may be European, American, or Bermudan. Each unit of notional principal of the bond can be converted into a specified number of shares of the stock, which is known as a conversion ratio. This ratio may be constant or may change over time or when certain conditions on the changing stock price are met.

The conversion ratio may depend on either the date of the conversion or the stock price. This is known, correspondingly, as a "date" or "stock price" conversion type. For the "date" conversion type, the conversion ratio may change as specified in the conversion schedule, consisting of date-conversion ratio pairs. In this case, each pair specifies a date and a conversion ratio that applies until the next date in the schedule. For the "stock price" conversion type, the conversion schedule consists of stock price / conversion ratio pairs. In this case, each pair specifies a stock price and a conversion ratio that applies until the next price in the schedule.

For European and Bermudan convertible bonds, the allowed conversion dates usually correspond to bond coupon payment dates. In this case, the accrued coupon is paid to the bond holder even if the conversion takes place. Similarly, for American convertible bonds, the accrued interest is usually paid to the bond holder if the conversion takes place in the middle of the bond coupon period. However, in some cases, the convertible bond holder may not receive accrued interest if the conversion takes place in the middle of the coupon period. This is known as the "screw clause." The screw clause is typically used with preferred stock, which can be seen as a type of a convertible bond.

The underlying bond may be callable (*i.e.,* the bond issuer has the right to buy the bond back from the holder at certain times at predetermined prices) and/or putable (*i.e.,* the bond holder has the right to sell the bond back to the issuer at certain times at predetermined prices). Similar to the conversion option exercise style, the call and put options can also be European, American, or Bermudan. If the bond is both callable and putable at the same time, the call usually has priority over the put. However, if the callable bond is called by the issuer, the bond holder typically, but not always, has an option to convert at that time rather than accept the principal repayment. Such an occurrence is called a forced conversion, and the bond call feature can be thought of as a way for the issuer to force conversion earlier than the holder would otherwise choose.

Sometimes the issuer's call option is conditional on the price of the company's stock being above a certain level for a certain period. Such a feature is known as a "soft call." With the soft call condition, the call is permitted only if the stock price stays above a specified level for the specified number of days prior to the call date.

Finally, convertible bonds might have a mandatory conversion feature in which the holder of the bond must convert into the underlying equity upon bond maturity. In this case, the holder receives the number of shares of the stock as specified by the applicable conversion ratio instead of the principal repayment.

Supported Option Types

The Barra Convertible Bond Model can calculate risk for the whole spectrum of convertible securities.

BarraOne supports puts and calls in the following types of convertible bonds:

- European
- American
- Bermudan

In addition to standard convertibles, callable, and putable bonds, the Barra convertible bond model handles the following special classes of bonds:

- LYONs (Liquid Yield Option Notes) are the most “bond-like” convertible structure. They are deep discount zero-coupon bonds convertible into common stock at any time with one or more put options (five years or less after issuance).

  LYONs are less sensitive to changes in interest rates than long maturity bonds or preferred stocks. The put prices are equal to the original offering price plus accrued interest to the put dates; thus, provided the issuer remains solvent, they offer a minimum total return equal to the yield to put. These features reduce the downside risk of the security, largely retain the equity participation characteristics of traditional convertible bonds, and provide tax advantages to issuers.

- PRIDES (Preferred Redeemable Increased Dividend Equity Securities) are the most “equity-like” convertibles. They are preferred shares (or debentures for certain exchangeable issues) in which conversion to common stock at maturity is mandatory, which means that there is no protection from a decline in the price of the underlying stock. They offer higher current yields than traditional convertibles to compensate for this greater downside risk.

  For stock price between two preset values, the conversion ratio depends on the stock price so as to maintain a definite total value. Fixed conversion ratios prevail above and below this range. At maturity, if the price of the common stock closes below the initial price, the PRIDES converts to one share of common stock (the maximum conversion ratio). If the price of the common stock exceeds the conversion price at maturity, the PRIDES converts into shares of common stock equal to *initial price/conversion price*. If the price of the common stock closes between the initial price and the conversion price, the PRIDES converts into shares of common stock equal to *initial price/common stock closing price*.

- DECS (Debt Exchangeable for Common Stock) are a structure similar to PRIDES.
- PERCS (Preferred Equity Redemption Cumulative Stock) are preferred shares with no conversion option. They offer limited upside participation in the underlying stock (typically capped at 30-35%). Conversion to common stock at maturity is mandatory, which means that there is no protection from a decline in the price of the underlying stock.

- Perpetual preferred shares are preferred shares convertible to common stock at any time and with no set redemption date.
- Reverse convertibles are bonds for which the conversion option belongs to the issuer. In essence, the investor sells a put on the stock and buys a bond. Reverse convertibles are modeled as certificates in BarraOne (refer to "Reverse Convertible (RC) and Barrier Range Reverse Convertible (BRRC) Certificate" on page 406).
- Soft calls are bonds that become callable if the underlying stock is above a trigger for a certain period. These are handled by a probability-weighted average of callable and uncallable values (single currency only).

The model supports several other specific features:

- For bonds that may be called without paying accrued interest, the "screw" clause flag is appropriate.
- The possibility of inefficient exercise of the call option is modeled with the stock call shift entry.

Note: When importing prices for convertibles, BarraOne expects the price format for Convertible Bonds to be in percent of par, and for Convertible Preferreds to be in absolute currency units (*i.e.,* the dollar amount). For example, consider a convertible with a par value of $1,000 and trading at $1,100. If it is a convertible bond, the price should be imported as 110. If it is a convertible preferred then the price should be imported as 1100.

Valuation Methodology

Necessary market data:

- equity value
- equity volatility
- interest rate yield curve

Pricing methodology: "Trinomial Tree Model" on page 450

In BarraOne, convertible bonds are valued using a single-factor lognormal equity model. In this model, the underlying equity price is assumed to be lognormal with the specified volatility. The continuous-time process used to describe the equity price uses a risk-neutral measure with the drift determined by the dividend yield of the equity and the risk-free interest rate term structure. Then, the evolution of the equity price in discrete time is modeled using a trinomial tree. The life of the tree is set equal to the life of the convertible bond, and the tree is constructed using a number of tree steps that depends on the maturity of the bond and on equity volatility.

The tree building procedure used is standard in the literature, and its description can be found in numerous books and papers. The general idea of tree construction is that at time t_i, for each node of the tree x_{ij}, the three branch nodes at the next time t_{i+1} are placed, and their associated probabilities are assigned, in a way that reproduces the theoretical value of the first and second moments of x at the next time, *i.e.,* $E[x_{i+1} \mid x_{ij}]$ and $E[(x_{i+1})^2 \mid x_{ij}]$. The theoretical values of these moments are obtained analytically from the continuous-time process used to describe the equity price. The implementation of the tree construction is similar to that described in J. Hull [1 and 2], with several differences in the way the nodes are placed in the tree used in order to improve convergence.

Once the equity price tree is constructed, it is used to derive the value of the convertible bond by rolling back through the tree and making optimal decisions regarding the exercise of various options (conversion, call/put, *etc.*) that are available at that time/tree node. Two separate components, contributing to the value of the convertible, are being tracked at each node: the equity component resulting from conversion and the bond component that tracks the value if conversion does not take place. When rolled back in the tree, these two components are discounted using different interest rates. The equity component is discounted using the risk-free rate, while the bond component is discounted using "risky" rates corresponding to the credit quality of the bond issuer (see “Credit Spread and Default Risk” on page 312). This is done to account for the fact that the promised cash flows of the bond component (coupons and principal) are subject to credit risk.

The value of the convertible at the final nodes of the tree (bond maturity) is calculated based on any conversion options that the holder has at that time. For example, it could be calculated either as the bond principal plus accrued when no conversion is allowed at maturity, or as the equity value (equity price times the applicable conversion ratio) at that node when there is a mandatory conversion feature. Rolling back through the tree, at the nodes where the terms of the instrument allow conversion, a test is performed whether immediate conversion is optimal, *i.e.,* if the current conversion value is higher than the value of holding the convertible. Based on this test, the equity and bond component values at that node are updated.

This is illustrated below with the following notation:

- EV = equity component value rolled to the node (represents the discounted value of potential future conversion)
- BV = bond component value rolled to the node (represents the discounted value of future bond cashflows until conversion or maturity)
- RV = EV + BV = total rolled value (sum of equity and bond components rolled to the node)
- CV = immediate conversion value (based on the node stock price and applicable conversion ratio)
- Accrued = accrued interest (if any) to the time corresponding to the node

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1 Hull, J., Options, Futures, and Other Derivatives, Seventh edition, Prentice Hall, 2008.

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2 Hull, J., Generalized Tree Building Procedure. Technical Note to accompany Options, Futures, and Other Derivatives, 7th edition. Available at: www.rotman.utoronto.ca/~hull/TechnicalNotes/index.html.

- CallStrike = Call option strike, *i.e.,* the value received by the holder if the bond is called by the issuer

Then:

- If CV ≥ RV (immediate conversion is optimal), then update EV = CV and update BV = Accrued
- Otherwise (keeping the conversion option is optimal), set EV = EV and BV = BV + Accrued

The update rule is slightly more complicated when there is also a call or a put option available at the node. In this case, additional tests need to be performed to check whether the issuer's position can be improved by calling the bond, or if the holder's position can be improved by putting the bond. If the bond is called by the issuer and the holder has the option to convert when called, then the conversion optimality is retested. This is equivalent to the following update rule for the case of the call option:

- If CallStrike < RV (calling is optimal for the issuer), then:
    - if CV ≥ CallStrike, (forced conversion is optimal), then set EV = CV and BV = Accrued
    - otherwise (conversion is not optimal). set EV = 0 and BV = CallStrike + Accrued
- Otherwise (issuer will not call), perform the regular conversion test and update the components as described above

The update rules are similar in the case when a put option is also available to the holder at the given node. Once the values of the equity and bond components are updated at a node, they are then rolled back in the tree and the process is repeated. The final value of the convertible bond is equal to the sum of the equity and bond components at the root node. A detailed example of tree-based convertible bond valuation using update rules similar to the ones described above can be found in Hull.

Calibration

There are three interrelated factors in BarraOne's convertible bond valuation model: convertible bond price; convertible bond option-adjusted spread (OAS); and the volatility (risk) of the underlying equity. BarraOne attempts to adjust either the price or the spread to satisfy its valuation model given the volatility of the underlying equity, which BarraOne calculates. The user can control which of these two factors, price or spread, is taken as the input and which is adjusted by BarraOne to calibrate it to the BarraOne model. The following table outlines whether price or spread will be taken as the input. Note that for Barra-provided (system) convertible bonds, calibration is always set to "true."

Table 16: Convertible Bond Calibration

Spread priority > Price priority	Calibration = TRUE	Calibration = FALSE (default)
No user price or spread exists	Fitted price is calculated using BIM model spread.	Fitted price is calculated using BIM model spread.

Table 16: Convertible Bond Calibration (Continued)

Only user spread exists	Fitted price is calculated using user-imported spread with highest priority.	Fitted price is calculated using user-imported spread with highest priority.
Only user price exists	Spread is calibrated using user-imported price with highest priority. If calibration fails, fitted price is calculated using BIM model spread.	Market value and weights are based on user-imported price with highest priority; asset-level risk measures are derived using BIM model spread.
Both user spread and price exist	Fitted price is calculated using user-imported spread with highest priority.	Fitted price is calculated using user-imported spread with highest priority.

Price priority > Spread priority	**Calibration = TRUE**	**Calibration = FALSE (default)**
No user price or spread exists	Fitted price is calculated using BIM model spread.	Fitted price is calculated using BIM model spread.
Only user spread exists	Fitted price is calculated using user-imported spread with highest priority.	Fitted price is calculated using user-imported spread with highest priority.
Only user price exists	Spread is calibrated using user-imported price with highest priority. If calibration fails, fitted price is calculated using BIM model spread.	Market value and weights are based on user-imported price with highest priority; asset-level risk measures are derived using BIM model spread.
Both user spread and price exist	Spread is calibrated using user-imported price with highest priority. If calibration fails, fitted price is calculated using BIM model spread.	Market value and weights are based on user-imported price with highest priority; asset-level risk measures are derived using BIM model spread.

Convertible Floating Rate Notes

Within the single-factor stochastic equity model, the valuation of convertible floating rate notes is equivalent to the valuation of convertible bonds, because in this model only the equity is modeled as stochastic, while interest rates are assumed to be deterministic. The only difference between the valuation of convertible floating rate notes and convertible bonds is that for underlying floating rate notes, the expected coupons are precomputed from the appropriate interest rate curve using the applicable forward rates and daycount conventions, while for underlying bonds the coupon is specified directly. Therefore, the description of the model for convertible bonds is also applicable to floating rate notes.

Exposure Analysis

As far as BarraOne convertible bond risk modeling methodology is concerned, convertibles are exposed to term structure and spread factors, as well as delta-adjusted exposures to the underlying equity.

The equity portion of specific risk is determined by scaling the underlying equity specific risk with the exposure scalar, while the fixed income portion of specific risk is calculated using the linear/transition/issuer-specific risk model, depending upon the bond characteristics. As such, convertible bond specific risk is the square root of the sum of the squares of equity specific risk and fixed income specific risk.

Barra uses a combination of methods to estimate the risk of convertible bonds. The exposures of a convertible bond in BarraOne consist of interest rate exposures calculated from local shocks to the term structure. Refer to "Exposure Analysis" on page 283 for more information. Equity factor model exposures to the underlying equity's risk model factors are scaled by elasticity, which is calculated as (*Stock Price / CB Price*) × *Delta*.

Exchange Rate Risk

For bonds paying in one currency but convertible into equity in another currency, the client may choose to account for exchange rate risk. To do this, the model makes appropriate changes to the drift and volatility of the underlying stock lattice. For this reason, the path-dependent soft call feature is unavailable unless exchange rate risk is ignored.

The underlying equity in a cross-currency bond is treated like an American Depository Receipt. For example, consider a dollar-denominated bond with an option to convert to a yen-denominated stock. Assume that the stock price S (in yen) and exchange rate Q (in dollars per yen) both follow geometric Brownian motion. Then SQ, the stock price in dollars, also follows geometric Brownian motion with drift and volatility determined by those of S and Q and their correlation.

Rather than keeping track of the two factors S and Q separately, we only build a lattice for SQ (the price of the stock in the bond currency). Since soft call strikes are conditions on S (not SQ) we cannot accurately deal with them.

Credit Spread and Default Risk

Barra's default model is more descriptive than explicit. The discount rates applicable to both bond and equity values are adjusted by a credit spread, which accounts for the market value of expected default. Although the traditional Black-Scholes model of stock price movements discounts equity value at the risk-free rate, we use the risky rate because it accounts, in effect, for the possibility of a stock price of zero due to default.[1]

Convertible Bond Greeks

Delta represents the sensitivity of the convertible bond value to a change in the underlying stock price. Delta for a convertible bond is computed as a symmetric numerical derivative, with the underlier shocked by a factor proportional to its volatility. The product of delta and the conversion ratio gives the change in convertible market value for a $1 change in the price of the underlying stock.

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1 See Mark Davis, "Learning Curve," Derivatives Week (May 8, 2000).

Gamma is the second-order derivative of the convertible price with respect to the underlying stock. This is similar to a bond's convexity, capturing the non-linearity of the sensitivity of the option price. For a change in the price of the underlying stock of $X, the total change in convertible market value will be: *delta * conversion ratio * X* + 0.5 * *gamma* * X^2. Gamma can also be seen as the sensitivity of delta to a change in the price of the underlying stock. Dividing gamma by the conversion ratio gives the change in delta for a $1 change in the underlying stock price.

For example, consider a convertible bond with a delta of 0.5, a conversion ratio of 40, and a gamma of 1. A $1 increase in the price of the underlying stock will cause the convertible's market value to increase by *delta * conversion ratio* = $20 and its delta to increase by *gamma/conversion ratio* = 0.025, giving a final delta of 0.525. Note that we ignored the effect of gamma on the market value, because it is very small.

Convertible Bond Greeks

$$Delta = \frac{f(S+x) - f(S-x)}{2x \text{ (Conversion Ratio)}}$$

$$Gamma = \frac{f(S+x) - 2f(S) + f(S-x)}{x^2}$$

where:

S	=	the stock price on the evaluation date
$f(S)$	=	the price of the convertible bond on the evaluation date
σ	=	the volatility of the stock price
x	=	variable proportional to σ

Vega is the sensitivity of convertible market value to volatility. For example, if the underlier's volatility is 30%, and vega is 900, then an increase in the volatility of 1% (to 31%) will increase the convertible's market value by approximately 900 * 1% = $9. Vega is calculated as a numerical derivative using ±1 basis point changes to the volatility.

Theta is the change in market value for a 1-day decrease in time to maturity. It is computed numerically by changing the analysis date by 1 day.

Floating Rate Note (FRN)

A Floating Rate Note (FRN) is a debt instrument that pays a regular interest amount until its maturity; unlike a fixed-rate bond, however, the interest payment varies over the life of the instrument, as it is reset against a short-term interest rate benchmark at each interest payment date.

For example, when the interest rate is reset quarterly, the rate for the first quarter is set *n* days before the issue date and determines the interest payment at the end of that quarter. The rate for the second quarter is set *n* days before the date of the first interest payment, *etc*. The rate is usually a spread over LIBOR.

Valuation Methodology

BarraOne supports two types of caps and floors on coupons: lifetime rate caps/floors, and periodic caps/floors.

Lifetime rate caps/floors are on the coupon rate, itself. For example, if the lifetime rate cap is 5%, the coupon will never exceed 5%, regardless of the reference rate level.

Periodic caps are on the change in the coupon rate. On the reset date, the coupon rate cannot increase (decrease) by more than the cap (floor) rate. For example, for a floater with no margin and a 50% periodic cap, if the 3M LIBOR for the previous period was 5%, and on the reset date it is 8%, then the coupon for the period will be 7.5%, due to the period cap (*i.e.,* 5% X 1.5 = 7.5%).

FRNs with calls, puts, lifetime rate caps, and/or lifetime rate floors, are valued using the "Hull-White Model" on page 425.

FRNs with periodic caps and/or periodic floors use the "Barra's Quasi-Random Principal Components (QRPC) Simulation" on page 440. The QRPC method also supports combining periodic caps/floors with lifetime rate caps and floors, but it does not support combining them with calls or puts.

Variable Rate Notes (Fixed-to-Float, Float-to-Fixed) are valued similarly. Callable fixed-to-floats are treated as if they mature on the next call date (relative to the analysis date).

Table 17: Summary of Floater Valuation Methodologies

Security Type	Methodology
Vanilla FRN	Discounted cashflow (DCF)
FRN with period caps/floors	QRPC
FRN with period and lifetime rate caps/floors	QRPC
FRN with period caps/floors and calls/puts	QRPC (puts/calls ignored)
FRN with only lifetime rate caps/floors	Hull-White
FRN with calls/puts and/or lifetime rate caps/floors	Hull-White
Fixed-to-Float with call schedule	Discounted cashflow (DCF, maturing on the next call date)

Analytics

This section provides a brief, semi-technical explanation for the calculation of present value and effective duration for floating rate notes. The main purpose is to explain how to derive effective durations for floaters that deviate significantly from the time to next reset.

A full treatment of floater valuation requires an understanding of the calculation of present value for securities with uncertain cashflows, because all floating rate coupons after the next one are unknown as of any analysis date. However, for a vanilla floater (*i.e.,* for which the coupon is equal to some margin over a short-term rate, with its term equal to the coupon period, and with no embedded caps or floors), the full calculation, accounting for uncertainty, can be reduced to a much simpler calculation that considers only the scenario in which the current forward curve is realized. That is, the uncertain future coupons are treated as though they were fixed and given by their values based on the forward curve. (By extension, this scheme also works for levered floaters. Inverse floaters have the complication that they always have caps and floors.)

Denote the time to next reset by τ and the payment frequency by f. Let the next interest payment be C_1, and denote the sequence of forward rates between coupon dates (derived from the underlying index, *e.g.,* LIBOR) by $r_1, r_2, \ldots, r_n$ (taking r_1 to be the rate from analysis date to the next coupon). Denoting the discount margin by s, the corresponding discount factors $d_1, d_2, \ldots, d_n$ are given by:

$$d_1 = \frac{1}{1+\tau(r_1+s)},\ d_2 = (d_1)\frac{1}{1+(r_2+s)/f},\ \ldots,\ d_n = (d_{n-1})\frac{1}{1+(r_n+s)/f}.$$

The corresponding future interest payments are:

$$C_k = (r_k+\delta)/f$$

The floater's present value is then:

$$F + I = \sum_{k=1}^{n} C_k d_k + d_n$$

where the accrued interest is:

$$I = C_1(1-\tau f)$$

and F is the clean price.

If $\delta = s$, we can use the recursion formula for the discount factors to collapse the present value sum. Each term after the first in the coupon sum can be rewritten as:

$$C_k d_k = (d_{k-1})\frac{(r_k+\delta)/f}{1+(r_k+s)/f} = (d_{k-1})\left(1-\frac{1}{1+(r_k+s)/f}\right) = d_{k-1} - d_k$$

The sum "telescopes," leaving $F+I = C_1 d_1 + d_1$.

If we happen to be on a coupon date (and assuming the reset date and coupon date are the same), then $I = 0$ and $1 = C_1 d_1 + d_1$, so the floater is priced at par. At later dates, the floater's price will deviate slightly from par due to change in the index rate. (There is also a very small deviation due to the way in which accrued interest is calculated.) The floater's price will also deviate from par if the discount margin s is not equal to the coupon margin δ.

From the telescoping sum formula, it follows that a par floater behaves like a one-period security, with payment of principal and one period of interest at the next coupon date.

The effective duration of a par floater is therefore, to a good approximation, equal to τ, the time to the next coupon date.

To understand the effective duration of a non-par floater, for which the index margin is not equal to the discount margin, it can be treated as a portfolio of two securities: a par floater, for which the index margin is equal to the discount margin, and an annuity (a series of equal cashflows) which exactly offsets the difference between the discount margin and the floater's actual index margin. The effective duration of the portfolio is the average of the constituents' effective durations, weighted by their present values. The effective duration of an annuity does not depend upon the size of the cashflows. The modified duration of an annuity with yield y and term T is:

$$D_{\text{ann. mod.}} = \frac{1}{y} - T\left(\frac{1}{1-\left(1+y/f\right)^{-Tf}} - 1\right)$$

If yT is not too large (*i.e.,* if it is much less than one), then to a good approximation this reduces to:

$$D_{\text{ann. mod.}} \approx T/2$$

Intuitively, an annuity's effective duration is roughly half its time to maturity. Note that the simpler formula is likely to fail for annuities with ten or more years to maturity. Asymptotically, the duration approaches $1/y$.

If we assume that the annuity's modified duration is close to its effective duration (a reasonable assumption if T is not too big and the term structure is not extremely sloped), then we find that the effective duration of a non-par floater is approximately:

$$D_{\text{eff.}} \approx \frac{\left(\tau\left(1+I\right)+\left(F-1\right)D_{\text{ann. mod.}}\right)}{F+I}$$

If the floater is priced at a discount ($F < 1$), and either the time to maturity is large or the time to next coupon is small, this formula can produce a negative value.

Intuitively, the present value of the floater's "deviation from par" increases when rates fall (and decreases when rates rise). If the floater is at a premium, the PV of the premium increases with a fall in rates, resulting in an effective duration greater than the time to reset.

Conversely, if the floater is at a discount, the PV of the discount increases with a fall in rates. The magnitude of the increase in discount may be large enough to more than offset the increase in floater value due to decreased discounting of the next coupon. In other words, the effective duration becomes negative.

The issuer-specific risk of a floating rate note uses the issuer/factor specific risk parameter scaled by the spread duration of the asset, rather than by effective duration.

Variable Rate Notes

Notes for which the coupon changes from fixed to floating or floating to fixed are evaluated appropriately in BarraOne. We refer to these types of notes collectively as Variable Rate Notes, in order to distinguish them from fixed rate notes and floating rate notes.

A Variable Rate Note is a fixed income security that pays a fixed coupon for part of its life and a floating coupon for the remainder. As such, it exhibits characteristics of both a fixed rate note and a floating rate note. The fixed-to-floating rate note enables the lender to offer competitive short maturity rates for long-term loans, while it enables the borrower to take advantage of low short-term rates. Floating-to-fixed rate notes are less common, but they are also supported in BarraOne.

Analytics

Variable Rate Notes are evaluated as FRNs. That is, if there are caps or floors, the Barra Quasi-Random Principal Components Simulation method is used to generate numerous interest rate scenarios. Each interest rate scenario results in a cash flow for the note, and the scenario present values are averaged to find a security present value. (During the fixed rate period, the coupon is held constant in the simulation runs.) If there are no caps or floors, a deterministic approach is used.

Notes:

- Perpetual Variable Rate Notes are supported by BarraOne.
- BarraOne does not take into account the optionality of such instruments, just as we do not account for the callability of floating rate notes, in the event that the instruments are capped or floored. Options on these instruments are ignored by our model.

Inflation Protected Bond (IPB)

Inflation Protected Bonds were issued by the U.S., U.K., and other treasuries in response to the inflation premium in long-term bonds. These treasuries were looking to lower their cost of capital by issuing debt securities indexed to realized (*ex-post*) inflation.

IPBs represent an asset class for asset allocation, and they are particularly appealing to tax-exempt, institutional investors. IPBs are less highly correlated with other asset classes, such as equities, and they closely track pension liabilities (which are almost always indexed to inflation).

Supported IPBs

BarraOne supports IPBs issued by the following markets:

- U.S.
- U.K.
- Brazil
- Canada
- EMU
- Australia
- Sweden
- New Zealand
- South Africa

TIPS are Treasury Inflation Protected Securities issued by the U.S. Treasury. There is a low amount outstanding (resulting in low liquidity), and the U.S. Treasury has stated that they will stop further issuance. TIPS are quoted on a real-clean basis, *i.e.*, as a percent of current face value, not including accrued interest.

Canada and EMU IPBs are also quoted on a real-clean basis. As of September 2005, U.K. IPBs are quoted on a real-clean basis, as well.

Accrued interest for TIPS is computed using interpolation for the two most recent monthly CPI observations to the settlement date and a specific rounding algorithm for final cash flows. CPI is the U.S. Consumer Price Index, computed from a typical basket of consumption goods to measure consumer (as opposed to producer) price inflation. The CPI is often used to adjust pension and Social Security payments for inflation.

Index Linked Gilts are U.K. government IPBs. Until September 2005, these were quoted on a nominal-clean basis, *i.e.*, the quoted price included the inflation-adjustment factor. For example, a price of “206% on original par face amount not including accrued interest” would mean that the current price of the bond with an *original* face value of £1000 is now £2060.

Australia, Sweden, South Africa, and New Zealand IPBs are still quoted on a nominal-clean basis.

Corporate IPBs

BarraOne also supports corporate IPBs issued from these countries. They are modeled in BarraOne as user-defined securities, unlike treasury IPBs, which are provided by Barra.

The valuation and interest rate factor exposure analysis for corporate IPBs is identical to the BarraOne treatment of treasury IPBs, in that both are exposed to the respective Barra-supplied real term structure. Credit factor exposures and specific risk for corporate IPBs are the same as for nominal corporate bonds.

Valuation Methodology

Pricing methodology: Discounted Cash Flow (with Barra-provided "real term structure")

Exposure Analysis

The common-factor risk model factors for IPBs are exposures to the real interest rate curve. The exposures are Shift and Twist factors only, because there are insufficient data to include Butterfly factors, and IPBs are not sufficiently volatile to require a third factor.

The real interest rate curve is obtained by fitting it to the market prices of IPBs. Refer to "Exposure Analysis" on page 283 for more information. Barra updates real interest rate curves daily for each covered market.

The model returns interest rate exposures (Shift and Twist), accrued interest, real duration, real convexity, average life, and real yield to maturity for IPBs. These exposures should not be aggregated with exposures from nominal interest rate bonds, because IPB numbers are computed with respect to a real interest rate curve.

Mortgage Backed Securities (MBS)

All mortgage pools in the market are mapped in BarraOne to one of two thousand Barra-constructed generic assets. The generic assets to which each pool is mapped determines to which fixed income factors the pool is exposed. That is, by default, BarraOne processes the prices and terms and conditions of each generic asset, and the processing results are then assigned directly to the pool to which the generic is mapped. Note that the user can determine to which generic asset a pool is mapped by referring to the Single Asset Detail window for the pool.

Creation of Generics

Mortgage generics are synthetic pools with characteristics representative of a class of tradable pools. A generic class comprises pools of common program type (*e.g.,* conventional 30-year fixed-rate loans securitized by FNMA), net coupon, and origination year. For example, the generic 2005 FNMA 30-year 5% has properties characteristic of all pools securitized by FNMA with 5% net coupon from loans originated in 2005. The analytical properties of a generic are quite similar to those of the corresponding pools. Therefore, rather than separately compute the characteristics of all individual pools in a mortgage portfolio, we can do the calculations for the smaller set of corresponding generics.

Valuation Methodology

Necessary market data:

- LIBOR zero curve
- Treasury zero curve
- Price of the generic (or pool price)

  The user does not need to feed prices for any pools, because BarraOne uses the Barra-provided prices of the generic assets. If the user imports a price for an MBS pool, BarraOne uses that price f*or that analysis date* regardless of what priority is assigned to it (unless the user has imported multiple prices). If no user-supplied price is available *for that analysis date*, BarraOne uses the price priorities of the generic Barra-supplied MBS to which the pool is mapped.

Pricing methodology: "Barra's Quasi-Random Principal Components (QRPC) Simulation" on page 440

Pricing model: "Hull-White Model" on page 425

Cash flows are path dependent upon interest rate scenarios and prepayment scenarios (which are in turn dependent upon interest rate scenarios). The scenario methodology is proprietary to Barra.

Exposure Analysis

MBS are exposed to the following factors in Barra's model:

- term structure factors (refer to "Interest Rate Factor Exposures" on page 283)
- a swap spread factor (refer to "Swap Factor Exposures" on page 287)
- an implied prepayment factor (refer to "Implied Prepayment" on page 291)
- an implied volatility factor (refer to "Implied Volatility" on page 291)
- one of five MBS credit spread factors (determined by the agency and program type):

  GNMA 30 year

  Conventional 30 year

  GNMA 15 year

  Conventional 15 year

  Conventional balloons

  These spread factors are how Barra sorts the universe of pools into categories to determine their spread risk.

  The value of the spread factor exposure (*i.e.,* the exposure of both the swap spread and MBS credit spread) is *Effective Duration – Spread Duration*.

Municipal Floating Rate Note

A municipal floater is a muni bond based upon a floating index.

Valuation

A muni floater is evaluated as an FRN, except that it uses the MMD Rate Index (identical to the Muni spot curve).

Analytics

The set of risk exposures for a municipal floater is the same as for a fixed coupon Muni bond:

- USD_MUNI_<*rating*> factor
- Specific Risk factor (transitional model)

There is no swap exposure.

The set of risk statistics for a muni floater is the same as for a fixed coupon muni bond. Effective Duration and all other fixed income analytics are calculated the same as for an FRN.

Repo

A repo is a money market instrument, with the term "repo" derived from "Repurchase Agreement." There are two parties to a repo transaction. One party "sells" bonds to the other while simultaneously agreeing to repurchase them at a specified future date. The buying party provides cash in exchange for the bonds and also receives compensation from the selling party for the temporary use of the cash.

Simply put, a repurchase agreement is collateralized loan where the collateral is the security sold and subsequently repurchased. The term of the loan and the interest rate a dealer agrees to pay are specified.

The transaction is, therefore, very close to being a risk-free loan. The interest rate is known as the repo rate, and it is the relevant risk-free rate for many arbitragers operating in the futures market.

The classic repo and the sell/buy back repo are the two main types of repo transactions.

Classic Repo

In a classic repo, the sale and repurchase prices are the same, although settlement values differ because of the addition of repo interest upon termination. Although legal title to the collateral is transferred, the seller retains both the economic benefits and the market risk of owning them. If a coupon is paid during the term of the repo, it will be handed over to the seller.

Sell/Buy Back

A sell/buy back is a spot sale and forward repurchase of bonds transacted simultaneously. The interest earned by the counterparty is the difference between the price at which the security is sold and the price at which it is repurchased.

In other words, the repo rate is not explicit; rather, it is implied in the forward price. Therefore, the end clean price in the trade is different than the start clean price. This simply reflects the repo interest, and it has nothing to do with the actual market price at the time. The difference between the purchase (repurchase) price and the sale price is the loan's dollar interest cost.

Coupon payments during the term of the trade are paid to the buyer, and they may be passed over at the time or handed over to the seller through incorporation into the forward price (in which case a payment is not received immediately).

The forward bond price is calculated by converting the termination payment, that is, dividing the termination payment by the nominal value.

The interest accrued on the bond during the term of the trade is added to the forward price to obtain the settlement price. If there is a coupon payment during the trade and it is not paid over until termination, a compensating payment is made of interest on the amount at the repo rate. When calculating a forward price where a coupon will be paid during the term, subtract the coupon payment from forward price. That is, the coupon is netted out with the interest payment, all factored into the forward price.

Valuation Methodology

Classic Repo

The user should provide the Sale Price, Repo Rate, Haircut, and terms and conditions for the underlying collateral. The classic repo can then be valued as follows:

Classic Repo Market Value

$$BuySell\left[S_0 \times (1 - HairCut) \times (1 + RepoRate \times \tau) \times D_{(T-t)}\right]$$

where:

$BuySell$	=	-1 if borrower +1 if lender
S_0	=	Sale Price (market value of collateral at Sale Date t_0)
$D_{(T-t)}$	=	LIBOR discount factor for period between valuation date and Repurchase Date
T	=	Repurchase Date

Classic Repo Market Value (Continued)

t	=	valuation date
$t0$	=	Sale Date
τ	=	daycount fraction $(T\text{-}t_0)/year\ basis$

Sell/Buy Back Repo

The user should provide the Repurchase Price (forward price). The Repo Rate must be entered as zero(0), because the repo rate and the haircut are implied in the repurchase price. The sell/buy back repo can then be valued as follows:

Sell/Buy Back Repo Market Value

$$BuySell\left[S_T D_{(T-t)} \right]$$

where:

$BuySell$	=	-1 if borrower +1 if lender
S_T	=	Repurchase Price
$D_{(T\text{-}t)}$	=	LIBOR discount factor for period between valuation date and Repurchase Date
T	=	Repurchase Date
t	=	valuation date

Exposure Analysis

The numeraire exposure of a repo equals its market value.

The repo contract is treated as a short-term loan. Repos have exposures to the swap (LIBOR) curve. These exposures are displayed in BarraOne as exposures to the Treasury vertices and/or factors, because we have covariances only for Treasury factors. The exposures to the Treasury curve and the swap curve are equivalent, assuming a constant swap spread. A constant repo rate is assumed, but the impact of this assumption is mitigated by the extremely short maturities of repos. BarraOne does not model credit risk for repos, because the lender's credit risk is implicitly captured in the haircut.

Note that the repo exposure is just the cash value of the rate (positive) or the repurchase (negative). The party that will own the bond after the termination of the agreement should have the bond in the portfolio to retain exposure to its price changes.

Cashflow Bond

Cashflow bonds are used to model bond-like instruments specified with principal and interest cashflows at nominal dates. That is, cashflow bonds are used to proxy assets by specifying their cashflows. For example, there may be an asset-backed security that Barra does not model accurately, while the client has access to the expected cashflows from the client's system. The client can enter the expected principal and coupon cashflows at different dates.

These bonds are discounted using the LIBOR curve. Cashflow bonds have sensitivity to KRDs and credit factors based on the sector and issuer. The KRD exposures are the KRD factors associated with the LIBOR curve. Cashflow bonds have specific risk as well, just like bonds.

BarraOne uses the sum of the principals after the valuation date to normalize the cashflows and value the assets. On a given valuation date, BarraOne takes the cashflows on all dates after the valuation date and follows these steps for valuation:

1. Add principal on all dates after the valuation date. Call this "TotalOutstandingPrincipal."
2. Multiply all principal and interest cashflows after the valuation date with (100/TotalOutstandingPrincipal). This normalizes all cashflows per 100 par outstanding.
3. Find the present value of the normalized cashflows. The spread specified must be the spread over the LIBOR curve. When no spread is used, it will give a price close to 100, when accrued interest is accounted.

Notes:

- The user-provided price is expected to be in bond price format, *i.e.,* percent of par (the price is similar to the standard bond price for a par value of 100). When the user provides a user price for these assets, it should be per 100 par outstanding. The prices will normally be around 100.
- Cashflow bonds have accrued interest, just as bonds do. To compute the accrued interest correctly, the first accrual date must be specified with a cashflow of zero (0).
- In the portfolio, the client is expected to have a holding that represents units of par amount outstanding, *e.g.,* if the remaining principal is 9000 and the par value is 1000, the holding should be 9. In general, the holdings should be (remaining principal/par value).
- The position value of a cashflow bond is *holding * (price + accrued) /100 * par value*.
- As time passes, and more principal gets paid, the client is expected to adjust the holding to reflect the par amount outstanding. In order for these assets to be valid, the principal must be non-zero at maturity.

Cashflow Asset

Cashflow assets are used to model a stream of cashflows, typically liability streams, with no distinction between principal and interest. Once this asset is created, a portfolio having just this asset can be used as a benchmark representing the liabilities.

For cashflow assets, there is no accrued interest computed, as there is no distinction between principal and interest. The cashflows are not normalized.

The present value of the cashflows is reported as the price. The price can be in millions or billions, depending on the magnitude and timing of the cashflows. If the user wants to provide a user price for these, the user needs to provide the present value of the entire stream of cashflows that are outstanding (not per 100 par).

In the portfolio, the client is expected to have 1 unit holding. The price of the asset and the position value is the same.

BarraOne discounts cashflow assets using the discounting curve specified.

Cashflow assets have sensitivity to KRDs and credit factors based on the issuer. The KRD exposures are the factors associated with the discount curve. When the user price is specified, BarraOne calibrates the spread over the discount curve specified. Cashflow assets have specific risk as well, just like bonds.

Inflation Linked Liability

An inflation-linked liability is a general, zero-coupon liability (cashflow) that is indexed to inflation, with indexation adjustments configurable in a flexible way. This cashflow instrument provides additional inflation modeling flexibility by enabling users to choose various inflation indexes as reference curves.

The instrument is very useful in modeling a complex liability portfolio, with liabilities linked to inflation indexes, and when other, non-financial risk factors affect the cash flows. For instance, a pension fund would like to model its liabilities, which are indexed to inflation, and future payables are determined by non-financial factors like mortality rates and other characteristics of the population of the pension members. A natural assumption is that non-financial and financial risk factors are independent.

This leads to an approach in which we assume that the mapping of liabilities into real cashflow items is externally provided to us, and we focus solely on the modeling of financial risk factors like interest rate and inflation (or real and nominal rates), and an explicit consideration of the special inflation adjustments defining those cashflows. Below, we describe a model of liabilities for a generic pension plan and define the cashflow items that must be specified by the user.

The most important features of a general liability instrument are the following:

1 Flexibility in specifying the discount curve. When calculating the present value of a liability instrument, any of a predefined set of discount curves could be selected. Flexibility is further enhanced by allowing for the optional addition to the discount rate curve of a user-specified constant discount spread.

2 Flexibility in specifying indexation to inflation. When the liability instrument is inflation indexed, its real currency value is determined by a) the change of the inflation index over a user-specified period, and b) the specification of inflation caps/floors that could be applied over that period.

3 Support of multiple inflation indexes per market. While financial instruments tied to inflation in a given market are linked to a specific index of realized inflation, liability cashflows are sometimes linked to different inflation indexes. We model cap/floor contingencies in the valuation of the liability cashflows indexed to realized inflation, and we model indexation to a different index by enabling the specification of an inflation spread and an inflation multiplier that increase (or in case of a negative spread and multiplier less than 1.0, decrease) the inflation adjustment. We provide for the specification of spread and multiplier, as a) constant values; or b) two different values corresponding to two portions of the indexation period separated by the switching date.

4 Support for year-on-year compounding of inflation effects. While the liability cashflow is easier to model when inflation effects are computed once over a user-specified period, in practice, inflation adjustments are computed and compounded yearly. In this year-on-year case, the modeling of yearly caps and floors is challenging as the instrument becomes path dependent, with a value depending not only on the terminal value of the realized inflation index at the end of the indexation period, but also on the yearly path of that index over the whole period.

Modeling Liabilities in a Pension Plan

To better understand the model motivation behind some of these features, let us describe in more detail the modeling of cashflow liabilities.

Liabilities of a pension fund require mapping to specific cashflow items that might or might not be adjusted for inflation. In the former case, the flow is in real currency; in the latter, it is in nominal currency. To understand the meaning of such cashflows, let us examine how they arise in the context of a simple but realistic model of the liabilities of a defined benefit pension plan. This analysis will also clarify how to aggregate individual members' liabilities into larger buckets corresponding to population groups.

Liabilities of a pension fund originate from those pension members who are currently vested into the system, *i.e.,* members toward whom the pension fund has a financial obligation in the future[1]. Each member is associated with a retirement date when actual pension payments start. Hence, if you are a pension member with vesting date d_v and retirement date d_r, and if d_0 is the analysis date, then:

1 If $d_v > d_0$, you do not contribute to liabilities.

2 If $d_v \le d_0 < d_r$, *i.e.,* you are past your vesting date but prior to your retirement date, we will consider only the liability associated with the contributions already made to the plan. Liability cashflows will start on d_r and will depend on years of service ($d_0 - d_v$), your current salary, and the pension plan formula.

3 If $d_r < d_0$, your pension payments are being disbursed to you on a monthly basis.

Indexing to inflation applies to case 3) above, although in some cases it might also apply to 2). The switching date mentioned above models the retirement date d_r and defines two periods over which different types of inflation indexation might apply, depending on the user's specification. If "apply whole period" is specified, inflation indexation applies to the entire period between d_0 and d_r, including cap and floor adjustments, which are assessed based on overall inflation in that period.

Additional assumptions of our model are that all members receive identically indexed payments after retirement date; after that date, indexation to inflation is done yearly, on the same date for all members. Later on we refer to $d_{i,0}$ as the most recent indexation date prior to d_0; and to $d_{i;\alpha}$, as the indexation date a years after ($\alpha > 0$), or before ($\alpha < 0$) $d_{i,0}$. Relaxing these assumptions would not change the applicability of our model, but only the aggregation rules. In addition, the potential liabilities of future members who are currently employed but vest in the future ($d_v > d_0$) are not considered here. The model could be simply generalized to account for the forecasted liabilities associated to future members.

Based on this model, member liabilities can be classified into two separate groups:

1 **Liabilities from retired members.** Inflation adjustments are done yearly, based on the growth of the inflation index. Their compounded effect until a given indexation date in the future determines the payments for the year following that indexation date. Cashflow items from member-level data can be aggregated into population data for all future payments in a given year. This can be done because the "real" currency liability corresponding to the last indexation date preceding d_0, $d_{i,0}$, is known for each member at d_0, and grows at the same rate until the last indexation date preceding the payment year[2].

2 **Liabilities from members retiring in the future.** In this case, for a given maturity (*i.e.,* the year when payments are made), we have a distribution of members corresponding to different retirement dates. Aggregation from member data to population level data is more problematic in this case, because liabilities of this type correspond to different retirement dates. However, by bucketing retirement dates by year, one can map the liability corresponding to a maturity

1 Before vesting, an employee and its employer do contribute to the plan, but the plan has no financial obligation at retirement of the employee. The associated liabilities, if any, depend on the plan and are simple to deal with, but they are neglected in this document.

date N years in the future to N cashflow items corresponding to switching dates given by $d_{i,\alpha}$, $\alpha = 1,\ldots,N$. Hence, a cashflow item labeled ($N;\alpha$) corresponds to the liability flow occurring in year N from current members that retired in year $\alpha(\alpha \leq N)$. Depending on the specifics of the plan, this could be modeled as a real flow in year N corresponding to a given real notional in year α (inflation protection only during retirement), or as a given real notional at $d_{i,0}$ (inflation protection from the vesting date). To support both cases and the possibility that inflation protection might be structured differently before and after the retirement date, our valuation model allows for distinct inflation adjustments in pre- and post-retirement phases.

Notes:

- Users may supply a market price for inflation-linked liabilities. If no price is supplied by the user, then BarraOne will compute a price:
  - If no market price is available, BarraOne uses the user-specified Discount Spread.
  - If no market price or Discount Spread is available, BarraOne uses the credit factor model spread as the Discount Spread.
  - If no market price or Discount Spread is available, and if the user has specified "None" for Credit Factor Exposure, then BarraOne uses a zero discount spread.
- User-supplied returns for inflation-linked liabilities are not accepted in VaR Backtesting. These instruments must be evaluated using realized market conditions.
- Monte Carlo VaR for inflation-linked liabilities uses the Delta Approximation Method.
- Historical VaR employs full revaluation. Historical realized inflation is used for simulation, while volatility is kept constant (applies to caps and floors).
- The Returns Calculator does not support inflation-linked liabilities.

Exposures

This section explains the requirements for calculating exposures to Barra fundamental factors using a simplified notation for the BEI (Breakeven Inflation) forward curve, while omitting details about inflation indexation lag and market rate compounding.

A forward value of CPI can be represented using a continuously compounded BEI forward rate as follows:

$$F_{CPI}\left(t,T\right) = I\left(t\right)\frac{P_{Real}\left(t,T\right)}{P_{Nom}\left(t,T\right)} = I\left(t\right)e^{\left(r_{BEI}\left(t,T\right)\left(T-t\right)\right)}$$

where P_{Real} and P_{Nom} are prices of real and nominal forward zero coupon bonds, and $I(t)$ is an inflation index.

2 For payments in the current year, one might distinguish between members that get full benefit from inflation growth between $d_{i;-1}$ and $d_{i;0}$ because they retired before $d_{i;-1}$, and those that get only partial benefit because they retired between $d_{i;-1}$ and $d_{i;0}$.

The BEI forward rate is defined as follows:

$$r_{BEI}(t,T) = r_{Nom}(t,T) - r_{Real}(t,T)$$

where r_{Nom} and r_{Real} define continuously compounded forward rates for nominal and real term structures.

In a simple case, the payoff function of a liability instrument can be defined as the return of the inflation index over a contract period scaled by a notional value, which is therefore represented by the BEI forward rate. The return is usually compounded over a number of observation periods, and it can be optionally constrained with cap and floor conditions. These complications, although important for the valuation of the instrument, are not material for the understanding of Barra's factor exposure definitions.

Barra's factor model requires the estimation of the exposures to nominal, real, and swap term structures. (Note that in BarraOne, swap term structure data is frequently labeled as LIBOR rates.) Exposures are defined through a set of Key Rate Durations derived numerically with a small shock to spot rates for a given set of maturity terms.

Definitions of these durations are driven by the requirements of the Barra factor model. Cashflows of a liability asset are discounted with a swap curve. Inflation-linked liabilities are exposed to term structure KRDs and to the AA credit spread factor in the respective market (Corporate AA in the JPN market).

In case no market price is provided by the user, the application uses the factor model spread as a discount spread for the asset evaluation. The user may override the default behavior with another credit factor exposure available in Barra covariance model, or alternatively eliminate the credit spread exposure altogether. In the latter case, the discount spread is set to zero, and no credit exposure is calculated. The value of the credit exposure is defined as the Spread Duration, calculated as the sensitivity of an asset price to the discount spread change (note that the sum of Spread Key Rate Durations should be very close to the ILL Spread Duration).

The discount curve used by the model is LIBOR by default. However, the user may use the IR Curve Associations import template to specify a different discount curve. Similarly, the user may use this template to override the default nominal curve (i.e., Treasury). For each curve association default override, enter either “Discount” or “Nominal,” respectively, in the appropriate row in the template column with the “<usage>” header.

Special treatment is required for a user-specified discount curve. In this case, the user is expected to provide a corporate risky curve, a curve type (LIBOR or Treasury), a discount spread (optional; default is zero), and the choice of a credit spread factor exposure (default is **_CDT_AA). If the curve is specified with a LIBOR type, both Government KRD and Swap Spread KRD exposures are created (exposure values are Effective Key Rate Durations and Spread Key Rate Durations, respectively). If the curve is specified with a Treasury type, only Government KRD exposures are defined. This means that Spread Key Rate Durations are not needed. Based on the selection of credit spread factor, its exposure is set to the asset’s Spread Duration. The user may eliminate the use of the credit factor exposure. However, should the discount spread be omitted or explicitly set to zero, as soon as a valid credit spread factor is set, the corresponding factor exposure is created.

Specific Risk

Inflation-linked liabilities are exposed to the heuristic (linear) specific risk model as applied to inflation-protected bonds. This model has two parameters: one to account for sovereign market risk; one to account for the credit riskiness of the corporate issuer. The heuristic model assumes that the specific risk of the bond is proportional to spread duration.

Expressed as return volatility, this specific risk is:

$$\sigma_i = D_i b_a + D_i c_a s_i$$

where:

σ_i = monthly specific risk of inflation-linked liability i

D_i = spread duration of inflation-linked liability i

b_a = constant spread return risk for inflation-protected government bonds in domestic market a, or the standard (non-inflation-protected) parameter otherwise.

c_a = constant to account for additional specific spread return volatility of corporate bonds in market a

s_i = OAS of asset i, either

1. the AA rating spread (over swap) from the credit model of market a, if the liability is discounted over the AA corporate curve
2. the discount margin over the swap curve specified for the liability, if it is not discounted over the AA curve:
   a. if the margin is specified as a spread over treasury, then it must be converted to a spread over the swap curve
   b. if the spread over the swap curve is negative, then zero

Securitized Products

Securitized products supported by BarraOne include the following:

- USD-denominated RMBS (Agency CMO/REMIC, Whole Loan CMO/REMIC)
- USD-denominated ABS (Home Equity, Manufactured Housing, Credit Card, Auto, Equipment, Student Loans)
- USD-denominated CMBS
- EUR-denominated RMBS, ABS, CMBS

Analytics Overview

Using client-provided prices or spreads (and optional cashflow assumptions), BarraOne produces Intex library-forecast cashflows, translated into exposures, risk, and standard analytics:

- Intex analytics integration provides BarraOne with a source of cashflow forecasts for many collateralized instruments
- Securities are modeled with simulated forward interest rate paths, calibrated to client-provided spreads or prices
- The collateral- and pool-level prepayment speeds are forecast with Barra prepayment models, accounting for historical cash flow of the collateral and market conditions (refer to "Prepayment Models" on page 441)
- Intex models are used to calculate tranche cashflows based on the deal's structure features, such as subordination structure, shifting interest schedule, coupon dispersion, clean-up call, and servicing spreads
- Tranche cashflows are used to compute traditional analytics, exposures, and risk forecasts

CMO and REMIC

- Each pool is modeled separately with Barra's Residential Mortgage Prepayment Models

ABS and CMBS

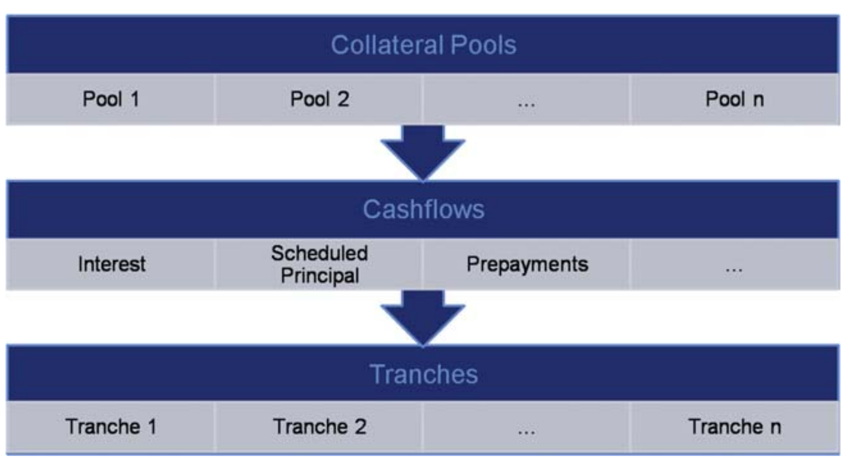
- Forward prepayment rates are projected using realized prepayments
- Forecast prepayment speed is the average trailing 12 months CPR (Conditional Prepayment Rate)

Valuation of CMO and ABS Tranches

CMO and ABS securities are valued by a combination of Barra interest rate modeling, prepayment modeling, and cashflow distribution rules from Intex.

CMO and ABS Securities

These securities are backed by collateral pools, *e.g.,* collections of home mortgages, student loans, or credit card receivables. A deal can be backed by a small number of these pools or by more than 100. Each CMO divides the collateral cashflows into deal tranches using rules that are often called cashflow "waterfalls": some tranches may receive only interest payments from the collateral, while some may receive only prepayment of principal.



Valuation Steps/Process

There are three steps in valuing a CMO tranche. Each step is internally complex, and there is an interaction among the steps, but the process is easy to understand if the overall process is kept clear.

1 Generate interest rate paths.

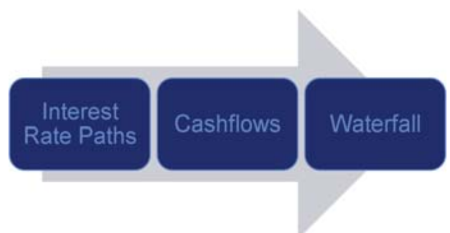
   We use the Hull-White interest rate model and simulate paths using principal components of the yield curve. We use variance reduction techniques, including quasi-random sequences, antithetic paths, and control variates, to allow efficient valuation.

2 Generate cashflows (including prepayments) from the deal collateral pools along the paths.

   We use five different types of behavioral prepayment models with thirteen sets of parameters fit to historical behavior.

3 Distribute the cashflows to the CMO deal tranches.

   We use the Intex database for the cashflow "waterfall" rules:



   Once the interest rate path is generated and collateral pool cashflows, including prepayments, are modeled on that path, the cashflows are distributed to the particular security analyzed, a CMO tranche. The "waterfall" rules of cashflows from collateral to deal tranche are provided by the Intex database and analytics that are integrated into the valuation.

Interest Rate Valuation Models

Necessary market data:

- LIBOR zero curve
- Treasury zero curve
- Price of the tranche (or spread if price is not available)
- User-provided cashflow assumptions (optional)

Pricing methodology: "Hull-White Model" on page 425

Pricing model: "Barra's Quasi-Random Principal Components (QRPC) Simulation" on page 440

Cashflow Assumptions

User-provided cashflow assumptions are fed into the Intex cashflow library as inputs for cashflow generation. (Note that these inputs are not applicable for MBS passthroughs.)

Cashflow assumptions are used to calibrate a spread, which enables the repricing of securities when the values are changed. They will affect the calculation of effective duration, convexity, yield, fitted price, etc.

Cashflow assumptions are not sensitive to interest rate of credit fluctuations. For example, an interest rate rally will not automatically increase prepayments for a CMO if CPR is specified.

Cashflow assumptions are not simulated in Monte Carlo VaR (i.e., the same set of cashflow assumptions is used in all scenarios): however, parametric VaR, historical VaR and MCVaR all use the schedule of cashflow assumptions.

Note that cashflow assumptions are applied at the deal level, but they are specified at the tranche (CUSIP) level.

Exposure Analysis

Securitized products are exposed to the following factors in Barra's model:

- Shift, Twist, and Butterfly term structure factors (refer to "Interest Rate Factor Exposures" on page 283), with no exposure to sector-by-rating or emerging market factors
- a swap spread factor (refer to "Swap Factor Exposures" on page 287) identical to an unrated bond
- currency (refer to "Currency Exposures" on page 293)
- specific risk (refer to "Specific Risk" on page 293)

Value at Risk and Stress Testing

For VaR, backtesting, and stress testing, BarraOne revalues securitized products using a "KRD approximation." The change in price is computed as follows:

$$\Delta P \approx \sum_{i=1}^{n}(-KRD_i \cdot \Delta r_i) - SpreadDuration \cdot \Delta OAS$$

BarraOne uses user-provided spreads, if available. If prices and spreads are available, BarraOne uses the Price/Spread priority to determine which to use. Valuation results may be used for up to 9 calendar days.

▷ **Note:** For stress testing, BarraOne offers the option to fully reprice securitized products using market conditions, rather than using KRD approximation. While this may provide greater accuracy for extreme market changes, it is very time consuming.

Syndicated Loan

A Syndicated Loan is a bank loan instrument modeled as a floating rate note. Syndicated loans are available as system-supplied assets with prices delivered on a daily basis, or they can be imported by the user. The system assets use a mapping between Industry and SIC codes and the BarraOne GICS sectors and subsectors used to assign factor exposures.

Analytics

Syndicated Loans use the floating rate note model. They use the corporate bond risk model, which means they are exposed to bond spread factors. For user-imported loans, the user is expected to provide the appropriate Barra sector.

Syndicated Loans use the same specific risk model as bonds.

Simulation

Syndicated Loans have the same treatment as FRNs.

Stress Test Module

Syndicated Loans are affected by both Credit Spread and Factor spread shocks (as well as interest rate shocks and all correlated shocks).

HVaR

Syndicated Loans are affected by the calibrated spread feature. If prices are not available, BIM spread returns are used.

MCVaR

Syndicated Loans are treated as bonds.

Syndicated Loan Columns

One of the features of Syndicated Loans is that they can be repaid at any time, and the incentives to do this may or may not be economic in nature (i.e., they may not be related to the interest rate environment). Thus, when analyzing bank loans, many investors like to look at durations, margins, and yields to various maturities. The typical maturities are 18 months, 3 years, 4 years, and T–1 (one year before the stated maturity). The following optional *Valuation Data* columns are available in the Positions Report, Single Asset Detail window, and Stress Testing (except for yield and spread convexity columns) for the analysis of the Syndicated Loans instrument type:

- Spread Duration to 18-months: Spread Duration computed as if the loan matured in 18 months.
- Spread Duration to 3-years: Spread Duration computed as if the loan matured in 3 years.
- Spread Duration to 4-years: Spread Duration computed as if the loan matured in 4 years.
- Spread Duration to 1-year Prior: Spread Duration computed as if the loan matured 1 year early.

- Discount Margin (DM): Reference and discount curves are flat and equal to the current LIBOR rate. Discount Margin is the spread added to the discount curve needed to reprice the bond.*
- DM to 18-months: Discount Margin computed as if the loan matured in 18 months.
- DM to 3-years: Discount Margin computed as if the loan matured in 3 years.
- DM to 4-years: Discount Margin computed as if the loan matured in 4 years.
- DM to 1-year Prior: Discount Margin computed as if the loan matured 1 year early.
- Yield to 18-months: YTM computed as if the loan matured in 18 months.
- Yield to 3-years: YTM computed as if the loan matured in 3 years.
- Yield to 4-years: YTM computed as if the loan matured in 4 years.
- Yield to 1-year Prior: YTM computed as if the loan matured 1 year early.
- Spread Convexity: Similar to IR convexity, but it uses spread shocks instead of interest rate shocks. Useful for FRNs, since their IR convexity is small.

* Discount Margin Calculation

Start with the current LIBOR rate corresponding to the coupon frequency, typically 3M. The reference and discount curves are taken to be this rate (*i.e.,* a flat curve ignoring the forward term structure and assuming all future realized rates will be equal to the current rate). Add a spread to the discount curve such that the calculated PV is equal to the market price. This spread is called the Discount Margin.

Example:

Current LIBOR 3M rate: 5%

Price: 95%

Margin: 25bps

Time to maturity: 1 year

DM calculation:

$$95\% = \frac{5\% * \frac{91}{360}}{(1+5\%+DM)^{0.25}} + \frac{5\% * \frac{92}{360}}{(1+5\%+DM)^{0.5}} + \frac{5\% * \frac{91}{360}}{(1+5\%+DM)^{0.75}} + \frac{100\% + 5\% * \frac{91}{360}}{1+5\%+DM}$$

DM = 2.3544%

Credit Default Swap

A Credit Default Swap (CDS) is an agreement to buy or sell protection against the risk of default by an issuer known as the reference entity on an underlying asset known as the reference asset. In case of a defined credit event (*e.g.,* default), the buyer of protection receives a payment from the seller of protection to compensate for the loss on the investment.

Typically, for transactions that are settled physically, this payment equals the notional principal amount, and the protection buyer delivers reference assets in exchange for that payment. For financially settled contracts, a recovery value of the reference asset is determined, and the payment is equal to the difference between par and the recovery value of the reference asset.

In return, the protection buyer pays a fee known as the CDS premium, or deal spread (standard coupon in the Big Bang Protocol). The fee is paid over the life of the contract at regular intervals. In addition, at contract inception a one-time upfront payment is made to the protection seller. If default occurs, the premium leg terminates after one final accrued payment.

There are a number of variations on the plain, vanilla CDS. In the case of a binary or fixed recovery CDS, the payoff amount in the event of a default is a fixed percentage of the notional. A forward CDS is a bilateral agreement between the parties to enter into a CDS at a specified later date at a specified CDS premium.

> **Note:** For valuation purposes, BarraOne does not distinguish between the physical delivery of the underlying asset and a cash settlement in the CDS.

Valuation Methodology

Necessary market data: CDS spread

Pricing methodology: Discounted cash flow

Pricing model: "Deterministic Intensity Reduced Form Model" on page 445

The mark-to-market value of the CDS contract is, to first order, given by

$$V_{MTM} = DV01_{spread} \cdot \Delta S$$

where $DV01_{spread}$ is the spread DV01 of the CLN contract, and ΔS is the difference between the present market spread and the fixed spread of the contract.

CDS valuation is performed in two steps:

1. To determine the value of a CDS on a given date, BarraOne calibrates a term structure of default intensities, a DI curve, from the term structures of market CDS spreads and upfronts.

2. This DI curve is then used, along with the contract terms and conditions and fixed contract spread, to determine the CDS mark-to-market value (price), spread DV01, and accrued payments.

Exposure Analysis

Single-name CDS exposures are determined by the sector and rating. This data is combined with the valuation data (MTM, durations, spread) to yield the risk. When aggregating risk in a portfolio, the specific risk of a CDS is linked to the specific risk of any relevant underliers (*i.e.,* the correlation of a long position in a bond and its CDS is −1).

⊳ **Note:** A system-supplied CDS may have a sector distinct from the sector of its underlier, but the risk analysis and credit exposure is still based on the sector and rating of the underlier.

STB exposures are calculated in the usual manner (via STB shocks).

The following is a summary of how exposures are calculated for a single-name CDS. In BarraOne, specific risk is positive, since correlation with reference entities is accounted for via specific risk linking.

CDS in covered markets use the issuer specific risk model based on the issuer and factor exposure of the reference entity. Unlike bonds, the risk parameter is scaled by the spread duration of the CDS.

For other markets, where there is no exposure to the credit factor, exposure to swap spread factor is computed as follows:

$$\text{Effective Duration} + (\alpha - 1) \cdot \text{Spread Duration}$$

and specific risk is calculated as shown below:

$$\text{Spread Duration} \cdot \left[b + c \cdot \max(S, 0) \right]$$

where:

- *MTM* is the mark-to-market value of the CDS
- S is the current market spread for the CDS
- α is a scaling factor
- b is the constant spread return risk for government bonds in the market
- c is a constant to account for additional specific spread return volatility of corporate bonds in the market

⊳ **Note:** The credit factor exposure is determined by the currency, sector, and rating of the underlier, but the swap spread exposure is determined by the currency of the CDS. For instance, if the user holds a euro CDS contract with a European Financial AA bond as underlier, then the credit factor exposure is to the European Financial AA sector-by-rating spread, and the swap spread is derived from the euro market. On the other hand, if the user holds a euro CDS contract with an U.S. Industrial AA bond as underlier, then the credit factor exposure is to the U.S. Industrial AA sector-by-rating spread, while the swap spread exposure is derived from the euro market.

The large risk numbers can be attributed to the leverage effect of the CDS. The market value of a CDS is the accumulated value since inception. It does not include the face amount of the contract. When you add this asset into a portfolio, the high risk numbers will contribute only a small fraction (market value-weighted) to the overall risk of the portfolio.

Spread Curve Priority

Valuation and HVaR

1 The highest priority curve source is used on a given analysis date, using both reference bond-level mapping and CDS-level mapping.

2 If both reference bond-level and CDS-level curve mapping exists for the same analysis date under the same source name, then the CDS-level mapping will be used.

3 If there is no available spread, then the reference bond OAS is used.

Credit Default Swap Basket

A Credit Default Swap Basket (CDS Basket) instrument is provided in BarraOne for users to enter the terms and conditions for, and specify the constituents of, a CDS Index. A CDS Index is a standardized credit derivative designed to buy or sell protection against a group of heavily traded reference entities. New series of popular indexes are typically constructed (rolled) every six months.

A CDS Index Swap (colloquially, CDS Index contract or just CDS Index) is a swap contract whose payoff is sensitive to any and all defaults in the index. Much like a single-name CDS contract, the CDS Index Swap is a bilateral contract between a protection buyer and a protection seller. The protection seller has agreed to compensate the protection buyer for default losses on any and all names in the index.

In exchange for this credit risk, the protection buyer must pay a fixed spread on the running notional of the contract. For some high-yield indexes, an upfront payment is also made in exchange for a lower fixed spread.

Each default is handled much like a default on a single-name CDS would be handled. Most CDS Index Swaps stipulate for physical delivery, so the protection seller pays the protection buyer par for the defaulted bonds. Cash delivery is less common but may become more popular. Here, the protection seller pays the protection seller $(1-R) \cdot w \cdot N_{orig}$, where R is the recovery rate for the defaulted issuer's assets, w is the weight of the issuer in the index, and N_{orig} is the original notional of the contract. In all cases, each default results in a reduction of the outstanding notional by $w \cdot N_{orig}$.

Funded CDS Baskets

There is a funded version of the CDS Index contracts in which an investor pays par to buy the note, thereby selling protection against any and all names in the index. The note then pays a fixed coupon or LIBOR plus a spread to compensate the investor for their credit exposure. If a reference entity in the index defaults, the investor is delivered the reference asset or $(1-R) \cdot w \cdot N_{orig}$ where R is the recovery rate for the defaulted issuer's assets, w is the weight of the issuer in the index, and N_{orig} is the original notional of the contract. Additionally, the notional of the note is written down by $w \cdot N_{orig}$.

> **Note:** If the user does not have access either to Markit CDS curve data or their own imported curve data (either curve data for the CDS basket, CDS basket constituents, and/or the constituents' reference bond par spread curves), then CDS baskets will be rejected.

Valuation Methodology

Necessary market data: CDS Index spread

Pricing methodology: Discounted cash flow

Pricing model: "Deterministic Intensity Reduced Form Model" on page 445

CDS Basket contracts are valued much like CDS contracts are. Again, the mark-to-market value of the CDS Basket contract is, to first order, given by

$$V_{MTM} = DV01_{spread} \cdot \Delta S$$

where $DV01_{spread}$ is the spread DV01 of the CDS contract, and ΔS is the difference between the present market spread and the fixed spread of the contract. If markets spreads have not changed, the contract has close to zero value. This does not take into account any sort of discounting or recovery rate assumptions.

CDS Basket valuation is performed in two steps: a calibration step and a valuation step. Valuation of the CDS Basket requires a snapshot of default likelihoods in the form of default intensities. This bottom-up method constructs a default intensity term structure for each individual issuer from the single-name CDS spreads and upfronts. All of these default intensities are bundled together into a single array and used with the contract terms and conditions and fixed spread to produce the bottom-up mark-to-market price of the contract. This is the valuation of the index purely from the single-name CDS market; the CDS Index spreads are not used in this valuation method.

To ensure that the valuation does reflect CDS Index spreads, an additional set of adjustments and recalibrations must be made. This workflow is described here:

1. First the CDS Index market spread term closest to the maturity of the user's contract is determined.

2. Next, a term structure of spreads and upfronts is constructed for each name in the index.

3 These term structures are used to produce a DI (default intensity) curve for each name in the index.

4 An array of all of the issuer DI curves is then used to calculate a “fair fixed spread” for the valuation date. This fair fixed spread is the spread that sets the value of the CDS Basket initiated at the value date to be zero based on the CDS spreads and upfronts. This should be close to but not necessarily equal to the market index spread. The difference between the fair fixed spread and the CDS Index market spread is called the “Fair Spread Basis.” For consistency, the application ensures that this fair fixed spread is equal to the market index spread by adjusting the single-name market CDS spreads, then recalibrating.

5 For each name in the index, all of the spreads are multiplied by the ratio of the index market spread to the “fair fixed spread.”

6 New DI curves are calibrated from the term structures of adjusted spreads and the original upfronts.

7 These DI curves are used to calculate the “fair fixed spread.” This fair fixed spread should now match the market index spread within tolerance (< 0.1 bp). If it does not, then steps 4–7 are repeated until it does.

8 These DI curves are then used to calculate the price, accrued payments, and the DV01s of the issuers to the index.

The CDS Basket will be exposed to credit factors of the constituents. These spread DV01s are used to aggregate constituent exposures and specific risk up to the CDS Basket. This description of CDS Basket valuation applies equally well to CLNs based on CDS indexes (“funded CDS basket”).

Spread Curve Priority

Valuation

Basket-level curve

1 If CDS basket mapping exists, then it is used at the basket level, and constituent spreads are calibrated such that their aggregated value matches the basket-level spread.

2 Otherwise, the basket-level spread is aggregated from the constituent-level curves using simple averaging of all available constituent curves; this average is also assigned to constituents without a spread curve.

3 If there is no basket mapping and no constituent-level curves, then CDS baskets are rejected.

Constituent-level curve

1 The highest source curve is used.

2 The user can import a bond mapping curve to override the Markit curve for underliers.

HVaR

1 If a basket-level spread curve exists, then the credit spread is simulated based on the basket-level spread curve time series; constituent-level curves are not simulated.

2 If a basket-level spread curve does not exist, then the credit spread shock is computed from aggregated constituent-level shocks, while constituent-level shocks are calculated from the corresponding bond credit factor return.

Exposure Analysis

Calculating the exposures of the CDS Basket requires sector and rating information on the names underlying the index. If a spread is missing, then the spread of the underlier is used as an estimate.

The formula for swap and credit exposure aggregation is:

$$X_{index} = \sum_{i=1}^{N} X_i \cdot w_i$$

where X_i is the exposure of constituent i to factor X (*e.g.,* spread duration for credit exposure, and effective duration for swap spread exposure).

Note: The credit factor exposure is determined by the currency, sector, and rating of each constituent, but the swap spread exposure is determined by the currency of the basket or index. For instance, if the user holds a euro CDS contract with a European Financial AA bond as underlier, then the credit factor exposure is to the European Financial AA sector-by-rating spread, and the swap spread is derived from the euro market. On the other hand, if the user holds a euro CDS contract with an U.S. Industrial AA bond as underlier, then the credit factor exposure is to the U.S. Industrial AA sector-by-rating spread, while the swap spread exposure is derived from the euro market.

The formula for CDS basket specific risk is similar to that for the specific risk of a composite of the bonds that are the reference entities in the CDS basket. The calculation takes into account the covariance of specific risk, and it is scaled by the weights of the constituents in the CDS basket:

$$\sigma_{basket\ (specific)} = \sqrt{wDw^T}$$

where:

D = constituent-by-constituent specific variance-covariance matrix

w = matrix of CDS basket constituent weights in which $w_i = \dfrac{Market\ \ Value_i}{Market\ \ Value_{basket}}$

Credit Linked Note

A credit-linked note (CLN) is a security that pays a fixed or floating-rate coupon and contains an embedded CDS. The investor pays par to get the note, thereby selling protection against default by the underlying reference entity. The note then pays a fixed coupon or LIBOR plus a spread to compensate the investor for their credit exposure. If the reference entity defaults, the investor is delivered the reference asset or its recovery value.

Note that these are like funded short positions in a single-name CDS. An investor who is long a CLN is assuming credit risk, not hedging it.

As in the case of a CDS, there are a number of variations on a CLN. In a principal-protected CLN, the investor does not lose the principal payment of the underlying asset in case of default. If default occurs, only the remaining coupon payments are lost. However, the principal payment is recovered only at maturity of the contract.

> **Note:** For valuation purposes, BarraOne does not distinguish between the physical delivery of the underlying asset and a cash settlement in the CLN.

Valuation Methodology

Necessary market data: Par spread

Pricing methodology: Discounted cash flow

Pricing model: "Deterministic Intensity Reduced Form Model" on page 445

When a CLN contract is first initiated, the spread is determined such that it has zero value. For the holder of that contract, the spread is fixed, while the market spread likely deviates from this spread, thereby changing the value of this contact. A seller of protection sees the mark-to-market value of that contract decrease as market spreads widen.

CLN valuation is performed in two steps:

1. To determine the value of a CLN on a given date, BarraOne calibrates a term structure of default intensities, a DI curve, from the term structures of market CLN spreads and upfronts.

2. This DI curve is then used, along with the contract terms and conditions and fixed contract spread, to determine the CLN mark-to-market value (price), spread DV01, and accrued payments.

Exposure Analysis

Single-name CLN exposures are determined by the sector and rating. This data is combined with the valuation data (MTM, durations, spread) to yield the risk. When aggregating risk in a portfolio, the specific risk of a CLN is linked to the specific risk of any relevant underliers (*i.e.,* the correlation of a long position in a bond and its CLN is +1).

STB exposures are calculated in the usual manner (via STB shocks).

The following is a summary of how exposures are calculated for a single-name CLN. In BarraOne, specific risk is positive, since correlation with reference entities is accounted for via specific risk linking.

CLNs in covered markets use the issuer specific risk model based on the issuer and factor exposure of the reference entity. Unlike bonds, the risk parameter is scaled by the spread duration of the CLN.

For other markets, where there is no exposure to the credit factor, exposure to the swap spread factor is computed as follows:

$$\text{Effective Duration} + (\alpha - 1) \cdot \text{Spread Duration}$$

and specific risk is calculated as shown below:

$$\text{Spread Duration} \cdot \left[b + c \cdot \max(S, 0) \right]$$

where:

- *MTM* is the mark-to-market value of the CDS
- S is the current market spread for the CDS
- α is a scaling factor
- b is the constant spread return risk for government bonds in the market
- c is a constant to account for additional specific spread return volatility of corporate bonds in the market

Note: The credit factor exposure is determined by the currency, sector, and rating of the underlier, but the swap spread exposure is determined by the currency of the CLN. For instance, if the user holds a euro CLN contract with a European Financial AA bond as underlier, then the credit factor exposure is to the European Financial AA sector-by-rating spread, and the swap spread is derived from the euro market. On the other hand, if the user holds a euro CLN contract with an U.S. Industrial AA bond as underlier, then the credit factor exposure is to the U.S. Industrial AA sector-by-rating spread, while the swap spread exposure is derived from the euro market.

Because a CLN is a funded instrument, its risk numbers should resemble those of a bond.

CDS Option

Since the CDS market is now well established (single-name credit default swaps are liquid, index CDS products are extremely liquid), derivatives based upon these underlying contracts are being created, among which are options on single-name credit default swaps and options on index portfolios.

A CDS option is a European option that entitles the holder the right (but not the obligation) to buy or sell protection on a specified reference entity for a specified future period at the specified strike spread at option maturity. A payer's option gives the option holder the right to buy protection/sell risk; a receiver's option gives the option holder the right to sell protection / buy risk.

Different front-end protection types are offered:

- Full protection offers protection even for underlier(s) that have defaulted prior to exercise
- Contingent protection offers protection only for non-defaulted underliers in a CDS index option

Notes:

- The Black model is used for valuation.
- Market Value (expressed as a percentage of the notional adjusted for any exchange rate) = Option Price × Holding × Contract size of underlier ÷100
- Users may supply a market price for CDS options. If no price is supplied by the user, then BarraOne will compute a price:
  - If no market price is available, BarraOne uses the user-specified Implied Volatility Schedule.
  - If no market price or Implied Volatility Schedule is available, BarraOne uses the total risk of the underlying CDS or CDS index as the option volatility.
- The Returns Calculator does not support CDS options.
- The volatility of a CDS option will not be shocked in a stress test market scenario.
- Monte Carlo VaR for CDS options uses the Delta Approximation Method. P/L is estimated by combining simulated factor returns and option exposures.
- Historical VaR employs a full revaluation of the option. Historical spreads of the option underlier(s) are used for credit spread simulation, while volatility is kept constant.
- If the user does not have access either to Markit CDS curve data or their own imported curve data (either curve data for the CDS basket, CDS basket constituents, and/or the constituents' reference bond par spread curves), then CDS options on CDS baskets will be rejected.

Exposure Analysis

A CDS option has delta-adjusted exposures to the same risk factors as the underlying instrument.

CDS Tranche

This is an instrument type similar to CDS Baskets. These instruments are alternatives to the traditional Credit Default Swaps Indexes, but they enable users to achieve more targeted exposures. When investing in a CDS Index, an investor is exposed to the entire basket, and any default will affect the position. With CDS tranches, however, investors are exposed to only a specific slice of the index.

The flip side of this targeted exposure is a change in the cost. For example, a user might want to increase income by offering protection on the first few defaults of an index. In this case, the user could sell a 0-3% tranche on CDS IG (125 names), which would offer protection on the first 5 defaults (assuming 40% recovery). In return, the user would receive a spread that is larger than the user would receive if selling protection on a plain CDS Index. Conversely, a user who wants to decrease exposure could sell a 15-30% tranche on CDX IG. In this case, the user would not incur losses until the 26th underlier had defaulted (assuming 40% recovery).

Valuation

Users should import a par spread curve for the CDS Tranche, in addition to specifying a recovery rate in the T&C. If no par spread is available for a date, then the spread curve of the underlying CDS Basket is used as the CDS Tranche's par spread curve. No theoretical spreads are calculated. The values are at the tranche level only. Underlier values are ignored; instead, each underlier has the same spread and recovery rate as the tranche.

With CDS Indexes, the main risk driver is the different default probabilities and recovery rates of each underlier. As the user is exposed to all names, correlation is not a valuation driver. However, with tranches the main driver is correlation. To simplify valuation, the market has adopted the One Factor Gaussian Copula model (GC1F.A) as the standard pricing model; it assumes that all the underliers have the same spreads and recovery rates (equivalent to the tranche spread), and instead calibrates correlations to the market value. As such, BarraOne does not need to take into account individual characteristics, nor does need to calibrate any fair spread.

Thus all underliers are equivalent and individual spreads and recovery rates are not used. Similarly, all underliers have the same risk sensitivities. So unlike CDS Baskets, there needs to be only a single delta returned to represent the sensitivity of all the underliers.

Exposures

CDS Tranche exposures follow the same rules as CDS Baskets, including exposure aggregation. However, due to the common values for spreads and recovery rates, the underliers are not unique and thus all have the same sensitivities.

The risk of the tranche is distributed according to the proportion of underlier exposed to a given credit factor. Mathematically, the exposure of the tranche to a credit factor is given by:

$$X_i = \frac{1}{N} \sum_{i=1}^{N} D \cdot 1_{X_i}$$

where:

X_i = the exposure to credit factor i

N = the number of underliers

D = the spread duration of the tranche and is the indicator function :

it is equal to 1 if the underlier is exposed to the factor, and 0 otherwise

The exposure to the swap spread factors is simply the spread duration of the tranche.

Specific Risk

Since we are assuming equal weighting of underliers, the formula for specific risk aggregation is:

$$\sigma_{Tranche} = \sqrt{\sum_{i=1}^{N} \left(\sigma_i \cdot w_i\right)^2}$$

where:

$w_i = 1/N$, where N is the number of constituents

Simulation

CDS Tranches have the same treatment as CDS Baskets.

Outputs

BarraOne computes the same outputs as for CDS Baskets.

Nth-to-Default

Nth-to-default Baskets are very similar to CDS Tranches; the only difference is the import template. Nth-to-Default baskets map internally to CDS Tranches and have the exact same treatment. The only difference is that BarraOne converts the basket default protection parameters into attachment and detachment points.

Conversion from Nth-to-Default to CDS Tranche

BarraOne leverage the CDS Tranche implementation to support Nth to default Baskets. BarraOne converts the Protection Start and End into Attachment and Detachment Points. The following formulas can be used to convert the fields:

$$a = \frac{m-1}{N}(1-R)$$

$$d = \frac{n}{N}(1-R)$$

where:

a = Attachment point

d = Detachment point

N = Total number of underliers

m = Protection Start

n = Protection End

R = Recovery Rate

Once this is done, they are equivalent to CDS Tranches.

Foreign Exchange Instruments

This section describes the techniques BarraOne uses to handle the following instruments:

- Foreign Exchange Conventions
- Exposure Analysis
- FX Forward
- FX Future
- FX Option
- FX Future Option

Foreign Exchange Conventions

BarraOne does not implement a foreign exchange rate convention for each individual market. It has one convention:

Exchange Rate = *Units of Pay Currency per One Unit of Receive Currency*

where:

Pay Currency = *Quote Currency*, and
Receive Currency = *Currency*.

This convention can lead to confusion, but there is a useful rule: if a BarraOne exchange rate is multiplied by one unit of Receive Currency (Currency), the result is the equivalent number of units in Pay Currency (Quote Currency). For example, the holder of a long FX forward contract with the exchange rate specified as:

Exchange Rate (JPY/USD)
= *Units of Pay Currency per One Unit of Receive Currency*
= *Units of Quote Currency per One Unit of Currency*
= 94.81835

on delivery will exchange $1.00 for:

Exchange Rate × $1.00 = (94.81835 JPY / 1.00 USD) × $1.00 = ¥94.81835

or pay ¥94.81835 and receive $1.00.

The same logic applies to the strike price of an FX option or FX future option. Given a call option to buy USD (Currency or Receive Currency) and pay JPY (Quote Currency or Pay Currency, the strike price of the option is specified as:

Strike Price (JPY/USD)
= *Units of Pay Currency per One Unit of Receive Currency*
= *Units of Quote Currency per One Unit of Currency*
= 94.81835

Exposure Analysis

In addition to the exposures to which individual FX instruments are exposed, all FX instruments are exposed to interest rate risk. While these exposures are relatively small, interest rate differences between the pay currency and the receive currency can increase interest rate risk, and interest rate risk can be significant, depending upon the time to maturity of the instrument.

BarraOne calculates the following IR exposures for both the funding currency and the contract currency interest rates:

- IR shift exposures: shift, twist, butterfly (STB) or key rate durations (KRDs) for all currencies in the transaction
- Spread exposures: swap only, because these are money market instruments, for all currencies in the transaction

These exposures are calculated using the same methodology used for fixed income instruments. Namely, interest rate exposures are calculated from local shocks to the term structure. Refer to "Interest Rate Factor Exposures" on page 283. Details about fixed income exposures can be found in the *Barra Risk Model Handbook*.

Notes:

- specific risk is zero, because FX instruments are money market securities
- while FX instruments will be exposed to STBs and KRDs, BarraOne will not display the duration of FX derivatives, as these derivatives tend to be short term and are typically not used to modify portfolio duration
- FX instruments are not exposed to sector-by-rating credit factors

FX Forward

An FX forward is a contract between two counterparties to exchange a specified amount of two currencies at a predetermined exchange rate (the contract forward rate) at a specific date in the future. The user is protected from adverse movements in forward exchange rates but does not benefit from favorable movements. FX forwards remove uncertainty and are therefore valid instruments for users to mitigate downside foreign exchange risk for future transactions denominated in a foreign currency.

Valuation Methodology

Necessary market data:

- FX spot rates
- Domestic and foreign zero rates
- Contract FX rate

Pricing methodology: Interest rate parity

FX forward rates, FX spot rates, and interest rates are interrelated by the interest rate parity principle. This principle is based upon the notion that there should be no arbitrage opportunity between the FX spot market, FX forward market, and the term structure of interest rates in the two countries.

Interest Rate Parity Principle

$$FX_{fwd} = Se^{(r_d - r_f)(T - t)}$$

where:

FX_{fwd}	=	fair forward FX rate (quoted in units of domestic currency per unit of foreign)
S	=	current price in domestic currency of one unit of the foreign currency
e	=	base of the natural logarithm
r_d	=	domestic interest rate (for term of forward) quoted on a simple interest basis
r_f	=	foreign interest rate (for term of forward) quoted on a simple interest basis
T	=	date at expiration of contract
t	=	current date

Model value: The value of foreign exchange forward contracts in numeraire currency is calculated as shown in the formula "FX Forward Contract Value."

FX Forward Contract Value

$$f = RX_{N/R}e^{-r_R(T-t)} - PX_{N/P}e^{-r_P(T-t)}$$

where:

f	=	forward contract value in numeraire currency
R	=	amount of receive currency
$X_{N/R}$	=	units of numeraire currency per receive currency
r_R	=	continuously compounded money market rate in the country of the receive currency
T	=	time to delivery or exercise
t	=	current time
P	=	amount of pay currency
$X_{N/P}$	=	units of numeraire currency per pay currency
r_P	=	continuously compounded money market rate in the country of the pay currency

The value of an FX forward is typically zero at the time it is initiated, but it will change as the spot rate between the two currencies changes during the life of the contract. The portfolio value is assumed to be non-zero. Otherwise, there is infinite leverage.

Exposure Analysis

The factor exposures of the contract to receive and pay currencies are calculated as shown in the formula “FX Forward Contract Exposures.”

FX Forward Contract Exposures

$$E_R = \frac{RX_{N/R}}{RX_{N/R} - PX_{N/P}e^{(r_r - r_p)(T-t)}}$$

$$E_P = -\frac{PX_{N/P}e^{-r_P(T-t)}}{RX_{N/R}e^{-r_R(T-t)} - PX_{N/P}e^{-r_P(T-t)}}$$

where:

E_R	=	receive currency exposure
R	=	receive amount presented in receive currency
E_P	=	pay currency exposure
P	=	pay amount presented in pay currency
$X_{N/P}$	=	units of numeraire currency per pay currency
e	=	base of the natural logarithm
r_P	=	continuously compounded money market rate in the country of the pay currency
T	=	delivery or exercise time
t	=	current time
$X_{N/R}$	=	units of numeraire currency per receive currency
r_R	=	continuously compounded money market rate in the country of the receive currency
$RX_{N/R}e^{-r_R(T-t)}$	=	present value of the receive currency leg

FX Future

Currency futures are exchange-traded FX forward instruments. The market value of an FX future differs from the value of an FX forward by a discount factor.

Valuation Methodology

Pricing methodology: Cost of Carry

FX futures have no market value; however, they have an effective market value.

FX Future Effective Market Value

$$f = RX_{N/R} - PX_{N/P}e^{(r_R - r_P)(T-t)}$$

where:

f	=	future contract effective market value in numeraire currency
R	=	receive amount presented in receive currency
$X_{N/R}$	=	units of numeraire currency per receive currency
$RX_{N/R}$	=	receive amount in numeraire currency
e	=	base of the natural logarithm
r_P	=	continuously compounded money market rate in the country of the pay currency
r_R	=	continuously compounded money market rate in the country of the receive currency
T	=	time to delivery or exercise
t	=	current time
P	=	pay amount presented in pay currency
$X_{N/P}$	=	units of numeraire currency per pay currency

FX Future Contract Exposures

$$E_R = \frac{RX_{N/R}}{RX_{N/R} - PX_{N/P}e^{(r_r - r_p)(T-t)}}$$

$$E_P = -\frac{PX_{N/P}e^{(r_r - r_p)(T-t)}}{RX_{N/R} - PX_{N/P}e^{(r_r - r_p)(T-t)}}$$

where:

E_R	=	exposure to receive currency in numeraire currency
E_P	=	exposure to pay currency in numeraire currency
P	=	value of the contract in pay currency
$X_{R/P}$	=	units of receive currency per pay currency
R	=	value of the contract in receive currency
e	=	base of the natural logarithm
r_P	=	continuously compounded money market rate in the country of the pay currency
r_R	=	continuously compounded money market rate in the country of the receive currency
T	=	time to delivery or exercise
t	=	current time

FX Option

A currency option is an option on a forward FX contract. An over-the-counter currency option gives the owner the right to buy or sell a specific amount of currency at a specified exchange rate on or before a certain date.

Supported Option Types

BarraOne supports puts and calls on the following types of FX options:

- European
- American
- Bermudan
- Single Barrier (European)
- Double Barrier (European)
- Asian (European)

Valuation Methodology

Necessary market data:

- FX spot rates
- Domestic and foreign zero rates
- Volatility of FX rates

Model value: Fair value from the valuation model

European

Pricing methodology: Closed form

Pricing model: "Garman-Kohlhagen Model" on page 424

American and Bermudan

Pricing methodology: "Trinomial Tree Model" on page 426

European Single Barrier

Pricing methodology: "Trinomial Tree Model" on page 426

Pricing model: "Single Barrier Model (European)" on page 432

European Double Barrier

Pricing methodology: "Trinomial Tree Model" on page 426

Pricing model: "Double Barrier Model (European)" on page 439

European Asian

Pricing methodology: Approximation

Pricing model: "Asian Model" on page 430

Exposure Analysis

The exposures (dollar amount change of the option values based upon the underlying exchange rate change) to the receive and pay currency factors in the integrated covariance matrix are calculated as shown in the formula "FX Option Exposures."

FX Option Exposures

$$E_P = X_{R/P} \frac{\delta_{R/P}}{R}$$

$$E_R = 1 - X_{R/P} \frac{\delta_{R/P}}{R}$$

where:

E_P	=	pay currency exposure
E_R	=	receive currency exposure
$X_{R/P}$	=	units of receive currency per pay currency
R	=	value of the option contract in receive currency
δ	=	delta of the option value R

The value of the option (R in the equation) is taken from one of the following, depending upon availability, in order of priority:

- User-supplied option price, if set to a priority higher than any available user-supplied implied volatility term structure attribute
- Calculated from the user-supplied implied volatility term structure attribute for the option (N/A for Asian and barrier options)
- Calculated from the user-supplied implied volatility schedule in the option terms and conditions
- Calculated from the user-supplied static implied volatility in the option terms and conditions
- Calculated using the implied volatility of the underlying asset, which is computed using BIM

FX Future Option

An option on an FX futures contract gives the holder the right to buy (call) or sell (put) the underlying futures contract. Upon exercise, a position is created in the underlying futures contract.

Supported Option Types

BarraOne supports puts and calls on the following types of FX future options:

- European
- American

Valuation Methodology

Necessary market data:

- FX spot rates
- Domestic and foreign zero rates
- Volatility of FX forward rates

Model value: Option value from the option model

European

Pricing methodology: Closed form

Pricing model: "Black Model (1976)" on page 422

American

Pricing methodology: Simulation

Pricing model: "Trinomial Tree Model" on page 426

Exposure Analysis

The exposures of an FX future option are equal to the exposures of an option on a forward FX contract. Refer to the formula "FX Option Exposures" on page 355.

Equity Instruments

An equity derivative contract is dependent upon, and derives its value from, the value of the underlying stock or basket of stocks. This section describes the techniques BarraOne uses to handle the following instruments:

- Private Equity
- Equity Rule-Based Proxy
- Equity Claim
- Equity Forward
- Equity Future
- Equity Index Future
- Equity Option
- Equity Index Future Option
- Contract for Difference
- Equity Volatility Derivatives

Private Equity

BIM covers private equity investments in the following categories:

- Asia large buyouts
- Asia small buyouts
- Asia distressed
- Asia early stage/balanced ventures (combined category)
- Asia late stage ventures
- Europe large buyouts
- Europe small buyouts
- Europe distressed
- Europe mezzanine
- Europe early stage/balanced ventures (combined category)
- Europe late stage ventures
- US large buyouts
- US small buyouts
- US distressed

- US mezzanine
- US early stage/balanced ventures (combined category)
- US late stage ventures

Exposure Analysis

Return

The return of a private equity asset is determined by the following components:

Private Equity Return

$$r_{i,t} = \sum_k \beta_{i,k} f_{p,k,t} + \sum_l x_{i,l} \phi_{l,t} + u_{i,t}$$

where:

$r_{i,t}$	=	private equity investee company i excess return
$\beta_{i,k}$	=	exposure of investee company i to public factor k
$f_{p,k,t}$	=	excess return to public common factor k
$x_{i,l}$	=	exposure of investee company i to private equity factor l
$\phi_{l,t}$	=	excess return to purely private equity common factor l
$u_{i,t}$	=	investee company i specific return

Exposures

Private Equity instruments have three sets of exposures:

1. Public Factor exposure: A set of non-currency factor exposures from the Proxy Portfolio, which is either specified by the user or determined by the Investment Type.

2. Private Equity exposure:100% exposure to the private equity factor determined by the Investment Type.

3. Currency Exposure: 100% exposure to the currency specified by the user in the Currency field.

Exposures to Public Factors and Exposures

Public Factor exposure rules:

1 If the Proxy Portfolio is not specified by the user, then the PEQ exposures are computed as the product of the beta and the Proxy Portfolio's exposures. The beta is a time-dimensional data deliverable specific to each Investment Type.

2 If the Proxy Portfolio is specified by the user, then the exposure is the set of non-currency exposures of the Proxy Portfolio.

3 If the Industry is specified (non-fixed income PEQ instruments only), then exposure to the industry factor is 100% multiplied by the Investment Type beta.

PEQ assets with Investment Types of either Distressed or Mezzanine are considered fixed income PEQ instruments. The main difference between equity and fixed income PEQ instruments is that any Industry inputs are ignored for fixed income PEQ instruments. Their treatment in HVaR and Stress Testing is identical.

As outlined above, the set of public equity factors and the exposure assignment to the relevant factors for each private equity investment depends on the user's available information, and it is handled in BarraOne (not in the private equity update). We distinguish the following three cases:

Case 1: the user has no information other than the type of private equity investment.

Each private equity investment gets mapped to a broad public equity portfolio (see below), and it is exposed to all of the common factors of the broad public equity portfolio. The proxy portfolio may consist of up to three portfolios. As such, BarraOne treats them as two-level trees, rather than as portfolios, in which each component portfolio is a leaf. The portfolios are system-provided indices; in the case of multiple portfolios, they are aggregated using market-value weighting, which is the default behavior for trees. Below is the mapping between Investment Type and Proxy Portfolio:

Investment Type	Proxied Factor	Underlier Index Short Name
ASIA LARGE BUYOUTS	AS_BUYOUT_PXY	MSAASIAIMID
ASIA SMALL BUYOUTS	AS_BUYOUT_PXY	MSAASIAIMID
ASIA DISTRESSED	AS_MEZZ_DIST_PXY	MLIC0A
ASIA EARLY STAGE/BALANCED VENTURES (COMBINED CATEGORY)	AS_VENT_PXY	MS655778
		MS655780
		MS655781
ASIA LATE STAGE VENTURES	AS_VENT_PXY	MS655778
		MS655780
		MS655781
EUROPE LARGE BUYOUTS	EU_BUYOUT_PXY	MS664980
EUROPE SMALL BUYOUTS	EU_BUYOUT_PXY	MS664980

Investment Type	Proxied Factor	Underlier Index Short Name
EUROPE DISTRESSED	EU_MEZZ_DIST_PXY	MLHE00
EUROPE MEZZANINE	EU_MEZZ_DIST_PXY	MLHE00
EUROPE EARLY STAGE/BALANCED VENTURES (COMBINED CATEGORY)	EU_VENT_PXY	MS655818
		MS655820
		MS655821
EUROPE LATE STAGE VENTURES	EU_VENT_PXY	MS655818
		MS655820
		MS655821
US LARGE BUYOUTS	US_BUYOUT_PXY	MSUSAIMID
US SMALL BUYOUTS	US_BUYOUT_PXY	MSUSAIMID
US DISTRESSED	US_MEZZ_DIST_PXY	MLH0A0
US MEZZANINE	US_MEZZ_DIST_PXY	MLH0A0
US EARLY STAGE/BALANCED VENTURES (COMBINED CATEGORY)	US_VENT_PXY	MS655708
		MS655710
		MS655711
US LATE STAGE VENTURES	US_VENT_PXY	MS655708
		MS655710
		MS655711

The non-private equity exposures are computed as exposures of the corresponding proxy portfolio multiplied by special "beta," which is defined by investment type and proxy portfolio, and it is time dimensional. This "beta" is provided by Barra as a data deliverable.

For private equity investment *i* belonging to the private equity type *l*, the exposures to each public equity factor *k* are:

Public Equity Factor Exposure: Case 1

$$\beta_{i,k} = \beta_{l,p} \times \beta_{p,k}$$

where:

$\beta_{l,p}$ = exposure of the private equity subtype to the corresponding broad public equity portfolio *p*, estimated by the private equity update

$\beta_{p,k}$ = exposure of the broad public equity portfolio *p* to public equity factor *k*

Case 2: the user has information on the industry breakdown.

The private equity investment is exposed to the corresponding Barra equity model public equity industry factor, with an exposure equal to the beta of the private equity type *l* to the corresponding broad public equity portfolio *p*, estimated by the private equity update.

The investment has no exposure to other public equity factors, and no multiple industry assignments.

Public Equity Factor Exposure: Case 2

$$\beta_{i,k} = \beta_{l,p} \times \beta_{p,k}$$

where:

$\beta_{l,p}$	=	exposure of the private equity subtype to the corresponding broad public equity portfolio *p*, estimated by the private equity update
$\beta_{p,k}$	=	exposure of the broad public equity portfolio *p* to public equity factor *k*

Case 3: the user has information beyond the industry and private equity type.

In this case, the user may build a proxy portfolio of comparable public equity companies.

The non-private equity exposures are computed as exposures of the corresponding proxy portfolio, and beta = 1.

The private equity investment will inherit the public equity common factors and factor exposures of the portfolio of comparable public equities:

Public Equity Factor Exposure: Case 3

$$\beta_{i,k} = \beta_{cp,k}$$

where:

$\beta_{cp,k}$	=	exposure of the portfolio of comparable public equities to public equity factor *k*

Exposures to Purely Private Equity Factors

The purely private equity factors are based on the private equity subtype aggregate indexes and public equity portfolios (see table above).

The main private equity subtypes in the US correspond to Investment Type in the import template. Below is the mapping between Private Equity Investment Types and Factors:

Investment Type	Factor Name
ASIA LARGE BUYOUTS	ASP1_AS_BUYOUT_LARGE
ASIA SMALL BUYOUTS	ASP1_AS_BUYOUT_SMALL
ASIA DISTRESSED	ASP1_AS_DISTRESS
ASIA EARLY STAGE/BALANCED VENTURES (COMBINED CATEGORY)	ASP1_AS_VENT_EARLY
ASIA LATE STAGE VENTURES	ASP1_AS_VENT_LATE
EUROPE LARGE BUYOUTS	EUP1_EU_BUYOUT_LARGE
EUROPE SMALL BUYOUTS	EUP1_EU_BUYOUT_SMALL
EUROPE DISTRESSED	EUP1_EU_DISTRESS
EUROPE MEZZANINE	EUP1_EU_MEZZ
EUROPE EARLY STAGE/BALANCED VENTURES (COMBINED CATEGORY)	EUP1_EU_VENT_EARLY
EUROPE LATE STAGE VENTURES	EUP1_EU_VENT_LATE
US LARGE BUYOUTS	USP2_US_BUYOUT_LARGE
US SMALL BUYOUTS	USP2_US_BUYOUT_SMALL
US DISTRESSED	USP2_US_DISTRESS
US MEZZANINE	USP2_US_MEZZ
US EARLY STAGE/BALANCED VENTURES (COMBINED CATEGORY)	USP2_US_VENT_EARLY
US LATE STAGE VENTURES	USP2_US_VENT_LATE

Every Private Equity instrument has exposure to one, and only one, Private Equity factor corresponding to its investment type, where exposure = 1.

Exposures to Currency Factors

All private equity assets have exposure = 1 to the specified currency factor and no other currency exposures regardless of the Investment Type and scalar values.

Specific Risk

Specific risk is computed in BarraOne (and handled by BarraOne, not by the private equity update) as a cap-weighted average of the specific risk of public equities in a given universe (*i.e.,* the proxy portfolio). The universe depends on the user's available information:

Case 1: If the user has no information other than the private equity type (i.e., if no Industry or Proxy Portfolio is specified), then specific risk is either the cap-weighted average of specific risks in the default portfolio (for non-fixed income PEQ), or the market-value weighted average of the specific risks (for fixed income PEQ).

Case 2: If the user specifies an industry (non-fixed income PEQ assets only), then the specific risk is computed as the cap-weighted average of the specific risks of the estimation universe of the instrument's local market.

Case 3: If the user can build a portfolio of comparable public equities, (i.e., if the user specifies a Proxy Portfolio), then specific risk is either the cap-weighted average of the specific risks in the portfolio (for non-fixed income PEQ), or the market-value weighted average of the specific risks (for fixed income PEQ). Non-equity assets in an equity PEQ Proxy Portfolio are given a market cap of 0.

Application Treatment

Stress Testing

PEQ assets are treated as mutual funds in Stress Testing. Equity shocks are computed by taking the beta to the ESTU portfolio and multiplying it by the shock amount. For shocks to interest rates or spreads, the return is the sum of the products of factor exposure and factor shock.

> **Note:** By definition, PEQ factors have 0 correlation with other factors, so they will be unaffected by correlated scenarios with shocks to equity or fixed income factors. PEQ instruments are affected only via their public factor exposures.

Historical VaR Simulation

Private Equity assets are modeled as having two components: a public factor component, and a private equity component. The risk of the public factor portion is modeled as the beta-adjusted risk of the Proxy Portfolio. The risk of the private equity portion is modeled by the PEQ factors. However, the PEQ factors do not have the return frequency necessary to support HVaR. Thus, their returns are proxied using the public factor portion (represented by the Proxy Portfolio).

For PEQ assets, HVaR is computed as it is for Mutual Funds.

The equity shocks are computed as follows:

1. Compute the beta of the asset to the estimation universe.
2. Take the returns of the ESTU portfolio and multiply them by the beta. These are the proxied returns of the PEQ asset.
3. Compute the HVaR as for any other equity.

The fixed income returns are computed by taking the product of the fixed income factor returns with the fixed income factor exposures.

The total return is the combination of the equity and fixed income returns.

Monte Carlo VaR Simulation

Monte Carlo VaR for PEQ assets simulates all of the factors to which a PEQ asset is exposed. They are simulated as mutual funds. The return of a PEQ asset is the sum product of the factor returns and factor exposures.

VaR Backtesting

Users must provide returns for Private Equity assets.

Performance Attribution

BarraOne does not support Private Equity assets in Performance Attribution.

Equity Rule-Based Proxy

Equity proxies generally fall into two usage categories: (1) Proxies for publicly traded securities that are not natively covered within the single country equity models, and (2) proxies for private equity holdings that are not traded.

Equity rule-based proxies rely on a set of equity asset descriptions. Using those descriptions, BarraOne assigns a set of exposures to the relevant equity risk model factors by comparing the user-provided asset descriptions with those of the assets natively covered by BarraOne. The specific asset characteristics that determine the proxy asset exposures are the following:

- market (country)
- currency
- industry
- market cap
- traded/not traded flag.

The assigned exposures can be thought of as the unit exposures to the industry and currency, and the cap-weighted, average style factor exposures of the estimation universe asset filtered for the specified industry within the specified market. Specific exposure rules for each factor type are outlined below.

Table 18: Equity Rule-Based Proxy Exposure Rules

Factor Type	Exposure Rule
Currency	100% exposure to currency specified by user.
Industry	100% exposure to industry specified by user.
Style	Cap-weighted average of the style exposures of all assets in the estimation universe of the appropriate model that share the same industry classification. This mimics the broadly used workflow of proxying equities to an industry subset of a broad market index. $X_{proxy} = \frac{\sum MCAP_{ni} X_{ni}}{\sum MCAP_{ni}}$ where: X_{proxy} = factor exposure of the proxy asset $MCAP_{ni}$ = market capitalization of asset n within industry i X_{ni} = factor exposure of asset n within industry i $\sum MCAP_{ni}$ = total market capitalization of assets within industry i
Size	Linearly interpolated Size exposure is based on the size exposures by market cap of the next largest and next smallest assets in the appropriate equity model. If the market cap is smaller than the smallest market cap of assets covered in the model, then the proxy is assigned the minimum Size exposure of all estimation universe assets in the risk model. If the market cap is larger than the largest market cap of assets covered in the model, the proxy is assigned the maximum Size exposure of all estimation universe assets in the risk model.
Trading Activity* Momentum* Volatility*	* The naming convention for similar factors may not be consistent across the single-country equity models. If the proxied asset is traded, the proxy is assigned the cap-weighted average exposure of all estimation universe assets in the risk model with the same industry classification (see Style above). If the proxied asset is not traded, then the proxy is assigned to the minimum exposure among all estimation universe assets in the risk model with the same industry classification. $X_{proxy} = \min\left(X_{ni}\right)$
Specific Risk	If the user does not specify either specific risk level or specific risk multiplier, then the default value for specific risk is the cap-weighted average of the specific risk of all assets in the relevant equity risk model with the same industry classification that are in the estimation universe. If a specific risk level is specified by the user, then this value is used directly. If a specific risk multiplier is specified, then the value is multiplied by the cap-weighted average of the specific risk of all assets in the relevant equity risk model with the same industry classification that are in the estimation universe. If both are specified, then specific risk level is used.

Equity proxies are treated exactly like regular equity assets during stress testing, Historical and Monte Carlo VaR simulations, VaR Backtesting, and Performance Attribution. In stress testing, equity price shocks are applied to equity proxy assets as the beta-adjusted shock based on the beta to the market portfolio specified in the scenario.

$$\Delta P = \Delta market \bullet \beta_{mkt}$$

Equity Claim

An equity claim is used to model equity subscription rights. A subscription right is an option that enables an equity holder to purchase additional new shares at a specified price (below the current price) for a specified interval (usually a few weeks).

Subscription rights may be granted by a corporation when new shares are issued, either to reduce leverage or to fund acquisitions or other investments. Exercising the rights enables the shareholder to avoid dilution of the percentage of their holdings in the corporation.

Valuation Methodology

BarraOne models equity claims as though they were deep-in-the-money equity options.

Equity Forward

An equity forward is analyzed in a manner similar to an equity future (see below), except an equity forward has a nonzero market value, and the user must supply a price.

Equity Future

An equity future is an exchange-traded equity forward.

Valuation Methodology

Necessary market data:

- Zero rate
- Underlying price

Model value: Fair value from the valuation model

Pricing methodology: Cost of Carry

Equity futures are valued by market-quoted prices based upon ticker.

The relationship between the forward price and the spot price of a security that does not pay a dividend is expressed as follows:

Security Paying No Dividend

$$F = Se^{r(T-t)}$$

where:

F	=	forward price
S	=	spot price
e	=	base of the natural logarithm
r	=	default-free continuously compounded interest rate
T	=	contract end date
t	=	contract start date

The relationship between the forward price and the spot price of a security paying a predictable dividend is expressed as follows:

Security Paying a Predictable Dividend

$$F = (S - I)e^{r(T-t)}$$

where:

F	=	forward price
S	=	spot price
I	=	present value of all income received during the life of the contract, discounted at the default-free rate
e	=	base of the natural logarithm
r	=	default-free continuously compounded interest rate
T	=	contract end date
t	=	contract start date

The relationship between the forward price and the spot price of a security paying a predictable dividend yield is expressed as follows:

Security with a Predictable Dividend Yield

$$F = Se^{(r-d)(T-t)}$$

where:

F	=	forward price
S	=	spot price
e	=	base of the natural logarithm
r	=	default-free continuously compounded interest rate
d	=	average dividend yield rate
T	=	contract end date
t	=	contract start date

The risk exposure of the equity future to the equity factor i is the corresponding exposure of the underlying asset. The exposures of the equity future to the equity factor i are calculated as shown in the formula "Equity Exposures."

Equity Exposures

$$E_i = x_i$$

where:

E_i	=	equity factor i exposure
x_i	=	exposure of the underlying equity to the equity factor i

Equity Index Future

An equity index future gives the party that is long the contract the opportunity to participate in the price changes of the underlying index without buying the constituent components in the index.

While an equity index future has a price, this value represents the level of the index and not the amount of money the investor must pay to enter into a long position in the contract. Therefore, equity index futures have no market value in the sense that stocks and bonds have a market value. The exception to this statement is the amount of margin that must be put up in order to enter into the futures contract, but this amount is typically small compared to the price changes incurred by the parties to the contract.

Valuation Methodology

Necessary market data:

- Zero rate
- Underlying price

The valuation methodology for an equity index future position in BarraOne is the same for all future assets. BarraOne treats a future instrument as a position opened on a particular future exchange. By default, its market value is zero.

The risk exposure of the equity index future to the equity factor *i* is the corresponding exposure of the underlying index. The exposures of the equity index future to the equity factor *i* are calculated as shown in the formula "Equity Index Exposures."

Equity Index Exposures

$$E_i = x_i$$

where:

E_i	=	equity factor *i* exposure
x_i	=	exposure of the underlying equity to the equity factor *i*

The duration of an instrument is its sensitivity (or exposure) to changes in interest rates. For equity index futures, this sensitivity is generally small and not computed by BarraOne.

Currency Exposures of Equity Index Futures

All equity index futures have long exposure to the currencies of the underlying index and short exposure to the price currency of the future. Currency exposures are generally zero for futures contracts on single currency equity indexes and nonzero for futures contracts on multi-currency equity indexes:

- A futures contract on the MSCI Japan index that is priced in Japan yen has 100% long exposure to yen from the underlying index and 100% short exposure to yen from the price currency. As a result, if the portfolio base currency is yen, the equity index futures contract has no currency risk.

- A futures contract traded on the MSCI World Index and priced in USD has long exposure to the weighted currencies of the underlying index constituents and short exposure to the USD price currency. In this case, the currency risk is partially hedged, because the short USD exposure hedges the long USD risk from the underlying index. There is residual short USD exposure and residual long currency exposure from the other currencies to which the index is exposed, such as euro and GBP, because not all the index is exposed to USD.

For the purpose of determining the exposures of futures contracts to risk factors, BarraOne models futures as forwards. These forwards are modeled by a long position in the deliverable (the receive leg) and a short position in price currency (the pay leg). Within this framework, the factor exposures of the futures contract are simply the difference in the exposures of the underlying legs. The excess return of the receive leg is:

$$R^{rec} = \sum_{currencies\ k} X_k^{rec} f_k + \sum_{local\ factors\ l} X_l^{rec} f_l + u^{rec} + q^{rec}$$

where:

X = factor exposures

f = factor returns

u = specific return of receive leg

q^{rec} = cross-product of local excess returns and currency price appreciation (typically small (~1bps) due to repatriation of local profits back to base currency)

f_k = the excess return from the base currency perspective of each currency held at the local risk-free rate

The excess return of the pay leg is given by the price currency:

$$R^{pay} = f_{price}$$

where:

f_{price} = the excess return of the price currency from the base currency perspective

The return of the equity index futures contract is modeled as the difference in receive and pay leg returns:

$$R^{fut} = \left(X_{price}^{rec} - 1\right) f_{price} + \sum_{k \neq price} X_k^{rec} f_k + \sum_{local\ factors} X_l^{rec} f_l + u^{rec} + q^{rec}$$

Equity Option

An equity option gives the holder the right to buy or sell an agreed amount of a specific equity at a specified price on or before a specified date.

Supported Option Types

BarraOne supports puts and calls on the following types of equity options:

- European
- American
- Bermudan
- Single Barrier (European)
- Double Barrier (European)
- Asian (European)

Valuation Methodology

The valuation methodology for equity options is dependent upon the style of the option and the dividend pattern of the underlying equity.

Necessary market data:

- Zero rate
- Spot price
- Volatility of equity index

Model value: Fair value from the valuation model

European

Pricing methodology: Closed form

Pricing models: “Black-Scholes Model” on page 419, “Black-Scholes Generalized (BSG) Model” on page 420, “Black-Scholes Continuous Dividend Model” on page 423, and “Black-Scholes Continuous Dividend Model” on page 423

For European-style equity options, the Black-Scholes framework is used to compute the value of the options. The specific model used is dependent upon the dividend pattern of the underlying equity:

- underlier pays no dividends
- underlier pays a continuous dividend yield
- underlier pays a discrete dividend

For stocks with a known dividend schedule, the stock price is discounted by the present value of the dividend payments occurring during the life of the option. The same technique is applied for equities with continuous dividend yields.

The "Black-Scholes Model" on page 419 is used in the simplest case when evaluating a European option on an equity paying no dividends. Variations on this formula (such as the Black-Scholes Generalized Model and the Black-Scholes Discrete Cash Flow Model) are used when the underlying stock pays dividends.

The "Black-Scholes Generalized (BSG) Model" on page 420 is used for options on an asset with continuous dividend payments (dividend yield). For options on an equity with discrete dividend payments (dollar dividend paying on each ex-dividend date), the "Black-Scholes Continuous Dividend Model" on page 423 is used.

American and Bermudan

Pricing methodology: "Trinomial Tree Model" on page 426

European Single Barrier

Pricing methodology: "Trinomial Tree Model" on page 426

Pricing model: "Single Barrier Model (European)" on page 432

European Double Barrier

Pricing methodology: "Trinomial Tree Model" on page 426

Pricing model: "Double Barrier Model (European)" on page 439

European Asian

Pricing methodology: Approximation

Pricing model: "Asian Model" on page 430

Exposure Analysis

Equity Risk Factor: The exposures of the contract to the equity factor *i* are calculated as shown in the formula "Equity Option Exposures."

Equity Option Exposures

$$E_i = \frac{S}{R}\delta x_i$$

where:

E_i	=	equity factor *i* exposure
S	=	price of the underlying equity or equity index
R	=	value of the option
δ	=	delta
x_i	=	exposure of the underlying equity to the equity factor *i*

The value of the option (*R* in the equation) is taken from one of the following, depending upon availability, in order of priority:

- User-supplied option price, if set to a priority higher than any available user-supplied implied volatility term structure attribute
- Calculated from the user-supplied implied volatility term structure attribute for the option (N/A for Asian and barrier options)
- Calculated from the user-supplied implied volatility schedule in the option terms and conditions
- Calculated from the user-supplied static implied volatility in the option terms and conditions
- Calculated using the implied volatility of the underlying asset, which is computed using BIM

Equity option risk is aggregated in portfolio risk calculations using the option delta (partial derivative of option value with respect to stock value) and Barra factor model exposures for the underlying equity.

Interest Rate Risk Factor: Exposures to interest rates are small and not calculated by BarraOne.

Foreign Exchange Factor: The option has a unit exposure to its price currency factor.

Equity Index Future Option

An equity index future option is an option on an underlying futures contract. Equity index future options are traded on several exchanges globally.

Supported Option Types

BarraOne supports puts and calls on the following types of equity forward options and equity index future options:

- European
- American
- Asian (European)

Valuation Methodology

Necessary market data:

- Zero rate
- Spot price
- Open price
- Volatility of futures or forward prices

Model value: Fair value from the valuation model

European

Pricing methodology: Closed form

Pricing model: "Black Model (1976)" on page 422

American

Pricing methodology: "Trinomial Tree Model" on page 426 (for an option on a futures contract)

European Asian

Pricing methodology: Approximation

Pricing model: "Asian Model" on page 430

Exposure Analysis

The numeraire exposure is equal to the contract size times price per unit.

Equity Risk Factor: The exposures of the contract to the equity factor *i* are calculated as shown in the formula "Equity Index Future Option Exposures."

Equity Index Future Option Exposures

$$E_i = \frac{S}{R}\delta x_i$$

where:

E_i	=	equity factor *i* exposure
S	=	spot price of the underlying equity index future
R	=	price of the option
δ	=	delta
x_i	=	exposure of the underlying equity index future to the equity factor *i*

The value of the option (*R* in the equation) is taken from one of the following, depending upon availability, in order of priority:

- User-supplied option price, if set to a priority higher than any available user-supplied implied volatility term structure attribute
- Calculated from the user-supplied implied volatility term structure attribute for the option (N/A for Asian options)
- Calculated from the user-supplied implied volatility schedule in the option terms and conditions
- Calculated from the user-supplied static implied volatility in the option terms and conditions
- Calculated using the implied volatility of the underlying asset, which is computed using BIM

Interest Rate Risk Factor: Exposures to interest rates are small and not calculated by BarraOne.

Foreign Exchange Factor: The option has a unit exposure to its price currency factor.

Contract for Difference

A CFD is an agreement between two parties to settle, at the close of the contract, the difference between the opening and closing prices of the contract, multiplied by the number of underlying shares specified in the contract.

CFDs are traded in a way similar to the way in which ordinary equity shares are traded. The price quoted by many CFD providers is the same as the underlying equity market price, and the buyer can trade in any quantity just as with an ordinary share. A commission will usually be charged on the trade. The total value of the transaction is simply the number of CFDs, bought or sold, multiplied by the market price.

Rather than pay the full value of a transaction, the buyer needs to pay only a percentage, called the "Initial Margin," when opening the position. The margin enables leverage, so that a larger amount of shares can be accessed than would be possible if buying or selling the shares themselves.

The margin on all open positions must be maintained at the required level over and above any marked-to-market profits or losses in order keep the position open. If a position moves against the owner and reduces the cash balance below the required margin level on a particular trade, the owner will be subject to a "Margin Call" and will either have to pay additional money into the account to keep the position open or be forced to close the position.

Risks of Contracts for Difference

- The geared nature if margin trading means that both profits and losses can be magnified, and unless a stop loss is place, very large losses could be incurred if the position moves against the owner.
- It is less suited to the longterm investor. If a CFD is held open over a long period, the costs associated increase, and it may have been more beneficial to have bought the underlying asset.
- The owner has no rights as an investor, including voting rights.

Characteristics of CFDs

- The CFD contract is marked-to-market at the closing stock or commodity price daily.
- The holder of a CFD account will be charged daily interest on the amount of the initial contract value. A holder of a long CFD pays interest on the value of the contract. Interest is charged at a percentage over LIBOR.
- Dividends and cash flows are automatically credited into the account.
- At expiration, the contract is valued as follows:
  (closing price – initial price) x contract size.

Valuation Methodology

Pricing methodology: Cost of Carry

Numeraire Exposure

Numeraire exposure is computed exactly like that computed for an equity.

Risk Exposures

Risk exposures are computed exactly like those computed for an equity future.

Equity Volatility Derivatives

Implied volatility factors are included in the U.S. and European equity models to model the risk of U.S. and European volatility futures curves. These factors are used to model volatility products such as the VIX and VSTOXX volatility indexes and volatility swaps. VIX measures 30-day expected volatility of the S&P 500 Index. The components of VIX are near- and next-term put and call options, usually in the first and second SPX contract months. Refer to The Barra Equity Volatility Future Model (EVX1) for detailed information.

Supported equity volatility derivatives include the following system and user asset types:

- Equity Volatility Future
- Variance Future
- Volatility Swap
- Variance Swap
- Forward Volatility Agreement
- Volatility Option

Data Deliverables

The following data is delivered by BarraOne:

Risk Model Data

- The covariance matrix that includes covariance values for all 5 factors
- Series of daily factor returns
- Daily and monthly specific risk estimates for a set of constant-maturity terms for both the U.S. and EU markets

Both daily and weekly factors returns are estimated from the corresponding regression of daily and weekly volatility indexes and future contracts price returns. Note that daily factor returns will not precisely sum up to corresponding weekly factor return.

For the U.S. market, 13 time points have been defined, from 0 to 12 months. (Each term is one month apart). For the EU market, 6 constant terms are defined, ranging from 0 to 5 months. The terms are also equally spaced with one month apart.

Market Data

- Daily history of VIX Index and VSTOXX index levels
- Daily history of VIX futures and VSTOXX futures prices

Terms and Conditions

- VIX index and VSTOXX index descriptive information (asset ID, currency)
- VIX futures and VSTOXX futures description information (asset ID, currency, delivery date, *etc.*)

Valuation

VIX and VSTOXX futures have no valuation on the analysis date. Prices are provided by BarraOne, and the market value is computed as Holdings × Contract Size × Price. For the other derivatives, the evaluation function computes a set of unadjusted exposures (not divided by underlying price) to the EVX model factors and the sensitivity to the underlying index price (delta for options).

Exposures

The equity variance factors are estimated based on the VIX index and VIX futures data in the U.S., and based on the VSTOXX Index and corresponding mini-futures data in Europe. Equity, bond, and hedge fund assets covered by existing risk models are not exposed to these factors.

For the U.S. market, we estimate three risk factors, called Shift, Twist and Butterfly. The shapes of equity variance factors are defined analytically. This means that they are specified through functions depending on a single model parameter and the contract settlement date.

For the EU market, it is sufficient to estimate only the Shift and Twist factors due to a relatively short price history of corresponding future contracts and the limited number of contracts traded on daily basis. The shapes of these Shift and Twist factors are defined analytically and they are the same as the shapes of corresponding US factors.

For the U.S. market, BarraOne estimates the following three factors:

USD_EVX_SHIFT, USD_EVX_TWIST and USD_EVX_BFLY

For the EU market, the following two factors are estimated:

EUR_EVX_SHIFT, EUR_EVX_TWIST

The risk factor exposures of a variance futures contract are calculated as follows:

$$F_1(T) = \frac{1}{k\Delta T}\left(e^{-kT} - e^{-k(T+\Delta T)}\right)$$
$$F_2(T) = \frac{1}{k\Delta T}\left(e^{-kT}(1+kT) - e^{-k(T+\Delta T)}(1+k(T+\Delta T))\right)$$
$$X_{USD\_EVX\_SHIFT} = 1$$
$$X_{USD\_EVX\_TWIST} = F_1(T) - F_1(1/k)$$
$$X_{USD\_EVX\_BFLY} = \frac{F_2(T)}{F_2\left(\frac{1}{k}\right)} - 1$$

where T is the time to expiration for a given futures contract calculated with an Actual/365 daycount convention, ΔT = Futures_Term/365 and k = 1.5.

To compute the beta between the spot index and a futures contract, the risk factor exposures to the spot index need to be defined. For both the U.S. and EU models, the risk factor exposures to the spot index are defined as follows:

$$X_{***\_EVX\_SHIFT} = 0$$
$$X_{***\_EVX\_TWIST} = 1$$

where *** can be replaced by USD or EUR. The exposures to USD_EVX_BFLY factor for T =0 is zero.

Note that with this choice of exposures, the TWIST factor describes the expected variance of the S&P 500 Index, and the SHIFT factor describes the risk of the eight-month $T = 1/k$ forward starting variance.

VIX Futures

The volatility forecast of VIX Futures contract should be calculated as the risk forecast of corresponding Variance Futures contract (ΔT =30/365) divided by a factor of 2. The variance future volatility forecast includes a specific risk component described below.

STOXX Variance Futures

The risk factor exposures of a variance futures contract on the STOXX index are defined as follows:

$$F_1(T) = \frac{1}{k\Delta T}\left(e^{-kT} - e^{-k(T+\Delta T)}\right)$$
$$X_{EUR\_EVX\_SHIFT} = 1$$
$$X_{EUR\_EVX\_TWIST} = F_1(T) - F_1(1/k)$$

VSTOXX Futures

The volatility forecast of a VSTOXX futures contract is calculated as the risk forecast of the corresponding variance futures contract (ΔT =30/365) divided by a factor of 2. The variance future volatility forecast includes a specific risk component described below.

Specific Risk

Note the following regarding specific risk:

- The estimation of the total risk of a variance future includes a specific risk adjustment. BarraOne receives daily and monthly specific risk forecasts for constant maturity terms. The calculation of the specific variance forecast of a futures contract is obtained by linear interpolation between constant maturity specific variances. The specific risk value of a futures contract with a time to expiration longer than the last constant maturity term is taken as the specific risk volatility of this longest constant maturity term. The risk forecast based on short-term covariance model uses daily specific risk data, while the risk forecast based on the BIM covariance matrix uses monthly specific risk data.
- The specific risk of a volatility swap or a variance swap is zero (0).
- The specific risk of a forward variance or forward volatility contract is calculated as the specific risk of corresponding variance or volatility futures contract.
- The specific risk of a volatility option is calculated as the delta-adjusted specific risk of the underlying futures contract.
- During aggregation, the specific risk is correlated based upon the rolling maturity future maturities.

  The specific return sources for variance futures curve are defined on a fixed set of maturity-dependent nodes. Two VIX futures / options that share one or both nodes will have correlated specific return, because they share a common source of specific return (the variance futures curve). This is analogous to the correlated specific return of two options on the same equity.

  The specific variance of any VIX derivative can be written as a linear combination of specific variances. For some VIX derivative that we label *i*, we have:

$$\sigma_{e,i}^2 = \sum_{n=0}^{N} w_{n,i}^2 \sigma_e^2 \left(t_{30} n\right)$$

  where *N* denotes the total number of months where specific return nodes are defined on the futures curve. The zero index corresponds to the specific return of the spot variance. The weights (*w*) depend on the instrument. For example, for a simple VIX futures contract, the weights are those implied by linear interpolation. Given the assumption that the specific return sources on the VIX futures curve are pairwise uncorrelated, the correlation between the specific return of two VIX derivatives *i* and *j* is:

  .

$$\rho_{e,ij} = \frac{\sum_{n=0}^{N} w_{n,i} w_{n,j} \sigma_e^2 \left(t_{30} n\right)}{\sigma_{e,i} \sigma_{e,j}}$$

Simulation

Stress Testing

The U.S. and EU market scenarios for equity implied volatility are applied to a spot index level. Then the change in the futures price is calculated as the beta-adjusted change of the spot index level. The beta of the futures contract to the spot index can be calculated as follows:

$$\beta_F = X_F F X_S^T \,/\, \sigma_S^2$$

where X_F is the futures contract exposure vector, X_S is the Index exposure vector and σ_S is the total risk of the underlying volatility index.

Historical VaR

The calculation of derivatives return in an historical VaR simulation scenario is ideally based on a perturbed futures price curve (which ideally starts from the perturbed value of the spot index level). To construct a sufficient history of historical futures returns, we use Rolling Maturity Futures (RMF) contracts.

The name "Rolling Maturity" comes from the following technique: If an investor buys a contract with a designated time to expiration, he or she might roll the funds into the next available contract once an existing contract's time to expiration shortened beyond a particular threshold near the designated time to expiration.

The thresholds used to derive RMF contracts for one to six months are shown in the table below. We start calculating RMF returns with actual futures prices. If the nearest futures contract has a time to expiration shorter than 15 days, then we derive the returns of all RMF contracts with linear interpolation between the return of the current and the next futures contract. The contract is dropped from the RMF return calculation when it has fewer than 6 days to expiration.

Table 19: RMF Strategy Contract Expiration Thresholds

Days / Contract	RMF1	RMF2	RMF3	RMF4	RMF5	RMF6
Lower threshold	6	34	62	97	125	153
Upper threshold	40	68	103	131	159	188

Then the return of a futures price is calculated by linear interpolation between the corresponding RMF returns. The futures contract return with time to expiration shorter than one month is taken as the RMF1 return. The spot index level return is calculated directly from the index price history. The return of the futures contract with time to expiration longer than the last available RMF return is taken as the return of the longest RMF contract.

Monte Carlo VaR

The return of volatility derivatives in a Monte Carlo VaR simulation scenario is calculated through a full revaluation with a perturbed futures price curve and interest rate curve, with the exception of futures contracts.

The futures contract return is calculated as follows:

$$r = X_h f_h + u_h$$

where X_h , f_h define the exposure and factor return vectors for the specified simulation horizon, u_h is the residual return derived from the scaled-to-horizon asset-specific risk. The change in the futures price curve is calculated from the return of the corresponding futures contract, with the X_h vector derived for the current analysis date.

VaR Backtesting

All equity volatility derivatives are revalued with the new market conditions on the analysis date.

Performance Attribution

BarraOne supports all of the volatility instrument types in all performance attribution models, and BarraOne computes the daily returns for the volatility instruments using their prices. Factor-based attribution in BarraOne supports analysis dates starting January 1, 2003.

Commodity Instruments

This section describes the techniques BarraOne uses to handle the following instruments:

- Commodities
- Commodity Future
- Commodity Index Future
- Commodity Future Option

Commodities

The BarraOne commodity model is based on daily returns from 34 commodities of the JP Morgan Commodity Curve Index (JPMCCI). The model is built directly from futures price data, using the concept of rolling maturity futures (RMFs). To capture the term structure of commodity rates, up to three risk factors (Shift, Twist, and Butterfly) per commodity are included in the model, depending upon the commodity. The commodity spot exposure is to the first RMF, plus currency exposure.

Complete information about the commodity model can be found in the The Barra Commodity Model (COM2).

Data Deliverables

The following commodity data is provided by BarraOne:

Market Data

- Futures prices corresponding to the futures contract traded on each given date. The number of futures contract depends on the commodity, and it can change over time.

Derived Data

- Rolling Maturity Futures: each RMF contract is characterized by a constant average maturity and a constant set of exposures to the *N* factors associated with the commodity. The "variable" data associated with RMFs on any given date is its return and its specific risk.
- Risk model data

Exposures

Commodities are priced in US dollars, and commodity spot instruments have USD currency exposure.

Futures price exposures to factors are computed by BarraOne, as described below, using the maturity of the futures price and the predefined exposures of RMFs. Similarly, the specific risk of a futures contract is computed from the maturity of the futures price and the specific risk of RMFs.

The time to maturity *T* of a futures contract changes on a daily basis. BarraOne linearly interpolates the exposure of each futures contract to the local factors. This is accomplished using the fixed set of RMF exposures to local factors and the set of RMF average maturities. In more detail, suppose that there are *N* RMFs with average maturities T_i and local factor exposures $X_1\left(T_i\right)$ to the first factor. We obtain the (daily) local factor exposure $Y_1(T)$ of a futures contract with maturity *T* to the first factor as:

$$Y_1(T)=\begin{cases} X_1\left(T_1\right),\ T<T_1, \\ \dfrac{T_{i+1}-T}{T_{i+1}-T_i}X_1\left(T_i\right)+\dfrac{T-T_i}{T_{i+1}-T_i}X_1\left(T_{i+1}\right),\ T_i\le T\le T_{i+1}, i=1,\dots,N-1 \\ X_1\left(T_N\right), T>T_N \end{cases}$$

Analogously, let $\sigma_u\left(T_i\right)$ denotes the RMF-specific risk forecasts. The specific risk forecast $\sigma_e(T)$ of a futures contract with maturity *T* is given by:

$$\sigma_e(T)=\begin{cases} \sigma_u\left(T_1\right),\ T<T_1, \\ \dfrac{T_{i+1}-T}{T_{i+1}-T_i}\sigma_u\left(T_i\right)+\dfrac{T-T_i}{T_{i+1}-T_i}\sigma_u\left(T_{i+1}\right),\ T_i\le T\le T_{i+1}, i=1,\dots,N-1 \\ \sigma_u\left(T_N\right), T>T_N. \end{cases}$$

Simulation

Stress Testing

Stress testing of commodity prices allows for both a parallel shift of the futures price curve and specification of the stress to a predefined (commodity-dependent) subset of RMFs. Futures price changes are derived from user-specified RMF returns defining the stress scenarios using liner interpolation based on the futures maturity and RMF average maturities.

Historical VaR

Historical simulation of commodity futures and options on commodity futures is obtained by using the return history of the RMFs associated with the commodity. If $P_k\left(0\right)$ is the futures price corresponding to contract *k* on the effective date *D*, and if we are interested in the historical scenario corresponding to the realized historical returns from a past date $(d-1)$ to date *d*, then we first identify the maturity *t* associated with contract *k* and date *D*. If *m* and *m* + 1 are the two RMFs spanning maturity *t*, with respective maturities of t_1 and t_2, and if $RMF_m\left(d\right)$, $RMF_{m+1}\left(d\right)$ are the returns of the corresponding RMFs on date *d*, then:

$$P_k\left(d-1->d\right)=P_k\left(0\right)\ \left(1+w_m RMF_m\left(d\right)+w_{m+1}RMF_{m+1}\left(d\right)\right)$$

where the weights $w_m + w_{m+1} = 1$ correspond to a linear interpolation of returns: $w_m = (t_2 - t) / (t_2 - t_1)$. Specific risk data is not used in this case.

Monte Carlo VaR

MCVaR simulation requires generating market scenarios from simulated factor returns. A new market scenario corresponds to a new set of prices for the futures price data corresponding to the effective date. If $P_k(0)$ is the futures price corresponding to contract *k* on the effective date, $P_k(T)$ is the simulated price at time *T*, $Y_{k,m}$ are the exposures of contract *k* to factor *m* (see above), F_m is the set of simulated factor returns, *N* the number of factors for the given commodity, and ε is an (uncorrected) normalized return, and σ_{sk} is the specific risk associated to the contract:

$$P_k(T) = P_k(0)(1 + \Sigma_{m=1,N} Y_{k,m} F_m + \varepsilon\sigma_{sk})$$

Note that both F_m and σ_{sk} are scaled to the holding period.

Performance Attribution

BarraOne supports all the commodity types in all performance attribution models, and it computes daily returns for all commodity assets. Factor-based attribution supports analysis dates starting January 1, 2003. BarraOne delivers the rolling maturity futures, the factor exposures, and returns, and computes the factor-exposures for the new commodity instrument types using these rolling maturity futures.

Commodity Future

The commodity future is one of the most common investment vehicles used to invest in commodities. Commodity futures are derivatives contracts that enable the investor to speculate on future spot commodity prices. These derivatives are traded on the New York and Chicago Mercantile Exchanges. Exposures are interpolated by time to maturity from the underlying RMF.

A commodity future does not have currency exposure.

Commodity Index Future

The commodity index future is also a popular investment vehicle used to participate in the commodities market. The analytics for the commodity index future are identical to those of the commodity future. The difference between the commodity future and the commodity index future is the underlier. The underlier for the commodity index future is the commodity index, from which exposures and specific risk are taken. Factor exposures are taken as the corresponding index exposures (i.e., the weighted commodity spot constituent exposures).

A commodity index future has currency exposure equal to the exposure of the underlying instrument. Thus, a commodity index future with a price currency of EUR would have +100% exposure to USD and –100% exposure to EUR.

Commodity Future Option

An commodity future option is an option on an underlying futures contract. Commodity future options are traded on several exchanges globally.

Supported Option Types

BarraOne supports puts and calls on the following types of commodity future options and commodity index future options:

- European
- American
- Asian (European)

Valuation Methodology

European

Pricing methodology: Closed form

Pricing model: "Black Model (1976)" on page 422

American

Pricing methodology: "Trinomial Tree Model" on page 426

European Asian

Pricing methodology: Approximation

Pricing model: "Asian Model" on page 430

Exposure Analysis

The numeraire exposure is equal to the contract size times price per unit. The price of the option is taken from one of the following, depending upon availability, in order of priority:

- User-supplied option price, if set to a priority higher than any available user-supplied implied volatility term structure attribute
- Calculated from the user-supplied implied volatility term structure attribute for the option (N/A for Asian options)
- Calculated from the user-supplied implied volatility schedule in the option terms and conditions
- Calculated from the user-supplied static implied volatility in the option terms and conditions
- Calculated using the implied volatility of the underlying asset, which is computed using BIM

Interest Rate Risk Factor: Exposures to interest rates are small and not calculated by BarraOne.

Foreign Exchange Factor: The option has a unit exposure to its price currency factor.

Funds

This section describes the techniques BarraOne uses to handle the following instruments:

- Hedge Funds
- Mutual Funds

Hedge Funds

Detailed information about hedge fund modeling can be found in The Barra Hedge Fund Risk Model (HFM2).

BarraOne models hedge funds without requiring access to the hedge fund underlying constituent holdings. (It is preferable to get the constituents/holdings or the Barra factor exposures for the fund provided by a third party; however, hedge funds are generally unwilling to provide their holdings.) Barra's approach is the equivalent of style analysis, where returns for hedge fund subindexes, such as long/short U.S. equity, are used to create a factor. Then the exposure of a given hedge fund to that factor is estimated by regression. The exposure of a specific hedge fund to the hedge fund factor is its Beta (this may be generalized to several factors). An alternative approach uses existing Barra factors such as Momentum and Value in a given model (e.g., USE3L), and the hedge fund's exposure is again estimated by regression.

Barra provides a Service Bureau to take customer provided hedge fund returns and categorization (*e.g.,* U.S. long-short, U.S. event-driven) and return a set of exposures to the BIM factors for that hedge fund. The format for the output is a vector of factors and exposures to those factors, it spans multiple models (*e.g.,* exposures to USE3L and UKE7), and it includes specific risk. Barra does not have permission to redistribute hedge fund (such as Tremont) indexes' returns history.

Hedge funds are exposed to existing equity and fixed income factors (USE3L_SIZE, UKE7_SIZE, USD_CDT_AGY, *etc*.), and they are exposed to factors specific to hedge funds. These hedge fund, equity, and fixed income factors can be used for analysis in the Risk Summary, Asset View, Risk Decomposition, and Exposure Analysis modules.

Customer access to the hedge fund model (HFM2) is determined by the user license. Additionally, the user must have a license for any equity model to which the hedge fund is exposed.

Note that all hedge funds are assumed to have a price of 1.0 in local currency, and that all positions are entered in terms of market value.

Mutual Funds

Detailed information about mutual fund modeling can be found in The Mutual Fund Model (MFM2).

Mutual fund analytics in BarraOne is very similar to the analytics of hedge funds. Namely, Barra does not have access to the details of a mutual fund's holdings (*i.e.,* the individual securities that comprise a fund). Rather, Barra has a set of factor exposures from which a "style analysis" is performed.

Mutual funds are exposed to various factors throughout the BarraOne models; that is, the exposures are not limited to one market (*e.g.,* an international equity mutual fund has exposures to factors in more than one market). The exposure of each mutual fund to its factors is estimated by regression of the fund returns against Barra factor returns.

Real Estate

Unit Exposure Real Estate

BarraOne supports real estate as a unit exposure asset. Sixteen unit exposure real estate assets (one per market across 16 markets) with a price of 1.0 are provided in BarraOne. Clients can model real estate by entering these unit exposure assets in their portfolio and setting the holding to equal the market or appraised value (since the price is 1 in local currency terms, *e.g.,* 1 dollar in the U.S.A. and 1 euro in the European Monetary Union).

Table 20: Real Estate Factors

Market	Factor Name
Australia: AUS	Property Trusts
Canada: CAN	Real Estate
China: CHN	Real Estate
Egypt: EGY	Real Estate
European Monetary Union: EUR	Continental Real Estate
Hong Kong: HKG	Properties
Indonesia: IDN	Property
Japan: JPN	Real Estate
Malaysia: MYS	Property
New Zealand: NZL	Property
Philippines: PHL	Real Estate (Excluding Reits)
South Africa: ZAF	Real Estate
Singapore: SGP	Properties
Thailand: THA	Property Development
United Kingdom: GBR	Real Estate
United States of America: USA	Equity REIT

Private Real Estate

PRE1

The factor models for direct real estate holdings cover core private real estate investments the United States and the United Kingdom. The models consist of property type-by-region factors: 17 United States (US) factors based on the National Council of Real Estate Investment Fiduciaries (NCREIF) indexes and US equity model REIT factors; 10 United Kingdom factors based on the Investment Property Databank (IPD) UK indexes and UK equity model REIT factors. Additionally, specific risk forecasts are delivered for each of the individual property type-by-region classifications.

Detailed information about Barra's private real estate model can be found in The Barra Private Real Estate Model (PRE1). The model enables plan sponsors to model their private real estate holdings in the same framework as their public market holdings for total plan risk. It provides a timely and responsive forecast of private real estate volatility at the portfolio level, and it captures the correlation between private real estate investments and other publicly-traded investments, in particular listed real estate (REIT and REIT equivalents).

To model direct real estate in BarraOne, users are expected to import user assets that have unit exposure to the individual property type-by-region factors.

Exposures

BarraOne assigns unit factor exposures to each of the factors that are associated with the property type and region. Specific risk is also based on the property type and region. The user may choose to define the specific risk or to scale it appropriately.

PRE2

Overview

The PRE2 model represents a major step forward in understanding the risk of private real estate, and it significantly expands the breadth and detail of private real estate coverage:

- Introduces 31 component models
- Adds detail to the existing models
- Expands coverage to farmland and timberland
- Captures new dimensions of real estate risk, such as income return, and quality in the U.K.
- Expands to a total of over 400 factors
- Introduces enhanced Bayesian risk methodology

Detailed information about this private real estate model can be found in Private Real Estate Model (PRE2) Overview.

Market Coverage

PRE2 extends private real estate model coverage from 2 markets (U.S. and U.K. to 31 markets:

- Australia
- Austria
- Belgium
- Canada
- China
- Czech Republic
- Denmark
- France
- Germany
- Hong Kong
- Hungary
- Indonesia
- Ireland
- Italy
- Japan
- Korea
- Malaysia
- Netherlands
- New Zealand
- Norway
- Poland
- Portugal
- Singapore
- South Africa
- Spain
- Sweden
- Switzerland
- Taiwan
- Thailand
- UK
- USA

Details

In addition to the expansion into 31 markets, PRE2 offers the following enhancements:

- Global property-type segmentation at the highest level (consisting of Offices, Retail, Residential, Industrial, Hotels, and Other), with a more granular property subtype below: The six property types are modeled in each country, with regional subdivisions as appropriate within each country.
- Second layer of factors with higher granularity in the U.S. and U.K. markets: In both the U.S. and U.K., the second layer enables drilldown to property subtypes. In the U.S., the second layer also enables drilldown to metro areas.
- Bayesian methodology: Data on alternative assets is scarce, lagged, and smoothed. Without careful treatment, such data can result in distorted risk estimates. The Bayesian methodology expands upon MSCI's desmoothing methodology by systematically incorporating all available information, both public and private, as well as economically motivated expectations.
- Factors to model income return in each market, separated from the capital growth component of risk and return.
- A Quality factor in the U.K., which captures the difference between low- and high-yield properties.

Notes:

- In the U.K. and the U.S., PRE2 also covers timberland and farmland.
- Daily Factor returns are not supported.

Simulation

Stress Testing

Only stress test scenarios with correlated mode will affect PRE2 assets. In uncorrelated mode, stress testing has no effect on private real estate. In correlated mode, it is treated like an equity, *i.e.,* BarraOne computes the shocked factor returns and then computes the return on the real estate asset.

Monte Carlo VaR

Private real estate is treated like an equity factor asset. Because there are no daily factor returns, the asset is treated like a hedge fund asset when using a short-term covariance matrix.

Historical VaR

Users-imported returns are needed for HVaR.

VaR Backtesting

The user must provide returns for the asset for evaluation in VaR Backtesting.

Performance Attribution

Private real estate is treated like an equity asset for attribution purposes, and users must provide returns.

Certificates and Trackers

Securitized derivatives encompass a range of different structured products, from trackers to principal-protected investments. They can be linked to a diverse range of assets, from single equities or commodities to investable sector or theme indexes. They are all delivered in securitized form and can typically be traded via a stock exchange. The market in securitized derivatives continues to show rapid growth, with over 120,000 products currently in issue globally and annualized exchange turnover approaching one trillion USD.

The underlying asset or assets to which these products provide exposure is equally diverse. There are currently products in issue linked to over 500 different assets across equities, commodities, currency rates, funds, fixed income instruments, interest rates, volatility indexes, economic indexes, and baskets thereof.

New products are typically issued off the back of: (1) new underlying/payoff innovations, (2) broader market demand/exchange volumes, (3) market conditions of a given underlying asset, (4) specific client demand, or (5) in response to expirations of existing issues. The issuer sets the precise terms (underlying asset, maturity, denomination, *etc.*) of each product (although some do have dynamic/contingent features). The same issuer typically provides secondary marketmaking. In essence, pricing is model based, as opposed to being driven by supply and demand. Products are typically cash settled, and exercise is usually automatic upon final maturity. All products are available in the secondary market (either via a third party exchange member, or direct to a client of the firm), but some are offered in the primary market for specific clients or on a subscription basis. The issue price may include an amount shared with a third party.

Market convention for what constitutes a “warrant” versus a “certificate” is somewhat arbitrary and varies by jurisdiction. Sometimes, “warrant” refers to option lookalikes only, while in other markets it refers to any leveraged product. “Certificate” typically refers to fully funded products. Irrespective, all products are securities issued by a third party institution.

Supported underliers:

- Equity indexes
- Single equities
- Commodity indexes
- Single commodities

Supported Certificate Types

Standard Certificate

A tracker certificate is a participation product that replicates the performance of an underlying asset directly, with no leverage. In technical terms, it is a zero-strike call, but in reality, it is very much like holding the underlying asset directly. Common trackers include: Bull tracker; DYNaMix; SaraZert tracker; Voncert; Liker; Momentum; Parti; Proper.

Trackers give investors a cost efficient means to trade an asset (such as a currency or commodity) or to diversify their exposure across an index. As with all securitized derivatives, trackers are stamp duty free. These instruments are typically long-dated or indeed undated with an indefinite lifespan.

Key features:

- each certificate gives unleveraged long exposure to the underlying instrument
- structured as a zero-strike call
- reflects the price movements of the underlying 1:1 (adjusted by conversion ratio and any related fees)
- risk is similar to direct investment
- charges generally in form of management fees or retention of profits attributable to underlying during term to maturity
- quanto feature is supported: if the certificate and one or more of its underliers are denominated in different currencies, then BarraOne adjusts the volatility of the underlier to incorporate the certificate's exchange rate risk (currency risk)

Payoff profile:

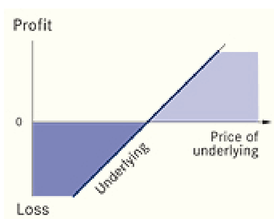


Figure 14: Tracker Certificate Payoff Profile

- replicates a position on the underlying, so its payoff at maturity (assuming conversion) is $1 + (S/S_0 - 1) = S/S_0$, where S = price level of underlying at expiry, S_0 = price level of underlying at inception date (contractually specified and may be in the past or future)

Reverse Certificate

As the name suggests, a reverse tracker certificate is a participation product that tracks the price of the underlying instrument in reverse, *i.e.,* a 1% fall in the FTSE 100 will bring about a 1% rise in the value of the reverse certificate, and vice versa. Common reverse trackers include: Bear tracker; bear Voncert.

The reverse tracker is close to reproducing a short position in the underlying. In technical terms, it is structured as a put option, but so deep in the money that the relationship with the underlying price is linear (unless the underlying price changes significantly during the life of the contract). Reverse trackers require specification of a strike price for pricing purposes.

Key features:

- each certificate gives unleveraged short exposure to the underlying instrument
- structured as a deep-in-the-money put option
- reflects the price movements of the underlying 1:1 (adjusted by conversion ratio and any related fees)
- risk is similar to direct investment
- charges generally in form of management fees or retention of profits attributable to underlying during term to maturity
- quanto feature is supported: if the certificate and one or more of its underliers are denominated in different currencies, then BarraOne adjusts the volatility of the underlier to incorporate the certificate's exchange rate risk (currency risk)

Payoff profile:

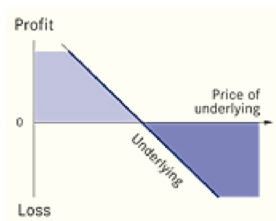


Figure 15: Reverse Tracker Certificate Payoff Profile

- K = strike price (typically equal to $2 \times S_0$ unless specified otherwise)
- S = price level of underlying at expiry
- S_0 = price level of underlying at inception date (contractually specified and may be in the past or future)
- Return-based payoff at maturity (assuming conversion):
  $1 + (1 - S / S_0) = 2 - S / S_0$
- Payout at expiration (price based):
  $(K - S)^+$

Outperformance Certificate

Outperformance certificates are participation products that include more than 100% participation in the upside, possibly capped to reduce the cost (capped outperformance certificates are yield enlacement products). They offer the chance to "outperform:" if a share performs well, an outperformance certificate linked to that share will perform better. Benefiting from better performance potential does not mean greater losses if prices fall. Investors have the same exposure to falling prices as investors in the underlying shares. Common outperformance certificates include: Accelerated tracker; booster certificate; OPER: Power; Sprinter. Capped outperformance certificates include: Impact certificate; TOP Units; VonTT.

Key features:

- participation level
- outperformance level
- quanto feature is supported: if the certificate and one or more of its underliers are denominated in different currencies, then BarraOne adjusts the volatility of the underlier to incorporate the certificate's exchange rate risk (currency risk)
- disproportionate participation in the positive trend if the underlying remains above the strike price at expiry
- direct participation in the price movement of the underlying at levels below strike price
- waiver of current income in favor of strategy—no dividend income

Payoff profile:

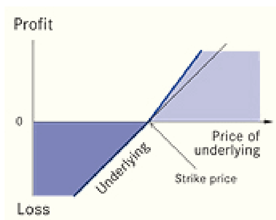


Figure 16: Outperformance Certificate Payoff Profile

- S_0 = inception price level of the underlying
- K = price level beyond which acceleration of profits takes place (strike), typically equal to S_0
- p = participation (% as a decimal), where 1 means no acceleration
- c = cap (% as decimal). Specifies the maximum payoff of the certificate. If P is the final payout, then $P \leq c$. $c > 0$. Defaults to no cap. Maximum underlying price level is given by $M = (c + K(p - 1)) / p$.
- S = price level of the underlying at expiry
- Payout at expiration (if return type is "no return," only the value in brackets applies):
  $1/ S_0 \times [S + (p - 1)(S - K)^+ - Indicator(c) \times p (S - M)^+]$
  where *Indicator(c)* is zero if there is no cap and one otherwise. Equivalent to a forward plus one or two regular call options.

Discount Certificate

Discount certificates provide the underlying at a discount by giving up upside via a cap. Some of the discount can be turned into more protection on the downside. Common discount certificates include: ToY Units (Title or Yield); CoY Units (Currency or Yield); Diskont Zertifikat; Voncore; Diamant; Boom; Toro; Clou; Coso; Casual.

Key features:

- discount level
- cap
- quanto feature is supported: if the certificate and one or more of its underliers are denominated in different currencies, then BarraOne adjusts the volatility of the underlier to incorporate the certificate's exchange rate risk (currency risk)

Payoff profile:

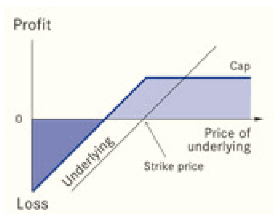


Figure 17: Discount Certificate Payoff Profile

- S_0 = inception price level of the underlying
- B = barrier price level for enhanced cap protection when final price is between B and S_0, ($B < S_0$)
- c = cap (% as decimal). Specifies the maximum return of the certificate. If P is the final payout, then $P \leq c$. $c > 0$. The maximum price level giving the maximum gain is $M = c$.
- S = price level of underlying at expiry
- Payout at expiration (if return type is "no return," only the value in brackets applies):
  $1/ S_0 \times [S - (S - M)^+ + KO_B (M - S)^+]$
  where KO_B denotes a knock-out put with barrier level at B

Bonus Certificate

Similar to an outperformance certificate, a bonus certificate is a participation product that provides an extra bonus payment if underlying stays in a certain price range. The investor receives the greater of the bonus level or the final underlying performance, unless the barrier level has been breached at any point during the term of the product, in which case the investor receives one exposure to the underlying.

The market expectation with this instrument is that the underlying security trades sideways to higher, and the underlying will not hit the barrier. Common bonus certificates include: Bonus; cushion; defender Voncert; Prealp; Plus; Condinote.

The Bonus Certificate is a combination product incorporating:

- zero-strike call
- barrier option known as a down-and-out put

Key features:

- reduction of downside risk
- higher performance (due to the "Bonus" level) in a range-bound market where the index is moving sideways
- unlimited upside participation, just as with a standard direct investment
- fixed bonus payment for sideways movement up to strike price
- bonus payment guaranteed until knock-out is hit
- once knock-out is hit, bonus certificate becomes a tracker certificate
- lower risk than a direct investment, because of partial protection until knock-out occurs
- quanto feature is supported: if the certificate and one or more of its underliers are denominated in different currencies, then BarraOne adjusts the volatility of the underlier to incorporate the certificate's exchange rate risk (currency risk)
- conditional capital protection (until knock-out is hit);
- bonus level support
- support for caps

Example:

A zero-strike call has no leverage and will expire to the closing level of the FTSE 100 index on the expiry date. Up until that point, it will track the index level at a discount to reflect the anticipated dividends that are due over the remaining duration of the product. The down-and-out put is a form of barrier option that ceases to exist when a defined level is reached—in this case, 75% of the initial level. Hence, if the FTSE 100 falls below 75% at any point during the five-year life of the product, the put will "knock-out," leaving the product as a simple zero-strike certificate that tracks the index level. However, if the FTSE 100 does not fall below the barrier level during the duration of the product, then the put option will remain and will have an intrinsic value at expiry equal to 140% minus the final index level. For instance, if the final index level is 76%, then the put will have 140% – 76% = 64% value; in turn, the zero-strike call will have a value of 76%, so the two combined will have an aggregate value of 140%, and the "Bonus" level is paid out.

Payoff profile:

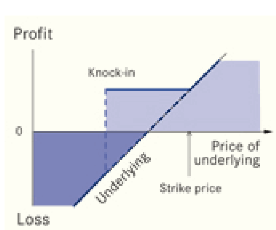


Figure 18: Bonus Certificate Payoff Profile

- S_0 = inception price level of the underlying

- K = price level below which bonus payout occurs (bonus level).
- p_u = participation (% as a decimal) for price levels above K (defaults to 1)
- B = barrier price level that must not be breached for downside protection to occur
- c = cap (% as decimal). Specifies the maximum payoff of the certificate. If P is the final payout, then $P \leq c$. $c > 0$. Defaults to no cap. The maximum price level corresponding to the cap value is given by $M = (c + K(p - 1)) / p$.
- S = price level of underlying at expiry
- Payout at expiration (if return type is "no return," only the value in brackets applies):
  $1/S_0 \times [S + KO_B (K - S)^+ + (p_u - 1)(S - K)^+ - Indicator(c) \times p_u (S - M)^+]$
  where $Indicator(c)$ is zero if there is no cap and one otherwise; and KO_B denotes a knock-out put with KO level at B

Reverse Bonus Certificate

Similar to an bonus certificate, a reverse bonus certificate is a participation product that provides an extra bonus payment if underlying stays in a certain price range. The investor receives the greater of the bonus level or the negative of the final underlying performance (potentially subject to a cap), unless the barrier level has been breached at any point during the term of the product, in which case the investor receives one exposure to the underlying. The bonus is paid if the underlying does not exceed the barrier; otherwise, it behaves like a reverse certificate.

The market expectation with this instrument is that the underlying security trades sideways or lower, and the underlying will not hit the barrier.

The Bonus Certificate is a combination product incorporating:

- reverse certificate
- barrier option known as an up-and-out call

Key features:

- reduction of downside risk of a short position
- higher performance than a short position (due to the "Bonus" level) in a range-bound market where the index is moving sideways
- unlimited upside participation, just as with a standard short position
- fixed bonus payment for sideways movement
- bonus payment guaranteed until knock-out is hit
- once knock-out is hit, bonus certificate becomes a reverse tracker certificate
- lower risk than a short position, because of partial protection until knock-out occurs
- quanto feature is supported: if the certificate and one or more of its underliers are denominated in different currencies, then BarraOne adjusts the volatility of the underlier to incorporate the certificate's exchange rate risk (currency risk)
- conditional capital protection (until knock-out is hit);

- bonus level support
- support for caps

Example:

A reverse certificate has no leverage and will expire at the closing level of the FTSE 100 index on the expiry date. Up until that point, it will track the index level at a discount to reflect the anticipated dividends that are due over the remaining duration of the product. The up-and-out call is a form of barrier option that ceases to exist when a defined level is reached — in this case, 125% of the initial level. Hence, if the FTSE 100 goes above 125% at any point during the five-year life of the product, the call will "knock-out," leaving the product as a simple reverse certificate that tracks the index level. However, if the FTSE 100 does not rise above the barrier level during the duration of the product, then the call option will remain and will have an intrinsic value at expiry equal to the final index level minus 80%. For instance, if the final index level is 96%, then the call will have 96% – 80% = 16% value; in turn, the reverse certificate will have a value of 104%, so the two combined will have an aggregate value of 120%, and the "Bonus" level is paid out.

Twin-Win Certificate

Similar to an outperformance certificate, a twin-win certificate is a participation product that provides an extra bonus payment if underlying stays in a certain price range. The investor receives at maturity one of the following: (1) geared exposure to a rise in the underlying asset if the final level is above the initial level; (2) positive (typically one delta) exposure to a fall in the underlying asset level if the barrier level has not been breached at any point during the term of the structure and the final is less than the initial level; or (3) one delta exposure to the underlying. Common Twin-win certificates include: Twin-Win Voncert; Prealp Stradius.

Key features:

- profit potential regardless of whether underlying trades higher or lower
- disproportionate participation where price increase in underlying
- price decline in the underlying generates profits down to the knock-in level
- turns into a outperformance certificate if knock-in is hit
- waiver of current income in favor of strategy

Payoff profile:

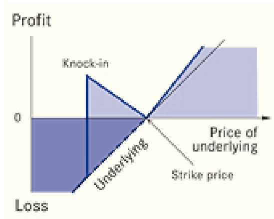


Figure 19: Twin-Win Certificate Payoff Profile

- S_0 = inception price level of the underlying
- K = price level below which bonus payout occurs (bonus level).
- p_u = participation (% as a decimal) for price levels above K (defaults to 1)
- B = barrier price level that must not be breached for downside protection to occur
- p_d = extra participation in bonus payment (% as a decimal) for price levels below K, if barrier is not breached. Defaults to $p_d = 0$, giving a flat bonus.
- c = cap (% as decimal). Specifies the maximum payoff of the certificate. If P is the final payout, then $P \leq c$. $c > 0$. Defaults to no cap. The maximum price level corresponding to the cap value is given by $M = (c + K(p - 1)) / p$.
- S = price level at expiry
- Payout at expiration (if return type is "no return," only the value in brackets applies):
  $1/S_0 \times [S + (1 + p_d)\, KO_B\, (K - S)^+ + (p_u - 1)\,(S - K)^+ - \mathit{Indicator(c)} \times p_u\,(S - M)^+]$
  where *Indicator(c)* is zero if there is no cap and one otherwise; and KO_B denotes a knock-out put with *KO* level at *B*

Airbag Certificate

These are participation products similar to the bonus certificates described above. They provide downside protection, but in a continuous manner. The investor receives at maturity either: (1) unit exposure to the underlying asset, if final level is above initial level; (2) initial nominal, if the final level is between the initial and protection level; otherwise (3) final level/protection level multiplied by nominal. A common airbag certificate is Bumper.

Key features:

- unlimited participation in price increase of the underlying
- partial protection between the protective threshold and strike price in case of decline
- if protective threshold is penetrated, smaller loss incurred than direct investment
- waiver of current income in favor of strategy
- above average return if the underlying trades sideways or slightly lower
- support for protection level, cap

- quanto feature is supported: if the certificate and one or more of its underliers are denominated in different currencies, then BarraOne adjusts the volatility of the underlier to incorporate the certificate's exchange rate risk (currency risk)

Payoff profile:

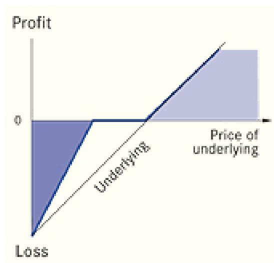


Figure 20: Airbag Certificate Payoff Profile

- S_0 = inception price level of the underlying
- K = price level below which partial protection occurs (usually equal to the initial price S_0)
- B = protection level, with $0 < B < K$
- (optionally) p_u = participation (% as a decimal) for price levels above K (defaults to 1)
- c = cap (% as decimal). Specifies the maximum return of the certificate. If P is the final payout, then $P \leq c$. $c > 0$. Defaults to no cap. Maximum underlying price level corresponding to the cap value is given by $M = (c + K(p - 1)) / p$.
- S = price level of underlying at expiry
- Payout at expiration (if return type is "no return," only the value in brackets applies): $1/ S_0 \times [K + p_u \times (S - K)^{+} - K / B\,(B - S)^{+} - Indicator(c) \times p_u\,(S - M)^{+}]$ where *Indicator(c)* is zero if there is no cap and one otherwise. Equivalent to cash plus two or three vanilla options.

Capital Protected Certificate

These certificates provide less than 100% participation in the upside (possibly capped) in order to provide capital protection on the downside.

Common capital-protected certificates without caps include: Guaranteed certificate w/o cap; principal protected certificate w/o cap; guaranteed equity bond w/o cap; Capital Protected Note; Pro Unit; Kapitalschultz Zertifikat; Exchangeable Unit; Vontobel Units; Juraction; Juroblig; CPC; Protein. Capital-protected certificates with cap include: Guaranteed certificate with cap; principal protected certificate with cap; guaranteed equity bond with cap; Pro Unit with cap; Vontifloor; Protec; Cappuccino.

Key features:

- capital-protection level

- participation level
- quanto feature is supported: if the certificate and one or more of its underliers are denominated in different currencies, then BarraOne adjusts the volatility of the underlier to incorporate the certificate's exchange rate risk (currency risk)
- possible cap

Payoff profile:

Figure 21: Capital-Protected Certificate Payoff Profile

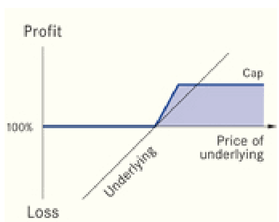


Figure 22: Capped Capital-Protected Certificate Payoff Profile

- S_0 = inception price level of the underlying, used to define cap and capital protection levels (see below)
- p = participation (% as a decimal)
- d = capital protection level (% as decimal). Specifies the maximum loss of the certificate as a percentage of S_0. If P is the final payout, then $P \geq d$, $d > 0$. The minimum price level giving the maximum loss is $m = S_0 (p + d - 1) / p$, when $p + d > 1$, else $m = 0$.
- c = cap (% as decimal). Specifies the maximum return of the certificate. If P is the final payout, then $P \leq c$. $c > 0$. Defaults to no cap. The maximum price level giving the maximum gain is $M = (c - d + S_0 \times p) / p$
- S = price level of underlying at expiry
- Payout at expiration (if return type is "no return," only the value in brackets applies): $d + 1 / S_0 \times [\, p\,(S - S_0)^+ - Indicator(c) \times p\,(S - M)^+]$ where *Indicator(c)* is zero if there is no cap and one otherwise. Equivalent to a zero-coupon bond and a leveraged long call and a short call.

Reverse Convertible (RC) and Barrier Range Reverse Convertible (BRRC) Certificate

Reverse convertible and barrier range reverse convertible certificates are yield enhancement products. Common reverse convertibles include: ICE (Income Cash or Equity); Vonti; Leman; Revexus; Runner. Common reverse convertibles with a barrier include: Knock-in ICE; defender Vonti; Leman Defensif; Soft Runner. Barrier range reverse convertibles include: Range defender Vonti.

Key features:

- cap
- quanto feature is supported: if the certificate and one or more of its underliers are denominated in different currencies, then BarraOne adjusts the volatility of the underlier to incorporate the certificate's exchange rate risk (currency risk)
- knock-in for reverse convertible with lower barrier (turns into normal reverse convertible if knock-in is hit)
- multiple barriers for barrier range reverse convertible
- "worst of" feature when the underlying is a basket is not supported

Payoff profile:

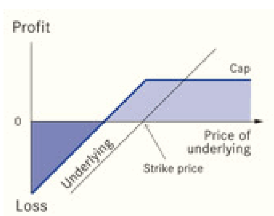


Figure 23: Reverse Convertible Certificate Payoff Profile

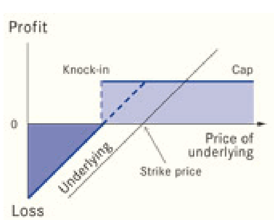


Figure 24: Barrier Reverse Convertible Certificate Payoff Profile

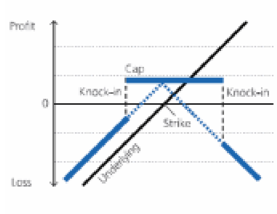


Figure 25: Barrier Range Reverse Convertible Certificate Payoff Profile

- K = strike price (usually equal to inception reference price)
- LB = lower barrier price level for knock-in (*e.g.,* 80%)
- UB = upper barrier price level for knock-in (*e.g.,* 130%). Used by barrier range reverse convertible only.
- C = coupon amount (%)
- S = price level at expiry
- For reverse convertible, the payout at expiration is:
  $Bond\,(C) - 1 / K \times KI_{LB}\,(K - S)^{+}$,where KI_{LB} denotes a knock-in put with barrier level at LB
- For a barrier range reverse convertible, the payout at expiration is:
  $Bond\,(C) + 1 / K \times \{KI_{LB,UB}\,(2K - S)^{+} - 2 \times KI_{LB,UB}\,(K - S)^{+} - K \times KID_{LB,UB}\}$
  where $KI_{LB,UB}$ means a knock-in option with either the LB or UB breached, and KID is a knock-in digital.

Valuation Methodology

The pricing of certificates is obtained by treating the reference underlying price as the single driver of risk for the certificate, by making the assumption that the price is lognormally distributed, and by decomposing the certificate in terms of bonds, forwards and embedded vanilla or barrier options. The details of the decomposition for each certificate type are specified below. The certificate is then valued by adding up the values of the embedded instruments. The Black-Scholes pricing formula is used to value vanilla options; a lognormal tree is used to value barrier options.

Necessary Market Data

To clarify the market data requirements, given the variety of certificate types supported, we consider three distinct cases: 1) the reference price is a specific equity, index, or basket with a single natural currency coinciding with the domestic currency of the certificate, 2) the reference price is a specific equity, index, or basket with a single natural currency different from the domestic currency of the certificate, and the certificate is a quanto, 3) the reference price is related to a combination of indexes with distinct natural currencies, and the certificate is a quanto.

In all cases, besides the market data specified below, we also require the value of the underlying at the inception of the certificate. This input might be considered as either market data or contract data.

Single equity, index, or basket, single currency

The required market data is given by:

- Risk-free, zero-coupon, interest rate curve
- Spot price and dividend yield of the underlying
- Volatility of the underlying. If not supplied directly by the user, it can be estimated using the Barra factor model, and the exposure profile and specific risk of the underlying.

Single equity, index, or basket, two currencies, quanto certificate

- Risk-free, zero-coupon, interest rate curve corresponding to the certificate currency
- Risk-free, zero-coupon, interest rate curve corresponding to the underlying currency
- Spot price, in its natural currency, and dividend yield of the underlying
- Volatility of the underlying. If not supplied directly by the user, it can be estimated using the Barra factor model, and the exposure profile and specific risk of the underlying.
- Volatility of the exchange rate between underlying and certificate currency. It can be estimated using the Barra factor model in underlying currency.
- Correlation between the exchange rate (the value of one unit of underlying currency in certificate currency units) and the underlying price. It can be estimated using the Barra factor model.

Multiple indexes, single currency

- Risk-free, zero-coupon, interest rate curve
- Spot price and dividend yield of the underlying
- Volatility of the underlying. If not supplied directly by the user, it can be estimated using the Barra factor model, and the exposure profile and specific risk of the underlying.

Multiple indexes, multiple currencies, quanto certificate

- Risk-free, zero-coupon, interest rate curve corresponding to the certificate currency
- Risk-free, zero-coupon, interest rate curves corresponding to each underlying currency distinct from the certificate currency.
- Spot price and dividend yield for each index, spot price in its natural currency units
- Volatility of each index. If not supplied directly by the user, it can be estimated using the Barra factor model, and the exposure profile and specific risk of each underlying.
- Correlations between each pair of indexes. They can be estimated using the Barra factor model.
- Volatility of the exchange rate between each underlying index and certificate currency. It can be estimated using the Barra factor model.
- Correlations (for N indexes with currencies distinct from the certificate currency, we need N correlation parameters) between the exchange rates and the corresponding underlying prices. They can be derived using the Barra factor model.

Risk Exposure Methodology

Because a certificate is effectively a portfolio of options, its risk exposures are calculated in the same way as those of an equity option, for example. The relevant risk factors are the underlying equity (or index) factors as well as term structure and spread factors of the interest rate curves described above. Exchange rate exposures are not relevant, because quanto certificates are supported.

To facilitate the calculation of exposures to the underlying risk factors, BarraOne returns deltas with respect to the spot price of each equity or index comprising the underlying of the certificate. The exposures of the certificate to the underlying equity factors are then be calculated by delta-scaling the exposures of the corresponding underlying. The specific risk of the certificate is determined similarly by scaling the underlying equity or index specific risk by the certificate delta to the underlying. Finally, sensitivities to the relevant term structure and spread factors are calculated directly by applying the corresponding adjustment to the interest rate curves and revaluing.

The risk is computed using the following formula:

Factor × *delta* × *weight* × *Price of underlier / Price of tracker*

Only one set of KRDs is computed. This is in the tracker currency.

Monte Carlo VaR

For Monte Carlo VaR calculation, the market scenarios of the data described above is simulated. Market changes in equity prices and interest rate curves data will have the largest effect (in addition to equity volatilities, once the corresponding implied volatility factors are added).

Regarding the treatment of cashflows with the passage of time: most of the certificates are European-type instruments with a single payoff at maturity. There are a couple of exceptions (*e.g.,* Reverse Convertibles), where a certificate has a bond-like feature. The handling of cashflows for these certificates is then very similar to that of the simple bond. In addition, many certificates have imbedded barrier options; this is handled in exactly the same way as for barrier options.

StructureTool Assets

StructureTool is a simulation-based tool designed to enable users to compute the values and hedge statistics of user-defined exotic and structured products. StructureTool enables users to specify arbitrary payoffs to value everything from plain vanilla options and bonds to complex structured products such as equity-linked notes, interest-rate "snowballs," exotic basket options, complex trigger options, Asian barrier options, and target return notes. It covers many asset classes, including equities, commodities, foreign exchange, and interest rates. Path-dependent and early exercise conditions may also be specified by the user.

StructureTool is licensed separately. Clients must contact Barra's Asset Modeling Desk to add coverage of these complex assets using specialized deal files. Once the deal file is imported into BarraOne, the asset can be processed and valued as any other BarraOne-covered asset.

Deal Files

The deal files serve several purposes. Each contains several sections that are used to specify the various features of each instrument, as follows:

Attributes and MetaUnderlyingData

These sections are used to specify various instrument attributes necessary for the BarraOne application to determine whether BarraOne has the data necessary to cover the given instrument, and they contain various display-related attributes. For example, the "Attribute" section includes instrument name, type, IDs, rating information, currency information, *etc.* The "MetaUnderlyingData" section contains the number of underlying assets, underlying information, *etc.* During the import process, BarraOne performs the necessary checks on these attributes to either accept or reject the instrument.

Pay-Off

This section contains information about the pay-off structure of the instrument (pay-off formulas, *etc.*) used by StructureTool to value the instrument appropriately.

Schedules

Although schedules are part of the instrument TnCs, they are provided in a separate section, because they are stored in the BarraOne database separately from the general pay-off of each instrument. This enables updates of certain schedules during the life of the instrument (for example, updates to rate and coupon histories that affect the pay-off of some instruments).

Sample Data

This section contains an instance of market data that is used to test the correctness of the newly created instrument deal file. It is also used to verify that the instrument is properly valued prior to the deal file import into BarraOne.

Supported Underliers and Exposures

The following underlying instruments are supported by StructureTool.

Interest Rate Only

1. Pure fixed-income instruments (*e.g.,* snowballs, steepeners, TRANs, rangeaccruals, and inflation-linked structures) with a single underlier use a discounting rate that is based on a stochastic interest rate model with self-consistent discounting. The exposures are the same as for regular FRNs, namely currency, KRDs, duration, IR volatility duration, and spread duration. The factors to which this instrument is exposed are determined in the same way as for other fixed income instruments (country, currency, industry, rating, *etc.*).

   - Currency: The currency exposure is only to the specified instrument currency.
   - KRDs: Sensitivities are calculated with respect to key rates as a hedge-curve; the output produced is a curve with entries given by $\delta \text{Price}/\delta \text{Rate}_i$. These are converted to KRDs by rescaling with −1/Price.
   - Spread duration: Calculated as spread sensitivity, rescaled by −1/Price.
   - Duration: $\delta \text{Price}/\delta \text{r}_{parallel\ shift}$, rescaled by −1/Price.
   - IR volatility duration: Sensitivity with respect to a 1% relative change in volatility, rescaled with 100**ConversionFactor*, where *ConversionFacto*r is used to convert from sensitivity with respect to Hull-White short rate volatility to the 10-year yield volatility used as a factor. The value of *ConversionFactor* depends on the parameters of the Hull-White model. It has been shown that:

     $$IRVolDur = \frac{\delta Price}{\delta \log \sigma} \times ConversionFactor$$

     And the first term in the above equation can be approximately written as:

     $$\frac{\delta \text{Price}}{\delta \log \sigma} = \frac{\delta \text{Price}}{\delta \sigma} \times \frac{\delta \sigma}{\partial \log \sigma} \approx \frac{\Delta \text{Price}}{\Delta \sigma} \times \sigma = \frac{\Delta \text{Price}}{0.01 * \sigma} \times \sigma = 100 \times \Delta \text{Price}$$

     Therefore:

     $$IRVolDur \approx 100 \times \Delta \text{Price} \times ConversionFactor$$

2 Instruments involving two underliers (*e.g.,* inflation-linked structures where the inflation rate is modeled purely as the difference between the nominal and real rates) are handled by calculating two sets of exposures and exposing the instrument to two sets of factors (*e.g.,* LIBOR and Real). Two sets of sensitivities are returned (all except currency and spread duration).

Equity/Commodity Only

Pure equity/commodity instruments (*e.g.,* rainbow-like options, equity linked notes, and convertible bonds) with an arbitrary number of underliers all being of equity and/or commodity type have a deterministic discounting interest rate curve. The exposures calculated by BarraOne include the elasticities to each of the underliers, a single set of KRDs, duration, and spread duration. KRDs and duration are calculated off the discounting interest rate curve based on the specified currency. We obtain $\delta Price/\delta r$ and $\delta Price/\delta r_i$, then rescale using $-1/Price$ to obtain the corresponding duration and KRDs.

- Currency: The currency exposure is only to the specified instrument currency.
- Deltas/Elasticities: Derivatives are returned with respect to each underlier using the specified return choice. If necessary, these are converted to price elasticities.

Mix of Equity/Commodity and Interest Rate

In this case, the discounting rate is also based on a stochastic interest rate model with self-consistent discounting. The exposure calculation is performed by combining the calculations in the interest rate and equity/commodity cases above: KRDs, duration, and IR volatility duration are calculated for each interest rate underlier; deltas/elasticities are calculated for each equity/commodity underlier. The currency exposure is still only to the instrument currency in this case.

Mix of FX with Interest Rate and/or Equity/Commodity

KRDs are calculated only for each of the interest rate underliers. We assume that all relevant interest rates are explicitly specified as the underliers in the instrument definition. We assume that all the dependence on all interest rates is explicitly and correctly incorporated into the instrument payoff definition. Therefore, the exposures to interest rates in different currencies is calculated as in the interest rate case above.

All the other relevant sensitivities to any other underlying types (*e.g.,* equity) are also calculated as in the corresponding cases described above. The only difference in this case is that now there will be currency exposure to currencies other than the instrument payoff currency N. For each currency P (corresponding to each FX(N/P) underlier), the currency exposure is the delta of the instrument price with respect to the FX(N/P) underlier. The currency exposure to the instrument payoff currency N is equal to $1 - \Sigma$ (*other currency exposures*).

FX Only, or FX Mixed with Equity

Multiple sets of KRDs are calculated from the local markets involved in each leg of FX rates. All the sensitivities except to interest rates and currency exposures are calculated as in the corresponding cases presented above. However, in this case, the relevant interest rate exposures (corresponding to the instrument discounting currency and to all currencies *P* other than the instrument payoff currency *N*) are calculated internally. This is because for currencies other than *N*, these interest rates are not specified explicitly in the payoff; while for the instrument currency *N*, we need to account not just for the discounting effect, but also for its effect on FX rates.

For each currency *P*, corresponding to the FX(*N*/*P*) underlier, the interest rate exposure is calculated numerically by shifting the relevant interest rate data, recalculating the resulting (changed) FX forward curve, and revaluing the instrument. Each FX underlier is set up as a forward curve to incorporate the FX dependence on interest rates for each tenor t_i in the interest rate curve:

$$FX_{N/P}(t_i) = spot\_fx_{N/P} * \exp((r_N - r_P)t_i)$$

Then the KRDs (duration) to the interest rate of currency *P* are calculated by changing r_P in the above formula (one currency *P* at a time).

For the instrument currency *N*, KRDs/duration are calculated numerically by changing r_N in the above formula for all underlying FX rates FX(*N*/*P*) involved in the definition of the payoff (all *P* simultaneously) and in the discounting interest rate curve.

Calculated Output

The following fields are calculated and output, depending upon the type of underlier(s).

Table 21: StructureTool Output Fields by Underlier Type

Field/Underlier Type	Equity/Commodity/FX	Interest Rate
Model Value	✓	✓
Accrued Interest		✓
MTM (dirty price)	✓	✓
Exposure	✓	✓
Dollar Duration		✓
Basis Point Value (BPV)		✓
Investment Value		
Parity Value		
Theoretical Premium		
Fitted Price	✓	✓

Table 21: StructureTool Output Fields by Underlier Type

Field/Underlier Type	Equity/Commodity/FX	Interest Rate
Maturity	✓	✓
Effective Duration	✓	✓
Aux (Pay Currency) Effective Duration		
Convexity		✓
Spread Duration		✓
Aux Spread Duration		✓
Modified Duration		✓
Macaulay Duration		✓
Duration to Worst		✓
Average Life		✓
Current Yield		✓
YTM		✓
Yield to Best		
Yield to Worst		
Yield to Next		
Spread	✓	✓
Model Spread		
PSA		
CPR		
Delta	✓	
Gamma	✓	
Theta	✓	
Vega	✓	
Rho	✓	
Phi	✓ Equity/Commodity only ($\delta P/\delta$Dividend)	
Implied Volatility		
Implied Repo Rate		
Exposure Scalar	✓	
Spread DV01		
Break Even Period		
Coupon		

Table 21: StructureTool Output Fields by Underlier Type

Field/Underlier Type	Equity/Commodity/FX	Interest Rate
Cost of Carry		
Swap Spread		
Fitted Price (%)	✓	✓
Refi Scale		
Time to Maturity	✓	✓
IR Volatility Duration	✓	✓
Prepayment Duration		
Fair Spread Basis		
KRD	✓	✓
STB	✓	✓

Custom Exposure Assets

A Custom Exposure Asset is composite-like instrument type that enables the user to define the vector of factor exposures used to model a security. This provides a basis for users to construct complex proxies without having to create replicating portfolios and without having to define a portfolio based on factor assets. Additionally, this instrument type can be used to model hedge fund holdings.

Derivative Valuation Methodology

The value of a derivative is the amount of cash that must be paid or received today in exchange for that instrument. The following methods and models are used in valuing various derivatives in BarraOne:

- Cumulative Normal Density
- Black-Scholes Model
- Black-Scholes Generalized (BSG) Model
- Black Model (1976)
- Black-Scholes Continuous Dividend Model
- Garman-Kohlhagen Model
- Hull-White Model
- Trinomial Tree Model
- Single Barrier Model (European)
- Double Barrier Model (European)
- Forward Starting Options
- Barra's Quasi-Random Principal Components (QRPC) Simulation
- Crank-Nicholson Algorithm with Adaptive Grid
- Deterministic Intensity Reduced Form Model
- Option Risk Measurements

Cumulative Normal Density

Many of the valuation models described in this chapter make use of the cumulative normal density function. This function is based upon the assumption that the movements in the price of an underlying asset are random, but that the potential range of outcomes can be defined with specific probabilities.

The cumulative normal density function for any variable $x \geq 0$ can be approximated as follows:

Cumulative Normal Density Function

$$N(x) = 1 - \left(\frac{1}{\sqrt{2\pi}} e^{-\frac{x^2}{2}} \right) \left(b_1 k + b_2 k^2 + b_3 k^3 + b_4 k^4 + b_5 k^5 \right)$$

where:

k	=	$\dfrac{1}{1 + ax}$
a	=	0.2316419
e	=	base of the natural logarithm
b_1	=	0.319381530
b_2	=	–0.356563782
b_3	=	1.781477937
b_4	=	–1.821255978
b_5	=	1.330274429

The following property of this function can be used for any variable $x < 0$, where $|x|$ is the absolute value of x:

$$N(-|x|) = 1 - N(|x|)$$

> **Note:** BarraOne uses the more precise approximation developed by W.J Cody, *Math. Comp. 22* (1969), 631-637.

Black-Scholes Model

The seminal work of Fischer Black and Myron Scholes in 1973 produced an elegant closed form solution for pricing European-style call options on equities. The Black-Scholes formula can be used to measure both the value and risk of an option in relation to its underlying equity. It can be used to predict how the price of an option will change given a change in another variable such as underlier's price or volatility. This information can then be used either to assess the risk of a particular option portfolio or to identify a unique trading opportunity.

The assumptions under which the formula was derived include:

- The option can be exercised only on the expiration date (European style)
- The underlying instrument does not pay dividends
- There are no taxes, margins, or transaction costs
- The default-free interest rate is constant
- The price volatility of the underlying instrument is constant
- The price movements of the underlying instrument follow a lognormal distribution

The formula for present value of the option premium is:

Black-Scholes Model

$$C = S_0 N(h_1) - Ke^{-rT} N(h_2)$$

$$P = -S_0 N(-h_1) + Ke^{-rT} N(-h_2)$$

where:

C	=	theoretical value of a call
P	=	theoretical value of a put
S_0	=	price of the underlying asset
$N(x)$	=	cumulative normal density function
h_1	=	$\frac{\ln\left(\frac{S_0}{Ke^{-rT}}\right)}{\sigma\sqrt{T}} + \frac{\sigma\sqrt{T}}{2}$
ln	=	natural logarithm
K	=	exercise price
e	=	base of the natural logarithm
r	=	continuously compounded default-free interest rate
T	=	time to option expiration in years
h_2	=	$h_1 - \sigma\sqrt{T}$
σ	=	annual volatility in percent

Black-Scholes Generalized (BSG) Model

The Black-Scholes Generalized model is suitable for evaluating European-style options on equities that are assumed to pay a continuous dividend yield during the life of the option. Since the option holder does not receive any cash flows paid from the underlying equity, this should be reflected in a lower option price for a call or a higher price for a put. The Black-Scholes Generalized model provides a solution by subtracting the present value of the continuous cash flow from the price of the underlying instrument.

The assumptions under which the formula was derived include:

- The option can be exercised only on the expiration date (European style)
- The underlying instrument does not pay dividends, or if it pays a continuous dividend yield, an option holder does not receive any cash flow paid from the underlying instrument

- There are no taxes, margins, or transaction costs
- The default-free interest rate is constant
- The price volatility of the underlying instrument is constant
- The price movements of the underlying instrument follow a lognormal distribution

The formula for present value of the option premium is:

Black-Scholes Generalized Model

$$C = A\left[S_0 e^{-dT} N\left(h_1\right) - Ke^{-rT} N\left(h_2\right)\right]$$

$$P = -A\left[S_0 e^{-dT} N\left(-h_1\right) - Ke^{-rT} N\left(-h_2\right)\right]$$

where:

C	=	theoretical value of a call
P	=	theoretical value of a put
A	=	contract size in units
S_0	=	price of the underlying asset (obtained from the market data set)
e	=	base of the natural logarithm
d	=	continuously compounded dividend yield (can be zero for asset with no dividend)
T	=	time to expiration in years, calculated as *(ExpiryDate –Valuation Date)/365*
$N(x)$	=	cumulative normal density function
h_1	=	$\dfrac{\ln\left(\dfrac{S_0}{K}\right) + \left(r - d + \dfrac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}$
K	=	exercise (strike) price
r	=	continuously compounded default-free interest rate, obtained by interpolation
h_2	=	$h_1 - \sigma\sqrt{T}$
ln	=	natural logarithm
σ	=	annual volatility in percent, interpolated from the market data set

Black Model (1976)

The Black model is used to value European-style exercise on futures options, including the following instruments: caps and floors, and bond future options. The model takes into consideration the fact that there are no financing costs related to a futures contract.

The following assumptions apply to the Black model:

- The option can be exercised only on the expiration date (European style)
- The underlying instrument does not pay dividends (or if it does, the dividends are not received by the option holder)
- There are no taxes, margins, or transaction costs
- The default-free interest rate is constant
- The price volatility of the underlying instrument is constant
- The price movements of the underlying instrument follow a lognormal distribution

Black Model (1976)

$$C = e^{-rT}\left[F_0 N(h_1) - KN(h_2)\right]$$

$$P = -e^{-rT}\left[F_0 N(-h_1) - KN(-h_2)\right]$$

where:

C	=	theoretical value of call option
P	=	theoretical value of put option
F_0	=	price of the underlying forward contract at the valuation date
e	=	base of the natural logarithm
r	=	default-free interest rate
T	=	time to option expiration in years
$N(x)$	=	cumulative normal density function
h_1	=	$\dfrac{\ln\left(\frac{F_0}{K}\right)}{\sigma\sqrt{T}} + \dfrac{\sigma\sqrt{T}}{2}$
ln	=	natural logarithm
K	=	exercise price
σ	=	annual volatility in percent
h_2	=	$h_1 - \sigma\sqrt{T}$

Black-Scholes Continuous Dividend Model

For an option on an equity with continuous dividends, the Black-Scholes Continuous Dividend model is used.

Black-Scholes Continuous Dividend Model

$$C = A\left[\left(S_0\left(1-d\right)\right)N\left(h_1\right) - Ke^{-rT}N\left(h_2\right)\right]$$

$$P = -A\left[\left(S_0\left(1-d\right)\right)N\left(-h_1\right) - Ke^{-rT}N\left(-h_2\right)\right]$$

where:

C	=	theoretical value of a call
P	=	theoretical value of a put
A	=	contract size in units
S_0	=	price of the underlying asset (obtained from the market data set)
d	=	continuously payable dividend rate
$N(x)$	=	cumulative normal density function
h_1	=	$\dfrac{\ln\left[\dfrac{S_0\left(1-d\right)}{Ke^{-rT}}\right]}{\sigma\sqrt{T}} + 0.5\sigma\sqrt{T}$
K	=	exercise (strike) price
e	=	base of the natural logarithm
r	=	continuously compounded default-free interest rate, obtained by interpolation
T	=	time to expiration in years, calculated as *(ExpiryDate –Valuation Date)/365*
h_2	=	$h_1 - \sigma\sqrt{T}$
ln	=	natural logarithm
σ	=	annual volatility in percent, interpolated from the market data set

Garman-Kohlhagen Model

The Garman-Kohlhagen model is suitable for evaluating European-style options on foreign exchange. This model alleviates the restrictive assumption, used in the Black-Scholes model, that borrowing and lending is performed at the same default-free rate. In the foreign exchange market, there is no reason to assume that the default-free rate should be identical in each country. The interest rate differential between the two currencies will impact the value of the FX option. The default-free foreign interest rate in this case can be thought of as a continuous dividend yield being paid on the foreign currency. It is identical to the case of an option on a stock paying a continuous proportional dividend.

Assumptions under which this formula was derived include:

- The option can be exercised only on the expiration date (European style)
- There are no taxes, margins, or transaction costs
- The default-free interest rates (domestic and foreign) are constant
- The price volatility of the underlying instrument is constant
- The price movements of the underlying instrument follow a lognormal distribution

Garman-Kohlhagen Model

$$C = S_0 e^{-r_f T} N(h_1) - K e^{-r_d T} N(h_2)$$

$$P = -S_0 e^{-r_f T} N(-h_1) + K e^{-r_d T} N(-h_2)$$

where:

C	=	theoretical value of a call
P	=	theoretical value of a put
S_0	=	price of the underlier
e	=	base of the natural logarithm
r_f	=	default-free interest rate in foreign currency
r_d	=	default-free interest rate in domestic currency
T	=	time to option expiration in years
$N(x)$	=	cumulative normal density function
h_1	=	$\dfrac{\ln\left(\dfrac{S_0}{K}\right) + \left(r_d - r_f + \dfrac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}$

Garman-Kohlhagen Model (Continued)

ln	=	natural logarithm
K	=	exercise price
σ	=	annual volatility in percent
h_2	=	$h_1 - \sigma\sqrt{T}$

Hull-White Model

The Hull-White one-factor model (also known as the Mean Reverting Gaussian model, or MRG) is used for determining the set of possible interest rate scenarios for a swaption, mortgage-backed security, adjustable rate mortgage, floating rate note, or variable rate note, or the underlying fixed income security of a future or option. The model describing the stochastic process for the normal instantaneous interest rate is written in the form of a differential equation, as follows:

Hull-White Model

$$dr = \left(\Theta_t - \kappa r\right)dt + \sigma dz$$

where:

dz	=	increment of standard Brownian motion
r	=	instantaneous short rate at time t
Θt	=	time-dependent drift of the instantaneous short rate
κ	=	Barra-supplied mean reversion strength
σ	=	Barra-supplied volatility parameter of the instantaneous short rate

The Hull-White term structure model is based upon the assumption that the short-term interest rate follows a mean-reverting Brownian motion. The short-term interest rate is the limiting (continuously compounded) rate as time approaches zero.

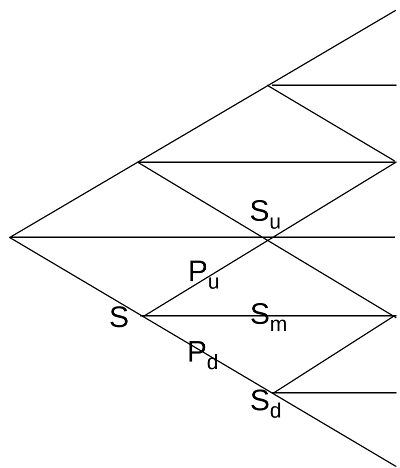
Trinomial Tree Model

The constant volatility trinomial tree is used for the following instruments:

- Convertible bonds (European and American)
- Equity options (American and Bermudan)
- Equity index future options (American)
- FX options (American and Bermudan)
- Commodity future options (American)

These instruments are implemented using numerical calculations of conditional expectations on a grid lattice.

The up and down movements illustrated below can be represented by the following system of equations:



Trinomial Movements

$$
\begin{aligned}
S_u &= Se^{\sigma\sqrt{2\Delta t}} \\
S_m &= S \\
S_d &= Se^{-\sigma\sqrt{2\Delta t}} \\
p_u &= \left(\frac{e^{\mu\Delta t/2} - e^{-\sigma\sqrt{\Delta t/2}}}{e^{\sigma\sqrt{\Delta t/2}} - e^{-\sigma\sqrt{\Delta t/2}}} \right)^2 \\
p_d &= \left(\frac{e^{\sigma\sqrt{\Delta t/2}} - e^{\mu\Delta t/2}}{e^{\sigma\sqrt{\Delta t/2}} - e^{-\sigma\sqrt{\Delta t/2}}} \right)^2 \\
p_m &= 1 - p_u - p_d
\end{aligned}
$$

where:

Δt	=	the time step of the tree
S, S_u, S_d, S_m	=	values of the underlying process
p_u, p_d, p_m	=	probabilities of the up, down, and middle movements of the underlier
σ	=	annualized volatility of the underlying asset
e	=	base of the natural logarithm
μ	=	expected return of the underlying asset for time step Δt

FX Options

The following is an example of the implementation of the tree for an American-style FX option. For an American-style FX option, the underlying stochastic process is the lognormal FX rate. It can be defined as follows:

American-style FX Forward Rate

$$S_t = S_0 e^{\left(r_{d_t} - r_{f_t}\right)t}$$

where:

S_t	=	FX rate at time t
S_0	=	FX spot rate
e	=	base of the natural logarithm
r_{dt}	=	domestic interest rate at time t
r_{ft}	=	foreign interest rate at time t
t	=	time between the valuation date and the observation date

By applying the arbitrage theorem, the expected return μ can be determined:

$$\mu = \ln\left(\frac{S_{t+\Delta t}}{S_t}\right) = \left(r_{d_{t+\Delta t}} - r_{d_t}\right) - \left(r_{f_{t+\Delta t}} - r_{f_t}\right)$$

where:

ln	=	natural logarithm

The expected value can be analytically calculated, and constitutes a simple forward FX rate.

$$E[x] = E[\ln(S_t)] = S_t$$

To calculate the expected value of an American-style FX option, the formula must obtain the integral of the conditional probability. This can be done in the following way:

$$S_t = \max\left(S_t - K, \left(p_u S_{u_{t+\Delta t}} + p_m S_{m_{t+\Delta t}} + p_d S_{d_{t+\Delta t}} \right) \frac{df_{t+\Delta t}}{df_t} \right)$$

where:

K = option strike price of the underlying asset (exchange rate in this case)

d_{ft} = domestic discount factor $exp(-r_{dt}\, t)$

Table 22 shows the implementation of the formula above to calculate the premium of the American-style FX option.

Table 22: American-style FX Option

	1M	2M	3M	4M	5M
					40.29
				31.90	32.04
			24.22	24.33	24.43
		17.25	17.27	17.34	17.42
	11.76	11.42	11.05	10.91	10.96
8.43	8.04	7.56	6.93	5.71	5.00
	6.24	5.96	5.68	5.71	0.00
		5.66	5.68	5.71	0.00
			5.68	5.71	0.00
				5.71	0.00
					0.00

Equity Options

For an American-style option on an underlying equity paying a constant dividend yield, the expected return μ can be defined with the same formula used for an FX option, except the continuously compounded dividend yield should be used instead of the foreign interest rate r_f.

For an equity asset with a dividend schedule, the lattice is adjusted at every node by the present value of all dividend payments expected between the lattice time steps. To preserve the recombining property of the lattice, the equity is assumed to have two components: one that is uncertain (stochastic), and one that is the present value of future dividends in a given interval. For instance, consider a case in which one dividend payment D is expected at time t_D between time steps t_i and t_{i+1} of the stock lattice, where $t_i \leq t_D < t_{i+1}$. Then, the value of underlying stochastic component at node t_i is computed as $S^P(t_i)+De^{-r(t_D-t_i)}$, where r denotes the default-free rate and $S^P(t_i)$ represents a set of expected asset prices at time t_i computed with the corresponding lattice probabilities (p_u, p_d, and p_m).

Asian Model

An Asian option is path dependent, and its payoff depends upon the average price of the underlying asset during a pre-specified period within the option's lifetime and a pre-specified observation frequency. In essence, these options enable the buyer to purchase the underlying asset at the average price, instead of at the spot price on the maturity date. Asian options are also called Average Price or Average Strike options.

Average Price Options

An average price option is an option for which the payoff is the difference between the strike price and the average price of the underlying asset during an averaging period. Average price options are cheaper than ordinary options, because the volatility of an averaged price is lower than that of the constituent prices. The arithmetic average is calculated using asset prices on predetermined discrete dates during the averaging period. The averaging period may begin at any time and always ends (unless price pool dates are specified) at option expiry. If the averaging period began in the past (*i.e.,* before the valuation date), then a running average is calculated.

Payoff

The payoff (to the holder) at expiration from an average price option is

$$\text{Call:} \quad \max\left(0, \frac{1}{n+1}\sum_{j=0}^{n} S_{t_j} - K\right)$$

$$\text{Put:} \quad \max\left(0, K - \frac{1}{n+1}\sum_{j=0}^{n} S_{t_j}\right)$$

where K is the strike price, $S_{t(j)}$ is the price of the underlying asset at time $t_j = t_s + j(T - t_s) / n$, $(n + 1)$ is the number of dates during the averaging period, T is the time to option expiry in years, and t_s is the time to the start of the averaging period in years. If the dates are input using price pools, the dates t_j need not be equally spaced in time.

BarraOne values average price options using a robust approximation known as "geometric conditioning."[1]

1 Curran M., "Beyond Average Intelligence," RISK, Vol. 5, No. 10 (November 1992), p. 60.

Average Strike Options

An average strike option is an option for which the strike price is set to the average price of the underlying asset at the end of an averaging period. The arithmetic average is calculated using asset prices on predetermined discrete dates during the averaging period. The averaging period may begin at any time and end at or before option expiry. If the averaging period began in the past (*i.e.,* before the valuation date) then BarraOne calculates a running average. Average strike options are cheaper than ordinary options, because the volatility of an averaged price is lower than that of the constituent prices.

Payoff

The payoff (to the holder) at expiration from an average strike option is

$$\text{Call:} \quad \max\left(0, S_T - \frac{1}{n+1}\sum_{j=0}^{n} S_{t_j}\right)$$

$$\text{Put:} \quad \max\left(0, \frac{1}{n+1}\sum_{j=0}^{n} S_{t_j} - S_T\right)$$

where $S_{t(j)}$ is the price of the underlying asset at time $t_j = t_s + j(t_e - t_s) / n$, $(n + 1)$ is the number of dates during the averaging period, t_s is the time to the start of the averaging period in years, t_e is the time to the end of the averaging period in years, and S_T is the price of the underlying asset at option expiry.

BarraOne values average strike options with the Barra-proprietary SPAV (for SPreads and AVerages) algorithm. Because it is impossible to obtain an analytical closed-form solution for the price of an option if the payoff is path dependent, as in the case of average strike options, the pricing formula used by the functions in SPAV is an approximate analytical solution for average price options on underlying assets.

Barra has performed extensive testing and comparisons between the approximate values returned by SPAV functions and the corresponding values obtained by solving the same underlying model numerically via Monte Carlo simulation. In all the cases, we obtained a very small error (<1%). The benefit of using the extremely fast SPAV algorithm, as opposed to the slow Monte Carlo simulation needed to obtain the same kind of accuracy, far outweighs the small loss of pricing accuracy. It is also worth noting that all the SPAV models preserve an exact, analytically derivable put-call parity relationship.

As with all approximations, however, SPAV is bound to fail in extreme cases. We have limited our testing to annual volatilities up to 50-60% and option tenors up to 2-3 years, since these are the conditions that are met in most practical cases. Because of the nature of the SPAV approximation, the pricing should be very accurate (and quite uniform with respect to other inputs) if these conditions are satisfied.

Single Barrier Model (European)

A barrier option is also called a trigger option, because its payoff depends critically on whether a specified barrier or trigger is touched during the life of the option. Barrier options are actually conditional options, and they are therefore path dependent. This model is used for European-style Barrier Options.

There are two basic types of barrier options: Knock-In and Knock-Out Barrier Options, or simply knock-ins and knock-outs. A knock-in is an option the holder of which is entitled to receive an option if the barrier is hit, and a rebate at expiration if otherwise. A knock-out option is an option the holder of which is entitled to receive a rebate as soon as the barrier is hit, and an option if otherwise.

As it makes a difference whether the settlement price is breached from above or below, there are down knock-ins and down knock-outs, as well as up knock-ins and up knock-outs, depending upon whether the barrier is above or below the current underlying price. Thus, there is a total of eight barrier options: down-in calls, up-in calls, down-out calls, up-out calls, down-in puts, up-in puts, down-out puts, and up-out puts. All of these are called standard, or vanilla, barrier options. If the option knocks out when the underlying option is in the money, then it is described as a Reverse barrier; for instance, an up-and-out call would be called a Reverse knock out.

Barrier options are the most common exotic options traded today. They are widely used throughout equity, fixed income, index, and foreign exchange markets. The attractiveness of barrier options is that they are cheaper than their corresponding vanilla option if there are no rebates. Volatility spreads on these options are much wider than on standard options. For example, a spread of 19-20 on a standard option might be 17-23 on a Barrier option. As the strike approaches the barrier price, the hedging costs increase and can become enormous.

These options are similar to American-style options, in the sense that their value depends upon the path of the price of the underlying security. However, since the barrier price is specified in advance, they are simpler to value than American-style options. In fact, a closed form solution is possible; sometimes these options are designed using resistance lines in charting techniques.

BarraOne uses the Merton (1973), Reiner and Rubinstein (1991) and Rich (1994) formulas for pricing European-style standard barrier options.

Single Barrier Model Symbols

$N(x)$ = cumulative normal density function

S_0 = observed “price” of the underlying asset at time zero (today)

K = strike price of the option

H = barrier price of the option

T = time in years to expiration

Single Barrier Model Symbols (Continued)

t	=	current time
R	=	rebate paid on option if canceled or never became exercisable
e	=	base of the natural logarithm
ln	=	natural logarithm
σ	=	annual volatility of the underlier
r_d	=	domestic interest rate
f	=	foreign interest rate for FX option
μ	=	coefficient equal to $r_d - f$
λ	=	coefficient equal to $\sqrt{\mu - \frac{\sigma^2}{2} + 2r_d\sigma^2}$
$K_\uparrow$	=	coefficient equal to max[K, H]
$K_\downarrow$	=	coefficient equal to min[K, H]

Up and In Barrier Option

Initially, the spot price of the asset is below the barrier (an Up option's barrier must be hit from below; the barrier is a ceiling). If the price goes up and hits the barrier during the option's lifetime, the option can be exercised at expiration. If not, the option will be canceled, and the rebate will be paid to the option holder, if it is specified. (If there is no rebate involved, the combination of an Up-and-Out and an Up-and-In equals the value of a standard option.)

- Call Option: $A_{CUI} + B_{CUI} + C_{UI}$
- Put Option: $A_{PUI} + B_{PUI} + C_{UI}$

where:

$$A_{CUI} = S_0 e^{-fT} N\left(\frac{\ln\left(\frac{S_0}{K_\uparrow}\right) + \left(\mu + \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}\right) - Ke^{-r_d T} N\left(\frac{\ln\left(\frac{S_0}{K_\uparrow}\right) + \left(\mu - \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}\right)$$

$$\begin{aligned} B_{CUI} = {} & S_0 e^{-fT}\left(\frac{H}{S_0}\right)^{\left(\frac{2\mu}{\sigma^2}+1\right)}\left[N\left(\frac{\ln\left(\frac{K_\uparrow S_0}{H^2}\right) - \left(\mu + \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}\right) - N\left(\frac{\ln\left(\frac{KS_0}{H^2}\right) - \left(\mu + \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}\right)\right] \\ & - Ke^{-r_d T}\left(\frac{H}{S_0}\right)^{\left(\frac{2\mu}{\sigma^2}-1\right)}\left[N\left(\frac{\ln\left(\frac{K_\uparrow S_0}{H^2}\right) - \left(\mu - \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}\right) - N\left(\frac{\ln\left(\frac{KS_0}{H^2}\right) - \left(\mu - \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}\right)\right] \end{aligned}$$

$$\begin{aligned} A_{PUI} = {} & Ke^{-r_d T}\left[N\left(\frac{\ln\left(\frac{K}{S_0}\right) - \left(\mu - \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}\right) - N\left(\frac{\ln\left(\frac{K_\downarrow}{S_0}\right) - \left(\mu - \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}\right)\right] \\ & - S_0 e^{-fT}\left[N\left(\frac{\ln\left(\frac{K}{S_0}\right) - \left(\mu + \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}\right) - N\left(\frac{\ln\left(\frac{K_\downarrow}{S_0}\right) - \left(\mu + \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}\right)\right] \end{aligned}$$

$$\begin{aligned} B_{PUI} = {} & Ke^{-r_d T}\left(\frac{H}{S_0}\right)^{\left(\frac{2\mu}{\sigma^2}-1\right)} N\left(\frac{\ln\left(\frac{K_\downarrow S_0}{H^2}\right) - \left(\mu - \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}\right) \\ & - S_0 e^{-fT}\left(\frac{H}{S_0}\right)^{\left(\frac{2\mu}{\sigma^2}+1\right)} N\left(\frac{\ln\left(\frac{K_\downarrow S_0}{H^2}\right) - \left(\mu + \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}\right) \end{aligned}$$

$$C_{UI} = \mathrm{Re}^{-r_d T}\left[N\left(\frac{\ln\left(\frac{H}{S_0}\right) - \left(\mu - \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}\right) - \left(\frac{H}{S_0}\right)^{\left(\frac{2\mu}{\sigma^2}-1\right)} N\left(\frac{\ln\left(\frac{S_0}{H}\right) - \left(\mu - \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}\right)\right]$$

Down and In Barrier Option

Initially the spot price of the asset is above the barrier (a Down option's barrier must be hit from above; the barrier is a floor). If the price goes down and hits the barrier during the life of the option, the option can be exercised at expiration. If not, the option will be canceled and the rebate will be paid to the option holder, if it is specified. (If no rebate is involved, the combination of a Down-and-In and a Down-and-Out equals the value of a standard option).

- Call Option: $A_{CDI} + B_{CDI} + C_{DI}$
- Put Option: $A_{PDI} + B_{PDI} + C_{DI}$

where:

$$A_{CDI} = S_0 e^{-fT}\left[N\left(\frac{\ln\left(\frac{K_\uparrow}{S_0}\right)-\left(\mu+\frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}\right)-N\left(\frac{\ln\left(\frac{K}{S_0}\right)-\left(\mu+\frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}\right)\right]$$
$$-Ke^{-r_dT}\left[N\left(\frac{\ln\left(\frac{K_\uparrow}{S_0}\right)-\left(\mu-\frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}\right)-N\left(\frac{\ln\left(\frac{K}{S_0}\right)-\left(\mu-\frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}\right)\right]$$

$$B_{CDI} = S_0 e^{-fT}\left(\frac{H}{S_0}\right)^{\left(\frac{2\mu}{\sigma^2}+1\right)} N\left(\frac{\ln\left(\frac{H^2}{K_\uparrow S_0}\right)+\left(\mu+\frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}\right)$$
$$-Ke^{-r_dT}\left(\frac{H}{S_0}\right)^{\left(\frac{2\mu}{\sigma^2}-1\right)} N\left(\frac{\ln\left(\frac{H^2}{K_\uparrow S_0}\right)+\left(\mu-\frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}\right)$$

$$A_{PDI} = Ke^{-r_dT} N\left(\frac{\ln\left(\frac{K_\downarrow}{S_0}\right)-\left(\mu-\frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}\right)-S_0e^{-fT}N\left(\frac{\ln\left(\frac{K_\downarrow}{S_0}\right)-\left(\mu+\frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}\right)$$

$$B_{PDI} = Ke^{-r_dT}\left(\frac{H}{S_0}\right)^{\left(\frac{2\mu}{\sigma^2}-1\right)}\left[N\left(\frac{\ln\left(\frac{KS_0}{H^2}\right)-\left(\mu-\frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}\right)-N\left(\frac{\ln\left(\frac{K_\downarrow S_0}{H^2}\right)-\left(\mu-\frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}\right)\right]$$
$$-S_0e^{-fT}\left(\frac{H}{S_0}\right)^{\left(\frac{2\mu}{\sigma^2}+1\right)}\left[N\left(\frac{\ln\left(\frac{KS_0}{H^2}\right)-\left(\mu+\frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}\right)-N\left(\frac{\ln\left(\frac{K_\downarrow S_0}{H^2}\right)-\left(\mu+\frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}\right)\right]$$

$$C_{DI} = \mathrm{R}e^{-r_dT}\left(N\left(\frac{\ln\left(\frac{S_0}{H}\right)+\left(\mu-\frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}\right)-\left(\frac{H}{S_0}\right)^{\left(\frac{2\mu}{\sigma^2}-1\right)}N\left(\frac{\ln\left(\frac{H}{S_0}\right)+\left(\mu-\frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}\right)\right)$$

Up and Out Barrier Option

With an Up-and-Out Barrier Option, initially the spot price of the asset is below the barrier (an Up option's barrier must be hit from below; the barrier is a ceiling). If the price goes up and hits the barrier during the option's lifetime, the option will be canceled and the rebate will be paid to the option holder, if it is specified. If not, the option can be exercised at expiration.

Up-and-Out calls are an implicit feature of convertible bonds where "soft calls" may force the convertible to be exercised. Up-and-Out puts are like standard puts, but the contract is canceled if the security exceeds the barrier. Up-and-Out puts are popular because they are cheaper than standard puts. (If there is no rebate involved, the combination of an Up-and-Out and an Up-and-In equals the value of a standard option.)

- Call Option: $A_{CUO} + B_{CUO} + C_{UO}$
- Put Option: $A_{PUO} + B_{PUO} + C_{UO}$

where:

$$A_{CUO} = S_0 e^{-fT}\left[N\left(\frac{\ln\left(\frac{H}{S_0}\right)-\left(\mu+\frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}\right)-N\left(\frac{\ln\left(\frac{K_{\downarrow}}{S_0}\right)-\left(\mu+\frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}\right)\right]$$

$$-Ke^{-r_dT}\left[N\left(\frac{\ln\left(\frac{H}{S_0}\right)-\left(\mu-\frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}\right)-N\left(\frac{\ln\left(\frac{K_{\downarrow}}{S_0}\right)-\left(\mu-\frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}\right)\right]$$

$$B_{CUO} = Ke^{-r_dT}\left(\frac{H}{S_0}\right)^{\left(\frac{2\mu}{\sigma^2}-1\right)}\left[N\left(\frac{\ln\left(\frac{S_0}{H}\right)-\left(\mu-\frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}\right)-N\left(\frac{\ln\left(\frac{K_{\downarrow}S_0}{H^2}\right)-\left(\mu-\frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}\right)\right]$$

$$-S_0e^{-fT}\left(\frac{H}{S_0}\right)^{\left(\frac{2\mu}{\sigma^2}+1\right)}\left[N\left(\frac{\ln\left(\frac{S_0}{H}\right)-\left(\mu-\frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}\right)-N\left(\frac{\ln\left(\frac{K_{\downarrow}S_0}{H^2}\right)-\left(\mu+\frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}\right)\right]$$

$$A_{PUO} = Ke^{-r_dT}N\left(\frac{\ln\left(\frac{K_{\downarrow}}{S_0}\right)-\left(\mu-\frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}\right)-S_0e^{-fT}N\left(\frac{\ln\left(\frac{K_{\downarrow}}{S_0}\right)-\left(\mu+\frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}\right)$$

$$B_{PUO} = S_0e^{-fT}\left(\frac{H}{S_0}\right)^{\left(\frac{2\mu}{\sigma^2}+1\right)}N\left(\frac{\ln\left(\frac{K_{\downarrow}S_0}{H^2}\right)-\left(\mu+\frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}\right)$$

$$-Ke^{-r_dT}\left(\frac{H}{S_0}\right)^{\left(\frac{2\mu}{\sigma^2}-1\right)}N\left(\frac{\ln\left(\frac{K_{\downarrow}S_0}{H^2}\right)-\left(\mu-\frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}\right)$$

$$C_{UO} = R\left[\left(\frac{H}{S_0}\right)^{\left(\frac{\mu-\lambda}{\sigma^2}-\frac{1}{2}\right)}N\left(\frac{\lambda T-\ln\left(\frac{H}{S_0}\right)}{\sigma\sqrt{T}}\right)+\left(\frac{H}{S_0}\right)^{\left(\frac{\mu+\lambda}{\sigma^2}-\frac{1}{2}\right)}N\left(\frac{-\lambda T-\ln\left(\frac{H}{S_0}\right)}{\sigma\sqrt{T}}\right)\right]$$

Down and Out Barrier Option

Initially, the spot price of the asset is above the barrier (a Down option's barrier must be hit from above; the barrier is a floor). If the price goes down and hits the barrier during the life of the option, the option will be canceled, and the rebate will be paid to the option holder, if it is specified. If the price does not hit the barrier, the option can be exercised at expiration.

A Down-and-Out call is similar to a standard call, except the contract is canceled if the price falls below the barrier. Down-and-Out calls are popular because they are cheaper than standard options. (If no rebate is involved, the combination of a Down-and-In and a Down-and-Out equals the value of a standard option).

- Call Option: $A_{CDO} + B_{CDO} + C_{DO}$
- Put Option: $A_{PDO} + B_{PDO} + C_{DO}$

where:

$$A_{CDO} = S_0 e^{-fT} N\left(\frac{\ln\left(\frac{S_0}{K_\uparrow}\right) + \left(\mu + \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}\right) - Ke^{-r_d T} N\left(\frac{\ln\left(\frac{S_0}{K_\uparrow}\right) + \left(\mu - \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}\right)$$

$$\begin{aligned} B_{CDO} = {} & Ke^{-r_d T}\left(\frac{H}{S_0}\right)^{\left(\frac{2\mu}{\sigma^2}-1\right)} N\left(\frac{\ln\left(\frac{H^2}{K_\uparrow S_0}\right) + \left(\mu - \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}\right) \\ & - S_0 e^{-fT}\left(\frac{H}{S_0}\right)^{\left(\frac{2\mu}{\sigma^2}+1\right)} N\left(\frac{\ln\left(\frac{H^2}{K_\uparrow S_0}\right) + \left(\mu + \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}\right) \end{aligned}$$

$$\begin{aligned} A_{PDO} = {} & Ke^{-r_d T}\left[N\left(\frac{\ln\left(\frac{K}{S_0}\right) - \left(\mu - \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}\right) - N\left(\frac{\ln\left(\frac{K_\downarrow}{S_0}\right) - \left(\mu - \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}\right)\right] \\ & - S_0 e^{-fT}\left[N\left(\frac{\ln\left(\frac{K}{S_0}\right) - \left(\mu + \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}\right) - N\left(\frac{\ln\left(\frac{K_\downarrow}{S_0}\right) - \left(\mu + \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}\right)\right] \end{aligned}$$

$$\begin{aligned} B_{PDO} = {} & S_0 e^{-fT}\left(\frac{H}{S_0}\right)^{\left(\frac{2\mu}{\sigma^2}+1\right)}\left[N\left(\frac{\ln\left(\frac{KS_0}{H^2}\right) - \left(\mu + \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}\right) - N\left(\frac{\ln\left(\frac{K_\downarrow S_0}{H^2}\right) - \left(\mu + \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}\right)\right] \\ & - Ke^{-r_d T}\left(\frac{H}{S_0}\right)^{\left(\frac{2\mu}{\sigma^2}-1\right)}\left[N\left(\frac{\ln\left(\frac{KS_0}{H^2}\right) - \left(\mu - \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}\right) - N\left(\frac{\ln\left(\frac{K_\downarrow S_0}{H^2}\right) - \left(\mu - \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}\right)\right] \end{aligned}$$

$$C_{DO} = R\left[\left(\frac{H}{S_0}\right)^{\left(\frac{\mu-\lambda}{\sigma^2}-\frac{1}{2}\right)} N\left(\frac{-\lambda T + \ln\left(\frac{H}{S_0}\right)}{\sigma\sqrt{T}}\right) + \left(\frac{H}{S_0}\right)^{\left(\frac{\mu+\lambda}{\sigma^2}-\frac{1}{2}\right)} N\left(\frac{\lambda T + \ln\left(\frac{H}{S_0}\right)}{\sigma\sqrt{T}}\right)\right]$$

Rebates

In the case of Out-type options, a rebate may be paid when the barrier is touched. In fact, this rebate is simply a form of a digital barrier option.

In the case of an In-type option, a rebate may be paid at the expiration date of the option if the barrier was never touched (*i.e.*, the option was never in). This is also a form of a digital barrier option.

Double Barrier Model (European)

Double Barriers are also called corridor options or dual-barrier options. They are most often called Corridors in the FX market. Corridor options, whether knock-ins or knock-outs, are canceled or activated if at any time within the life of the option the underlying asset price hits an upper or lower barrier.

A corridor option is made up of two barriers: one above the spot price and one below. Initially, the asset price is between them. It makes no difference whether the upper or lower barrier is touched first. Therefore, there are only four kinds of double-barrier options: out calls, out puts, in calls, and in puts, because the direction of approaching the barrier is no longer a factor affecting the option value.

Once the spot price touches any of these barriers, the option will be canceled and the corresponding *RebateUp* or *RebateDown* will be paid to the option holder. If the asset price remains in the specified corridor during the life of the option, the option can be exercised at expiration.

There are exotic double barriers as well as multiple barriers, known as Rainbows, which have barriers that behave differently above or below the spot price; for instance, option knocks in if the upper barrier is hit and out if lower barrier is hit.

Compared to vanilla barrier options with one barrier, corridor options with double barriers have lower premiums, because they impose an additional barrier that restricts the movement of the underlying asset prices and in turn the payments of the options.

With the concept of range trading most commonly related to the FX market, corridor options are actively trading in it. They are also popular in index options when buyers want to express their view of the market as a whole.

Forward Starting Options

An option is called forward starting when its strike price at the issue date is specified as a percentage of the future underlying security price at the option starting date. The payoff of a put-style forward starting option can be defined as follows:

$$Payoff_{Forward} = \max\left\{0, \alpha S_t - S_T\right\}$$

where S_t is the underlying security price at the option starting date $t<T$, T is the time to option expiration date, α represents an adjustment coefficient for the strike calculation, and S_T is the underlying security price at option expiration.

All supported equity options and FX option types (European, American, *etc.*) can be designated to be forward starting. Forward starting options are not treated as either a separate instrument or option type. Any supported option security deal file that contains a link to the iForwardStartOption table is considered to be forward starting, and this link will trigger the forward starting valuation model.

This option is identical to a standard option, except that the strike price is set at some future date (prior to expiration) as a constant fraction of the underlying security price at that date. If the fraction is one, the contract specifies that the option will be at-the-money on the future fixing date (also referred to as the grant date). An example of a forward starting option is a corporate incentive stock option. This option is usually at-the-money on the day it is granted to an employee.

If the *FwdStartDate* in the *iForwardStartOption* table is later than the valuation date, all option parameters (strike, barrier, rebate, *etc.*) will be treated as a proportion of the current underlying asset price. For example, if the strike is specified as 1.1 and the asset price is 100, this means that the strike is 110.

LIBOR Zero Curve

Equity (index) options are discounted against the LIBOR term structure. There are no specific requirements for forward starting options. Zero rates can be fed into the system directly, or zero rates can built by BarraOne using money market rates and swap rates.

Barra's Quasi-Random Principal Components (QRPC) Simulation

Path-dependent fixed income securities include mortgages (MBS), securitized products, and some types of floating rate notes (*i.e.,* with caps and floors) and structured notes. For these securities, the cash flow at a future date generally depends upon the asset's entire history. Unlike fixed or stepped coupon bonds with embedded options, these securities can be valued only by individual evaluations of multiple interest rate and cash flow scenarios.

Barra's path-wise valuation method, called the "Quasi-Random Principal Components" (QRPC) algorithm, combines two previously known techniques for addressing the valuation of MBS and other path-dependent securities.

The first technique, the principal components method, decomposes the sample paths into variations on different time scales. A typical path of interest rates varies on many different time scales:

- Short-run daily and weekly fluctuations with no long-term trend
- Longer-term monthly, yearly, and decade-long variations

This decomposition can be made mathematically precise, and it enables the use of the following observations:

- The determinants of value for most securities are the long-run changes in rate levels
- Daily or weekly variations have negligible impact on value, provided that they are not part of a longer-term trend

Thus, in constructing sample paths for valuation, it is necessary to account for only the long-term changes, while the short-term fluctuations can be ignored. The components of the variation of interest rates can be broken down into discrete sets by analyzing the principal components of the covariance matrix of changes in rates over time. The principal component with the largest weight is the one corresponding to a very long-term increasing or decreasing trend. The next one corresponds to a single “whipsaw,” with rates first going one way, then coming back and changing in the other direction. Subsequent components with smaller weights correspond to two, three, and more whipsaws.

The other ingredient in Barra’s method is the use of so-called “quasi-random sequences” to determine the weights of the principal components. There is nothing random about *quasi-random* sequences. They are designed to overcome the statistical deficiency of Monte Carlo methods—namely, that the random number sequences exhibit clumps and gaps that gradually diminish only by using longer sequences (*i.e.,* more paths).

Quasi-random sequences are contrived precisely to minimize clumps and gaps. Instead of choosing points at random, a quasi-random sequence “keeps track” of the holes in the sequence and fills them in as evenly as possible as additional points are added. The set of points that results at any stage has gaps that are as small as possible, given the number of points used, and a corresponding minimal level of clumping.

In implementing the QRPC method, Barra uses a quasi-random sequence to generate a normal distribution of weights for each principal component. These are then summed to obtain the sample interest rate paths.

Prepayment Models

Like all cashflow-generating securities, MBS and ABS have interest rate risk due to the variability in cashflow discounting. However, they have two additional sources of risk: first, their cashflow amounts vary as a function of interest rates and prices due to prepayment; second, their spreads vary due to changes in speeds and expectations of prepayments. Barra risk factors account for all of these sources of risk.

Behavioral Prepayment Model

Calculation of MBS cashflows requires a model of their principal repayment behavior. The vast majority of U.S. residential mortgage loans are prepayable. This means simply that borrowers are free to refinance their loans when interest rates fall and it becomes economically favorable to do so. Borrower prepayment behavior is, on average, inefficient: not all borrowers refinance when it would be beneficial to do so.

Structurally, Barra's prepayment model is based on a cohort approach to modeling individual pool characteristics. A pool, which is backed by a collection of similar loans, is viewed as obligations of three cohorts of borrowers with differing prepayment propensities, loosely referred to as "slow," "moderate," and "fast" payers. If rates fall after origination, the fast payers rapidly disappear from the pool, producing an initial surge in prepayments. Prepayments subsequently slow down as the moderate payers prepay, eventually leaving behind only the slow payers. This model naturally reproduces the empirical observation of pool "burnout."

Model Fitting

Each cohort's refinancing behavior is modeled using heuristic functions of pool gross coupon (the average loan rate), current market mortgage rate, home price index, and yield curve slope. These functions are defined by a small number of parameters estimated from historical experience. Seasonal and aging effects are, similarly, modeled by heuristic functional forms consistent with observations. Only the interest-rate-independent contribution to the prepayment rate is subject to seasonal variation. To prevent misidentification of a change in interest rates as a seasonal effect, the estimation uses a Fourier transform method to suppress high-frequency variation, without imposing any particular functional form.

The prepayment model is estimated by fitting its parameters to historical prepayment experience. Because of the enormous volume of data (over one million pools outstanding, each with monthly prepayment experience), we initially aggregate pools by issuer, program type, age, and coupon range, with narrower groupings for newer and current coupon pools. Including data back to 1987, we end up with anywhere from 30,000 to 200,000 monthly aggregate prepayment events for each of five combinations of issuer and program: conventional 30- and 15-year, and balloons, and GNMA 30- and 15-year. Aggregate prepayments are modeled as a Poisson process, where we think of each loan prepayment as a random discrete event whose probability (as a function of mortgage characteristics and market interest rates) we are trying to predict. Subject to the distribution implied by the Poisson model, we use a nonlinear optimization algorithm to find the best-fit parameters for each of the five pool categories. In-sample weighed R^2s are typically 0.94 or above.

We calibrate parameters for each of the following models:

- Five Fixed Rate Agency Models: Conventional 15- and 30-year loans, GNMA 15- and 30-year loans, and Balloons
- Four Fixed Rate Whole Loan Models: 1-5 and 30-year full and low doc
- ARMSs: Conventional and GNMA. Hybrid ARMs (fixed-to-floating pools) are supported.

  ⊳ **Note:** Defaults cause prepayments for agency pools and are not modeled for other pool types.

Please see “U.S. Residential Mortgage Prepayment Model” and “The New Barra Prepayment Model Incorporating Home Price Effects” for more details on the model.

Implied Prepayment Factors

In additional to the multi-cohort behavioral prepayment model, the Barra model includes factors to account for changes in prepayment speed, *i.e.,* how fast mortgage payers respond to changes in interest rates, and market expectations of changes in prepayment rates. Increased prepayment speed increases the value of discount pools and decreases the value of premium pools. The impact of prepayment speed on MBS value can be as large as that of interest rate movement. Risk analysis based solely on a static, historically estimated behavioral prepayment model fails to capture this risk.

The Barra implied prepayment factors capture the uncertainty in prepayment speeds beyond that due to interest rates alone. Observed MBS prices reflect both the market price for bearing this prepayment risk and market expectations for prepayment speeds. Theoretical valuation of MBSs, however, proceeds by specifying a model for prepayments, generating interest rate scenarios, and discounting the modeled cash flows. Since cash flows in a given scenario are treated as known, this leads to the wrong result to the extent that the model differs from market expectations, and that the discounting does not account for the price of prepayment risk.

The spreads implied by such a valuation model mix together compensation for prepayment risk with compensation for interest rate risk. Proper accounting for both the market price of prepayment risk and market expectations for prepayments can be handled with an implied prepayment model. In order to separate prepayment risk due to interest rates from risk due to uncertainty about prepayment speeds, each prepayment spread factor is matched with an implied factor. The exposure of a pool to the prepayment spread factor is spread duration, and the exposure to the implied factor is its sensitivity to the global prepayment speed. Returns of the two factors are calculated by regression of aggregate pool returns onto the two factors.

See “Mortgage-Backed Securities Implied Prepayment Model” for more information on this model.

Adjustable-Rate Mortgage Prepayment

ARMs can have a much richer dependence on rates than fixed-rate instruments, as both the interest and principal component of cashflows can change due to rate changes. In BarraOne, if the mortgage prepayment model is set to match historically observable prepayment rates, the resulting durations for regular and hybrid ARMs are too high for comfort, perhaps as an artifact of the interest rate path generation in the Monte Carlo simulation. In the current interest rate model, the projected rates are not bounded in any way (can be negative), nor is the index the ARM is following. When the interest rate on a path is so low that the mortgage rate of the ARM (index + margin) would become 0 or less, it is kept at 1 bps to avoid nonsensical results. But a "floored" ARM stops behaving like an ARM, and its duration becomes higher. We have compensated for this characteristic of the interest rate model by increasing the forecasted prepayment speed, bringing the durations to a reasonable range.

ABS Prepayment Model

For ABS pools, we use the last 12-month historical average constant prepayment rate (CPR) for the future CPR rate. If this rate is not available, we use 10%. Analysis of a number of ABS pools in the categories of CMBS, auto loans, student loans and credit card pools shows that many ABS pools are well modeled by this treatment.

Crank-Nicholson Algorithm with Adaptive Grid

Many bonds contain embedded put options, call options, or combinations of these. Such securities can be valued using elaborate numerical methods for solving partial differential equations. The partial differential equation in this case is the analog of the equation "Black-Scholes Generalized (BSG) Model" on page 420 appropriate to the Mean Reverting Gaussian (MRG) model, also known as the "Hull-White Model" on page 425.

As with the Black-Scholes equation, European options can be valued analytically in the MRG model. But many common bond options—ordinary callable bonds, bonds with multiple put dates —cannot be valued analytically.

One conventional technique for handling such cases is the binomial tree, in which interest rate evolution is modeled as a branching lattice, with the additional feature that the branches of the tree "recombine"—that is, an up move followed by a down move is equivalent to a down followed by an up. The binomial tree algorithm is the simplest of a more general class called finite difference methods[1].

Barra uses the significantly more efficient Crank-Nicholson method with minor modifications for bond valuation. This method is faster and more accurate than the binomial or trinomial lattice, especially for calculation of interest rate risk exposures, such as effective duration, key rate duration (KRD), and effective convexity.

Barra's implementation of the Crank-Nicholson method uses a so-called "adaptive grid" to achieve high accuracy for solving option valuation problems, such as a short call on a long bond. The structure of the grid is shown schematically in Figure 26 on page 445.

1 The binomial tree algorithm also happens to be one of the least efficient in terms of accuracy achieved for a given amount of computation time. What began as a pedagogical device has become a widely used tool.

The adaptive grid uses a coarse grid covering a wide range of interest rates for times far in the future (when the present value of any numerical errors is small but the range of possible outcomes is large), and “refines” and narrows the grid for nearer events (for which the present value of errors is potentially large but the range of likely interest rates is small).

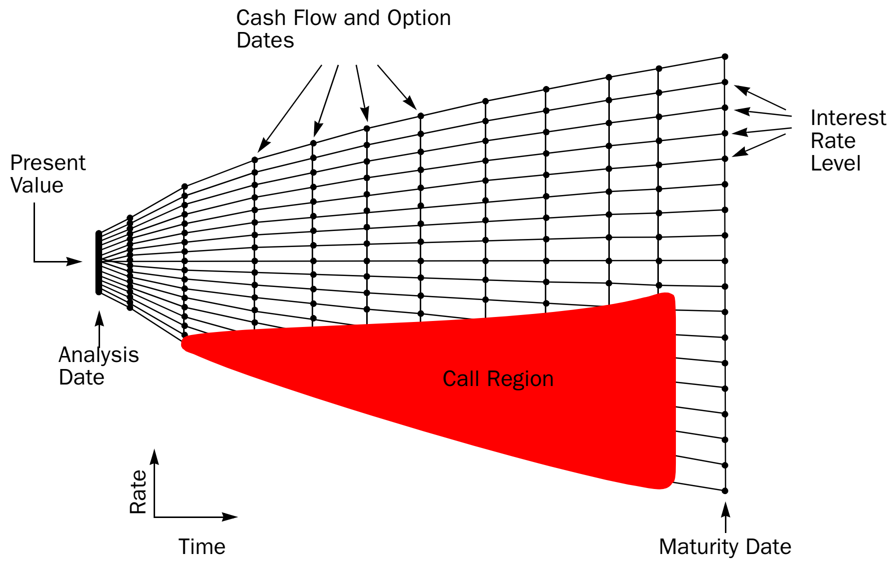


Figure 26: Adaptive Grid for a Callable Bond

Deterministic Intensity Reduced Form Model

The Deterministic Intensity Reduced Form Model (RF Model) is a continuous-time model of default, where the default arrival process is modeled as a non-homogeneous Poisson process. This model can be characterized using a survival probability, $L(t)$, which is the probability that the reference entity does not default by time t:

$$L(t) = P[\tau > t] = e^{-\int_0^t \lambda(s)ds}$$

where τ is the default time, and $\lambda(t)$ is the time-dependent intensity of the default arrival process. The probability density function of default time, $q(t)$, required for valuation is given by:

$$q(t) = \tfrac{d}{dt}(1 - L(t)) = \lambda(t)e^{-\int_0^t \lambda(s)ds}$$

In such a model the hazard rate is just $\lambda(t)$.

Calibration

BarraOne calibrates a piecewise constant term structure of intensities of the default arrival process given CDS premium quotes for a reference entity. Default intensities are sensitive to assumptions about the recovery rate in the event of default. A simple bootstrapping procedure is used to calibrate the term structures of intensities to a set of recovery rates.

Option Risk Measurements

BarraOne provides Greek analysis for the risk of option instruments. “Greeks” is trader slang for the partial derivatives delta, gamma, vega (kappa), theta, rho, *etc.* These Greek letters summarize an option’s sensitivity to various model parameters, *i.e.*, the change that will occur to the value of an option due to a small change in a particular input while all other inputs are held constant.

Derivative risk measures are displayed only at the asset level. The definition of each Greek result is dependent upon the type of option being evaluated, so there is usually no need for aggregation.

Vega and Rho are calculated for all non-IR derivatives (*i.e.,* Commodity, Equity, FX). For IR derivatives, the underlier is either an interest rate or based on interest rates, so we do not compute rho or vega for IR derivatives. Instead we compute IR Vol Duration as the sensitivity to volatility, and dollar duration is used as the equivalent of rho (dollar duration gives the dollar change in the instrument’s market value for a 100 basis point change in rates, so it is a pure derivative). Greeks (including rho) are calculated per unit contract size and are not adjusted for holdings, while dollar duration is calculated based on contract size and holdings. There is no adjustment necessary for the underlier’s contract size.

Table 23: Greek Calculations per Instrument Type

Instrument Type	Delta	Theta	Vega	Rho
Equity option	Calculated	Calculated	Calculated	Calculated
Equity index future option	Calculated	Calculated	Calculated	Calculated
Volatility option	Calculated	Calculated	Calculated	Calculated
FX Option	Calculated	Calculated	Calculated	Calculated
Convertible Bonds	Calculated	Calculated	Calculated	Calculated
Bond option	Calculated	Calculated	IR Vol Duration	Dollar duration / (holdings * contract size)
Bond Future	Calculated	Calculated	IR Vol Duration	Dollar duration / (holdings * contract size)
Bond Future Option	Calculated	Calculated	IR Vol Duration	Dollar duration / (holdings * contract size)
Caps/Floors	Calculated	Calculated	IR Vol Duration	Dollar duration / (holdings * contract size)
EuroDollar Futures	Calculated	Calculated	IR Vol Duration	Dollar duration / (holdings * contract size)
EuroDollar Future options	Calculated	Calculated	IR Vol Duration	Dollar duration / (holdings * contract size)
Swaption	Calculated	Calculated	IR Vol Duration	Dollar duration / (holdings * contract size)

Black-Scholes Generalized Model Options

All options that are priced using the "Black-Scholes Generalized (BSG) Model" on page 420, or an alteration based upon this model, use the following definitions for their Greeks.

Delta

Delta represents the sensitivity of an option premium to changes in the spot price of the underlying asset. It is expressed in terms of a percentage change in the option premium to a unit (dollar) change in the underlying spot price. For instance, swaption delta is the change in swaption price with respect to a a change in the underlying swap price.

A high delta (100%) indicates that the option is in the money and likely to be exercised. A moderate delta (50%) indicates that the option is at the money. A low delta (0%) indicates the option is out of the money and unlikely to be exercised.

$$\Delta_{call} = \frac{\partial C}{\partial S_0} = e^{-dT} N\left(h_1\right) > 0$$

$$\Delta_{put} = \frac{\partial P}{\partial S_0} = -e^{-dT} N\left(-h_1\right) < 0$$

Delta is useful in creating hedging strategies, because the value indicates the number of underlying units that need to be bought or sold to hedge against changes in the underlying price.

Gamma

Gamma represents the sensitivity of an option's delta (which changes over the life of the option) to a unit (dollar) change in the spot price of the underlying asset; thus it is a measure of the stability of an option's sensitivity to changes in the spot price of the underlying asset.

$$\Gamma_{call} = \frac{\partial^2 C}{\partial S_0^2} = \frac{e^{-dT} N\left(h_1\right)}{S_0 \sigma \sqrt{T}} > 0$$

$$\Gamma_{put} = \frac{\partial^2 P}{\partial S_0^2} = \frac{e^{-dT} N\left(h_1\right)}{S_0 \sigma \sqrt{T}} > 0$$

A low gamma (1%) indicates low delta sensitivity to changes in the spot price of the underlying asset.

Rho (r-d)≠0

Rho represents the unit (dollar) sensitivity of an option premium to a one percent change in the underlying interest rate. In the Black-Scholes model, the interest rate is used to take into account the time value of money. Using the interest rate, forward values are converted to present value amounts to determine the option premium.

$$\mathrm{P}_{call} = \frac{\partial C}{\partial r} = TKe^{-rT} N\left(h_2\right) > 0$$

$$\mathrm{P}_{put} = \frac{\partial P}{\partial r} = -TKe^{-rT} N\left(-h_2\right) < 0$$

Rho (r-d)=0

In cases where the continuously compounded dividend yield and the continuously compounded default-free interest rate are equal, rho can be represented by the following expressions:

$$\mathrm{P}_{call} = \frac{\partial C}{\partial r} = -TC < 0$$

$$\mathrm{P}_{put} = \frac{\partial P}{\partial r} = -TP < 0$$

Vega (Kappa)

Vega (or kappa) represents the sensitivity of an option premium to a one percent change in the volatility expectation for the return of the underlying asset.

$$\mathrm{K}_{call} = \frac{\partial C}{\partial \sigma} = S_0 e^{-dT} N\left(h_1\right)\sqrt{T} > 0$$

$$\mathrm{K}_{put} = \frac{\partial P}{\partial \sigma} = S_0 e^{-dT} N\left(h_1\right)\sqrt{T} > 0$$

The more volatile the asset, the greater the value of a bought option. Because volatility is a multiplier of time in the model, volatility has a greater effect for options that have a long term to expiry. Thus, vega (kappa) will be larger for options on these assets.

Theta

Theta represents the sensitivity of an option premium to time (theta itself is sensitive to whether an option is at the money). Options with a greater time to expiry have greater value. The value of theta indicates the rate of decay in the value of the option premium given the passage of one day.

$$\Theta_{call} = -\frac{\partial C}{\partial T} = -\frac{S_0 e^{-dT} N\left(h_1\right)\sigma}{2\sqrt{T}} + dS_0{}^{-dT} N(h_1) - rKe^{-rT} N(h_2) <> 0$$

$$\Theta_{put} = -\frac{\partial P}{\partial T} = -\frac{S_0 e^{-dT} N\left(h_1\right)\sigma}{2\sqrt{T}} - dS_0{}^{-dT} N(-h_1) + rKe^{-rT} N(-h_2) <> 0$$

Exotic Options

BarraOne defines the Greeks for all exotic options as follows:

Greek	Definition
Delta	dollar amount change as the underlying asset price changes 1%
Gamma	delta dollar amount change as the underlying asset price changes 1%
Interest Rate Delta (Rho)	dollar amount change as the interest rate changes 1 basis point
Interest Rate Gamma	delta dollar amount change as the interest rate changes 1 basis point
Foreign Exchange Delta	dollar amount change as the foreign exchange rate (financial product currency per reporting currency) changes 1% for foreign instrument
Foreign Exchange Gamma	delta dollar amount change as the foreign exchange rate (financial product currency per reporting currency) changes 1% for foreign instrument
Vega (Kappa)	dollar amount change as the volatility changes 1% for derivatives
Theta	dollar amount change as the valuation date moves one day forward

Trinomial Tree Model

Instruments that are valued using the "Trinomial Tree Model" on page 426 include the following:

- Swaptions (Bermudan)
- Cancelable swaps
- Convertible bonds (European and American)
- Equity options (American and Bermudan)
- Equity index future options (American)
- FX options (American and Bermudan)
- Commodity future options (American)

For these instruments, the Greeks are calculated from the tree lattice.

Chapter 4

Value at Risk

This chapter is dedicated to the treatment of Value at Risk in BarraOne.

Introduction

Value at Risk (VaR) can be defined as the worst-case loss that might be expected from holding a security or portfolio over a given period of time (say a single day or 10 days for the purpose of regulatory capital reporting), given a specified level of probability (known as the "confidence level"). While volatility as measured by standard deviation and tracking error have been the traditional risk measures of choice for most asset manager and asset owners, these managers increasingly look to complement the use of standard deviation and tracking error with VaR.

The appeal of VaR revolves around:

- Intuitiveness of the VaR measure as a dollar or numeraire loss for a given confidence level
- Flexibility in terms of confidence level and holding period
- Useful related measures such as marginal VaR, relative VaR, and incremental VaR that provide further insight to the potential losses of the portfolio in the tail

There are a number of different methods of calculating VaR, including non-parametric, parametric, historical simulation, and Monte Carlo simulation. Each method embodies methodological choices and assumptions, such as the amount of historical data used and the weighting of historical results.

BarraOne provides fast, efficient parametric VaR forecasts using the Barra Integrated Model (BIM). BIM is Barra's global, multi-asset class factor risk model. Monte Carlo VaR complements this offering, and this chapter introduces the key features of the historical VaR and Monte Carlo VaR offerings in BarraOne.

Valuation Methodology

BarraOne uses the same pricing methodology for VaR simulation as it does for standard factor risk analysis. In standard factor risk analysis, equity factor exposures are set monthly, while fixed income and interest rate derivatives are valued daily using current market conditions to determine risk factor exposures. In VaR simulation, a complete revaluation of all fixed income and derivative assets in the portfolio is carried out using the market risk factors applicable to each day in the simulation period (for equities, daily returns are stored and used directly in the simulation).

The valuation methodology for specific instruments can be found in "Overview" on page 258 in Chapter 3, "Asset Analytics."

VaR Analytic Definitions

VaR

The potential loss—either in currency units or in percent of value—in a given period for a given probability (confidence level). VaR is always reported as a positive number when it represents potential loss. In the case of a potential gain, both VaR (currency units) and VaR (%) are reported as 0.

VaR (currency units)

The VaR corresponding to the set of historical/simulated P&L $\{\Delta P_1, \Delta P_2, \Delta P_3, \ldots, \Delta P_N\}$ and corresponding to scenarios $\{t_1, t_2, t_3, \ldots, t_N\}$, (ordered from present to past in historical VaR, and ordered by scenario number in Monte Carlo VaR), is obtained by first sorting the P&Ls from the highest loss to the highest gain: $\{\Delta Po_1, \Delta Po_2, \Delta Po_3, \ldots, \Delta Po_N\}$, where o_i gives the scenario corresponding to the i^{th} highest loss. For example, if the worst loss corresponds to scenario t_{10}, then o_1=10.

Each scenario ΔPo_i is then assigned a probability weight $P_i \propto \lambda^{o_i}$ depending on a user-specified decay factor that gives more weight to recent observations (λ=1 corresponds to an equal weighting scheme, where $P_i = 1/N$). The VaR statistic is defined in the usual way:

VaR (currency units) = abs [min (ΔPo_i*, 0)]*

where i is the scenario number such that $\sum_{k=1}^{i} P_k = (1 - \text{confidence level \%})$

and N is the number of simulation runs.

Note: If i does not fall on a whole number, then VaR is computed with a linear interpolation. The interpolation is given as follows:

$$VaR\ (currency\ units) = abs[min(((c_{m+1} - c)\Delta Po_m + (c - c_m)\Delta Po_{m+1})/(c_{m+1} - cm), 0)]$$

where:

$c = (1 - confidence\ level\ \%)$

m and m+1 = two consecutive integers such that $c_m \equiv \sum_{k=1}^{m} P_k < c < \sum_{k=1}^{m+1} P_k$

Excel Replication

To replicate the calculation of VaR (currency units) in Microsoft Excel, you may perform the following steps:

1 Export the raw VaR simulation data to Excel, including the Portfolio P/L and the weight of each observation in the simulation.

2 Sort the columns in step 1 by Portfolio P/L from smallest to largest.

3 Create a new column of cumulative weights, where the first row is the weight of the first simulation observation, the second row is the sum of the weights of the first and second observations, and so on.

4 In the column of cumulative weights, find the two observations that straddle (1– confidence level). For instance, if the confidence level is 90%, find the two rows where one has a cumulative weight just below 10% and the other has a cumulative weight just above 10%.

5 Perform a linear interpolation on the Portfolio P/Ls corresponding to the two rows in step 4 as follows:

$$P_1 + \frac{P_2 - P_1}{CW_2 - CW_1}\left(CL - CW_1\right)$$

where:

P_1 = Smaller Portfolio P/L

P_2 = Larger Portfolio P/L

CW_1 = Cumulative weight associated with P_1

CW_2 = Cumulative weight associated with P_2

$CL = 1$ - confidence level (*e.g.*, 0.1 for a 90% confidence level)

Alternatively, you may use the Excel FORECAST() function as follows:

$$FORECAST(CL, P_1 : P_2, CW_1 : CW_2)$$

6 Take the result of step 5, and multiply by the market value of the portfolio or asset to obtain the VaR (currency units) value.

VaR (%)

The above expressions use ΔP defined in terms of absolute P&L, *i.e.,* P&L expressed in currency terms. We can analogously define $\Delta P\%$ in terms of returns by rewriting:

$$\Delta P\% = \Delta P / Po = \sum_j (Po_j / Po)\, \Delta P_j \;/ Po_j \; = \sum_j w_j\, \Delta P\%_j$$

where the index 0 indicates the mark-to-market value of the portfolio (Po) or the mark-to-market of an asset or subportfolio j (Po_j), and $w_j = (Po_j / Po)$. Note that assets or subportfolios with mark-to-market potentially equal to zero have weights w_j and $\Delta P\%_j$ defined in terms of an effective price, but always:

$w_j \, \Delta P\%_j = \Delta P_j \, / \, Po.$

The derivation of VaR% simply replaces ΔPo_i with $\Delta P\%o_i$.

Component VaR

Component VaR is a measure of the contribution to portfolio VaR from each asset or subportfolio. The component VaR corresponding to asset or subportfolio j ($CmVaR_j$) provides insight into position level sources of VaR and is defined so that:

$$VaR = \sum_j CmVaR_j \quad \text{or} \quad VaR\% = \sum_j CmVaR\%_j$$

We see that VaR% depends linearly on the set of w_j, and we can write:

$$VaR\% = \sum_j w_j \partial VaR\% \, / \, \partial w_j$$

From the above, we can identify:

$$CmVaR\%_j = w_j \, \partial VaR\% \, / \, \partial w_j$$

Thus, $CmVaR_j$ (or its % equivalent) can be identified with the contribution to ΔPo_i (or its % equivalent) coming from asset (or subportfolio) j, *i.e.,*

$$CmVaR_j = \Delta Pjo_i$$

$$CmVaR\%_j = w_j \Delta P\%jo_i$$

Incremental VaR

The change in portfolio VaR due to adding or deleting a position from the portfolio.

$$IVaR_j = \text{VaR (portfolio including asset } j\text{)} - \text{VaR (portfolio excluding asset } j\text{)}$$

Marginal VaR

Marginal VaR measures the change in portfolio VaR due to a 1% increase in the weight of the underlying asset or subportfolio. We can write, to a first approximation:

$$MVaR\%_j = VaR\%(w_j{+}1\%) - VaR\%(w_j) = \partial VaR\% \, / \, \partial w_j \, / \, 100 = CmVaR\%_j \, / \, (100 w_j)$$

Equivalently,

$$MVaR\%_j = \Delta P\%_j \, o_i \, / \, 100$$

Note that $MVaR\%_j$ answers the following question: Given a portfolio with an asset characterized by a weight equal to n%, what would the change in VaR be (in percentage return) if the weight goes from n% to (n+1)%?

Excel Replication

To replicate the calculation of Marginal VaR in Microsoft Excel, you may perform the following steps:

1. Export the portfolio's raw VaR simulation data to Excel, including the Portfolio P/L and the weight of each observation in the simulation.

2. In the portfolio's Excel worksheet from Step 1, sort the rows by Portfolio P/L from smallest to largest.

3. Create a new column of cumulative weights, where the first row is the weight of the first simulation observation in Step 2, the second row is the sum of the weights of the first and second observations, and so on.

4. In the column of cumulative weights, find the two observations that straddle (1− confidence level). For instance, if the confidence level is 90%, find the two rows where one has a cumulative weight just below 10% and the other has a cumulative weight just above 10%.

5. Record the Scenario numbers and the respective cumulative weights corresponding to the two observations in Step 4.

6. Export the asset's raw VaR simulation data to Excel, including the Portfolio P/L.

7. In the asset's Excel worksheet, record the asset's Portfolio P/Ls corresponding to the Scenario numbers recorded in Step 5.

8. Perform a linear interpolation on the asset's Portfolio P/Ls from Step 7 as follows:

$$P_1 + \frac{A_2 - A_1}{CW_2 - CW_1}\left(CL - CW_1\right)$$

where:

A_1 = Asset's Portfolio P/L associated with Scenario number of P_1

A_2 = Asset's Portfolio P/L associated with Scenario number of P_2

P_1 = Smaller of portfolio's Portfolio P/L

P_2 = Larger of portfolio's Portfolio P/L

CW_1 = Cumulative weight associated with P_1

CW_2 = Cumulative weight associated with P_2

CL = 1 - confidence level (*e.g.*, 0.1 for a 90% confidence level)

Alternatively, you may use the Excel FORECAST() function as follows:

$$FORECAST(CL, A_1 : A_2, CW_1 : CW_2)$$

9 Take the result of Step 8, and divide by the effective weight X 100 of the portfolio or asset to obtain the Marginal VaR (currency units) value.

Expected Shortfall (Conditional VaR)

The expected loss once a VaR event occurs. While VaR can be interpreted as the best possible loss breaching VaR, given a certain confidence interval, ES (Expected Shortfall) provides an indication of the magnitude of the expected loss, given that a VaR breaching event takes place.

Mathematically, ES is the average of all the losses beyond VaR, *i.e.,*

$$ES = E < \Delta Po_1, \Delta Po_2, \dots, \Delta Po_i > = \sum_{k=1}^{i} \frac{p_k}{W} \Delta Po_k$$

where $E < >$ denotes the expected value, and i and p_k are defined as in "VaR (currency units)" on page 453, but the probabilities are now normalized using only scenarios where the loss equals or exceeds VaR

$$(W = \sum_{k=1}^{i} p_k).$$

Note: If i does not fall on a whole number, then ES is computed in the following way:

Let c = (1 – confidence level %), and assume that m and m+1 are two consecutive integers such that:

$$c_m \equiv \sum_{k=1}^{m} p_k \leq c \leq \sum_{k=1}^{m+1} p_k \equiv c_{m+1}$$

We define the weight of the estimated VaR loss to be:

$$p = \frac{(c - c_m)}{c_{m+1} - c_m} p_{m+1}$$

and compute:

$$ES = \frac{pVaR + \sum_{k=1}^{m} p_k \Delta Po_k}{W} \text{ where } W = p + \sum_{k=1}^{m} p_k .$$

VaR Diversification

The benefits of diversification due to lack of perfect correlation between assets in a portfolio.

$$Diversification\ Gains = \sum_{j=1}^{n} VaR_j - VaR(Portfolio)$$

where VaR_j is the VaR for asset j in the portfolio.

Active VaR

The risk of underperformance of a portfolio relative to a benchmark or reference portfolio for a given confidence interval and time horizon.

Active VaR (currency units)

$$\textit{Active VaR} = abs\ [min\ (\ \{\Delta AP^*_i \mid \Delta AP_0, \Delta AP_1, \Delta AP_2, ..., \Delta AP_i ..., \Delta AP_n\}\ ),\ 0)]$$

where ΔAP_1, ΔAP_2, ΔAP_3, …, ΔAP_n are the simulated active profits and losses in reporting currency, ranked from worst loss to highest gain,

$$\Delta AP_i = MV_p \times \sum_{j=1}^{m} (w_{jp_i} - w_{jb_i})(R_j)$$

m includes all assets in the portfolio and the benchmark, w_{jp} = weight of asset j in portfolio, w_{jb} = weight of asset j in benchmark, R_j = return of asset j, MV_p = Market Value of portfolio at evaluation date, and

i is defined such that $\displaystyle\sum_{l=1}^{i} \frac{w_l}{\sum_{k=1}^{N} \lambda^k} = (1 - \text{confidence level }\%)$

where $w_l = \lambda^k$, λ is the decay factor for the data series, k is the scenario number corresponding to ΔAP_1, ΔAP_2, ΔAP_3, …, ΔAP_i, ranked from worst loss to highest gain, and N is the number of simulation runs.

Note: If i does not fall on a whole number, then VaR is computed with linear interpolation.

Excel Replication

To replicate the calculation of Active VaR (currency units) in Microsoft Excel, you may perform the following steps:

1 Export the raw VaR simulation data to Excel, including the Portfolio P/L, the Benchmark P/L, and the weight of each observation in the simulation.

2 In Excel, for each simulation observation, subtract the Benchmark P/L from the Portfolio P/L to obtain the Active P/L for each observation in a new column.

3 Take the resulting column from step 2 along with the respective column of observation weights, and sort these columns by Active P/L from smallest to largest.

4 Create a new column of cumulative weights, where the first row is the weight of the first simulation observation, the second row is the sum of the weights of the first and second observations, and so on.

5 In the column of cumulative weights, find the two observations that straddle (1– confidence level). For instance, if the confidence level is 90%, find the two rows where one has a cumulative weight just below 10% and the other has a cumulative weight just above 10%.

6 Perform a linear interpolation on the Active P/Ls corresponding to the two rows in step 5 as follows:

$$AP_1 + \frac{AP_2 - AP_1}{CW_2 - CW_1}(CL - CW_1)$$

where:

AP_1 = Smaller Active P/L

AP_2 = Larger Active P/L

CW_1 = Cumulative weight associated with AP_1

CW_2 = Cumulative weight associated with AP_2

CL = 1 - confidence level (*e.g.*, 0.1 for a 90% confidence level)

Alternatively, you may use the Excel FORECAST() function as follows:

$$FORECAST(CL, AP_1 : AP_2, CW_1 : CW_2)$$

7 Take the result of step 6, and multiply by the market value of the portfolio or asset to obtain the Active VaR (currency units) value.

Active VaR (%)

Active VaR (%) = Active VaR (currency units)/abs (MV [portfolio|asset])

▷ **Note:** The absolute market value of the portfolio is used so that in the short portfolio case the VaR (%) has the same sign as VaR (currency units).

Active Marginal VaR

The change in portfolio VaR due to a 1% increase in the active weight of the underlying asset or subportfolio.

$$AMVaR_j = \partial \frac{AVaR_p}{w^a{}_j} \quad \text{(scaled to 1\%)}$$

Active Component VaR

The contribution of each asset or subportfolio to the portfolio's Active VaR; provides insight into position-level sources of Active VaR.

$$ACompVaR = AMVaR_j * w_j^a$$

Active Incremental VaR

The change in Active VaR due to adding or deleting a position from the portfolio.

$AIVaR_j$ = Active VaR (portfolio including asset j) – Active VaR (portfolio excluding asset j)

Note: Marginal VaR computation does not require resimulation of the portfolio.

Using $\text{Active Contribution to P\&L}^{i}_{j}$, one can recompute the VaR for the portfolio with or without a particular asset or subportfolio.

Active Expected Shortfall (Active Conditional VaR)

The potential loss once a VaR event occurs. It provides a sense of the magnitude of loss in an event outside the selected confidence level. Mathematically, it is the mean of the tail distribution (Active P&L).

$$AES\ /\ ACVaR = \mu(\Delta AP_{i-1}, \Delta AP_{i-2}, \Delta AP_{i-3}, \ldots, \Delta AP_{i-n}, \ldots, \Delta AP_1)$$

Refer to "Active VaR (currency units)" on page 458 for a discussion of the ranking and weighting of P&Ls, a definition of VaR scenarios, and an explanation of linear interpolation.

Active VaR Diversification

The benefits of diversification due to lack of perfect correlation between assets in a portfolio in active space.

$$Active\ Diversification\ Gains = \sum_{j=1}^{n} AVaR_j - AVaR(Portfolio)$$

where VaR_j is the VaR for asset j in the portfolio or subportfolio. Active VaR at the asset or subportfolio level is defined relative to the portfolio benchmark for the purposes of calculating active diversification gain.

Portfolio / Benchmark VaR Ratio

The ratio of portfolio VaR to benchmark VaR.

Ratio of Portfolio VaR to Benchmark VaR = Portfolio VaR / Benchmark VaR

expressed as a percentage. For example, if the portfolio VaR is twice as large as the benchmark VaR, then the ratio of portfolio VaR to benchmark VaR is 200%. For this computation, the VaR (%) of the portfolio and benchmark is used.

VaR Analytic Summary

BarraOne produces the following VaR statistics at the portfolio, group, and asset level:

Table 24: VaR Statistics

Analytic	Definition	Portfolio Level	Group Level	Asset Level
VaR	The potential loss—either in currency units or percent of value—in a given period for a given probability (confidence level)	Yes	Yes	Yes
Component VaR	The contribution of each asset or subportfolio to the portfolio's VaR; provides insight into position-level sources of VaR	No	Yes	Yes
Incremental VaR	The change in portfolio VaR due to adding or deleting a position in the portfolio	No	Yes	Yes
Marginal VaR	The change in portfolio VaR due to a 1% increase in the weight of the underlying asset or subportfolio	No	Yes	Yes
Expected Shortfall/CVaR	The potential loss once a VaR event occurs. It provides a sense of the magnitude of loss in an event outside the selected confidence level. Mathematically, it is the mean of the tail distribution.	Yes	Yes	Yes
VaR Diversification	The benefits of diversification due to lack of perfect correlation between assets in a portfolio	Yes	Yes	No
Active VaR	The risk of underperformance of a portfolio relative to a benchmark or reference portfolio for a given confidence interval and time horizon	Yes	Yes	Yes
Active Component VaR	The contribution of each asset or subportfolio to the portfolio's Active VaR; provides insight into Position-level sources of Active VaR	No	Yes	Yes
Active Incremental VaR	The change in Active VaR due to adding or deleting a position in the portfolio	No	Yes	Yes
Active Marginal VaR	The change in portfolio VaR due to a 1% increase in the active weight of the underlying asset or subportfolio	No	Yes	Yes
Active VaR Diversification	The benefits of diversification due to lack of perfect correlation between assets in a portfolio in active space	Yes	Yes	No
Active Expected Shortfall/CVaR	The potential loss once a VaR event occurs. It provides a sense of the magnitude of loss in an event outside the selected confidence level. Mathematically, it is the mean of the tail distribution (Active P&L)	Yes	Yes	Yes
Portfolio/ Benchmark VaR Ratio	The ratio of portfolio VaR to benchmark VaR	Yes	No	No

User Settings

This section outlines the effects of various user choices on VaR calculations.

Base Value

All VaR analytics are calculated in terms of the Base Value of the Strategy, rather than in terms of the net Market Value. Users set a Base Value different from net to capture leverage. For example, the net market value of a portfolio may be $750MM, while the capitalization is only $250MM. In this case, the user assigns a Base Value of $250MM. This implies financial leverage of 300%.

If the user sets a Base Value for the portfolio, then this Base Value is used as the market value for the portfolio for the purposes of the VaR calculations. The weights used are also based on the Base Value instead of the portfolio's net market value. BarraOne supports the following Base value types: Assigned, Long, Long+Short, and Net.

For the assumptions behind this approach, see the following table:

Measure	Base Value > Net Market Value	Base Value < Net Market Value
Portfolio Value	Increases	Decreases
Portfolio Returns	Decreases	Increases
VaR (currency units)	Stays the same	Stays the same
VaR (%)	Decreases	Increases

Analytically, the leverage is taken into account by adding/subtracting cash from the portfolio. Notice that VaR (currency units) stays the same, because cash has zero return. If one adds cash to the portfolio (the case in which Base Value > Net Market Value), the extra cash reduces the risk of the portfolio, and therefore VaR (%) decreases.

For active VaR calculations, the benchmark market value will not depend on the portfolio's base value. The benchmark uses its Net Value, regardless of the Base Value type saved for the benchmark. For comparability, the benchmark market value used for Benchmark VaR (currency units)—displayed in the Portfolio P/L Distribution report and the Portfolio VaR Overview report—is based on the portfolio's Base Value.

Base Currency Versus Reporting Currency

If a portfolio's strategy contains an assigned base value, and if the reporting currency assigned by the user in the VaR export set is different from the portfolio's base currency in the strategy, then BarraOne adjusts the portfolio's assigned value to its equivalent in the reporting currency and displays weight and risk numbers in the report accordingly.

For example, suppose the portfolio's strategy contains an assigned base value of 1,000,000 and a base currency of USD. Also suppose that an export set is created that includes the VaR Positions Report and that EUR is selected as the reporting currency. When the report is exported, BarraOne adjusts the portfolio's assigned base value to the EUR equivalent of 1,000,000 USD (such as 750,000 EUR, or whatever the exchange amount is on the analysis date) and reports the weight and risk numbers accordingly.

User Spreads

Users may import spreads for the following asset types, and that spread will be used when revaluing the asset:

- Bonds (system and user assets)
- Convertible bonds (system and user assets)
- Credit default swaps (price is quoted in spread)
- Structured products

Simulation Methods

The following table describes the simulation methods in detail for the different asset types:

Table 25: Simulation Methods

Instrument (Market)	Simulation Method
Agency Bond (U.S.)	Apply historical/simulated term structure changes to current term structure. Revalue bond using simulated term structure.
Bond Future (Australia, Canada, U.K., Euro, Germany, Japan, Korea, Spain, Sweden, Switzerland, U.S.)	Apply historical/simulated term structure changes to current term structure. Revalue the deliverable bonds using simulated term structure. Compute the profit/loss of the future based on the change in value of the underlying bonds.
Bond Future Option	Apply historical/simulated term structure changes to current term structure. Revalue the deliverable bonds using simulated term structure. Compute the profit/loss of the future option based on the change in value of the underlying bonds.
Bond Option	Apply historical/simulated term structure changes to current term structure. Revalue the underlying bond using simulated term structure. Revalue the bond option using the Crank-Nicholson algorithm.
Commercial Paper	Apply historical/simulated term structure and spread changes to current term structure. Revalue commercial paper using simulated term structure and credit spread.
Commodity	Historical/simulated change in the commodity price is applied to the commodity price as of the analysis date.
Commodity Future Commodity Index Future	Historical simulation of commodity (index) futures is obtained by using the return history of the Rolling Maturity Futures associated with the commodity. Monte Carlo simulation requires generating market scenarios from simulated factor returns. A new market scenario corresponds to a new set of prices for the futures price data corresponding to the effective date.
Commodity Future Option	Historical simulation of options on commodity (index) futures is obtained by using the return history of the Rolling Maturity Futures associated with the commodity. Monte Carlo simulation requires generating market scenarios from simulated factor returns. A new market scenario corresponds to a new set of prices for the futures price data corresponding to the effective date. In HVaR, if the price currency and base currency are different, then FX rates are incorporated in the analysis.
Composite of Barra-supplied index or the user's own portfolio	To revalue composite assets, BarraOne simulates the profit/loss of the composite's constituent assets over the holding period. The composite's profit/loss is computed as the sum of the profit/loss of each constituent asset. If the user provides returns for the composite, then BarraOne uses those returns, rather than the constituent returns, to compute the historical VaR for the composite.

Table 25: Simulation Methods (Continued)

Instrument (Market)	Simulation Method
Convertible Bond (U.S. and Global)	Apply historical/simulated term structure and spread changes to current term structure. Revalue bond portion of the security using simulated term structure and credit spread. Apply historical/simulated equity price changes to the underlying equity and revalue the conversion option. The value of the convertible is computed as the sum of the value of the bond portion and the value of the option. The interest rate volatility for embedded options is held constant over the holding period in historical VaR, but it is simulated in Monte Carlo VaR. The equity implied volatility is held constant in both historical VaR and Monte Carlo VaR.
Corporate Bond (U.S. and Global)	Apply historical/simulated term structure and spread changes to current term structure. Revalue bond using simulated term structure and credit spread. The interest rate volatility for embedded options is held constant over the holding period in historical VaR, but it is simulated in Monte Carlo VaR.
Credit Default Swap	Apply historical/simulated credit spread changes to current CDS spread. Use the new CDS spread to revalue the instrument.
CDS Option	Historical VaR employs a full revaluation of the option. Historical spreads of the option underlier(s) are used for credit spread simulation, while volatility is kept constant. Monte Carlo VaR for CDS options uses the Delta Approximation Method. P/L is estimated by combining simulated factor returns and option exposures.
Currency	Historical/simulated changes in exchange rates are applied to the current exchange rate. The currency is marked to market with the simulated exchange rate.
Currency Forward	Historical/simulated term structure changes are applied to the current term structure. Historical/simulated currency exchange rates are applied to current exchange rates. The simulated term structure and exchange rates are used to compute the net present value of the two legs of the currency forward.
Currency Future	Historical/simulated term structure changes are applied to the current term structure. Historical/simulated currency exchange rates are applied to current exchange rates. The simulated term structure and exchange rates are used to compute the holding period profit/loss for the currency future.
Duration Proxy	If key rate durations have been provided, the duration proxies are revalued using a "KRD approximation." The change in price (as a percentage of par) is computed as follows: $\Delta P \approx \sum_{i=1}^{n}(-KRD_i \cdot \Delta r_i) - SpreadDuration \cdot \Delta OAS$ With accrued interest, the percentage P&L change is computed as follows: $\Delta P \approx \left[\sum_{i=1}^{n}(-KRD_i \cdot \Delta r_i) - SpreadDuration \cdot \Delta OAS\right] \times \frac{P_{Clean}}{P_{Dirty}}$

Table 25: Simulation Methods (Continued)

Instrument (Market)	Simulation Method
Equity Future Equity Index Future	For HVaR, the raw simulation P/L(%) = user-imported return. If the user-imported return does not exist, then the raw simulation P/L(%) = the raw simulation P/L(%) of the underlying equity (index). For MCVaR, the simulated change in the underlying equity's price is applied to the equity price as of the analysis date. The profit/loss of the future position is based on the change in the underlying equity's price. If the price currency and base currency are different, then FX rates are incorporated in the analysis.
Equity Index (Selected Global)	Historical/simulated change in the equity index's price is applied to the equity index price as of the analysis date.
Equity Option	Historical/simulated change in the underlying equity's price is applied to the equity price as of the analysis date. The historical/simulated change in the applicable term structure is applied to the current term structure. The simulated equity price and simulated term structure is used to revalue the equity option. In HVaR, if the price currency and base currency are different, then FX rates are incorporated in the analysis. If the user provides a prioritized price for the option, the implied volatility will be calibrated using this price. Alternatively, the user can provide the implied volatility (either term structure attribute, schedule TnC, or static TnC). If neither the price nor the implied volatility is supplied, BarraOne will use the underlier's risk as forecasted by the Barra Integrated model as the implied volatility. The implied volatility of option is simulated in historical VaR, but is held constant over the holding period in Monte Carlo VaR. In MCVaR, the dividend yield on the analysis date is used for the initial valuation of the option, and the dividend yield on the horizon date is used for the simulated P&L of the option.
Equity Security (Global)	Historical/simulated change in the equity's price is applied to the equity price as of the analysis date.
Equity Volatility Derivative	The historical return of a futures price is calculated by linear interpolation between the corresponding Rolling Maturity Future returns. The simulated return of non-futures instruments is calculated through a full revaluation with a perturbed futures price curve and interest rate curve. The simulated return of futures instruments is the change in the futures price curve calculated from the return of the corresponding futures contract.
Eurobond (Global)	Apply historical/simulated term structure changes to current term structure. Revalue bond using simulated term structure.
Exchange-Traded Fund	Historical/simulated daily changes in the price of the ETF are applied to the current price of the ETF.
Floating Rate Note (U.S. and Global)	Apply historical/simulated term structure and spread changes to current term structure. Revalue the bond using the new term structure and spread. The interest rate volatility for embedded options is held constant over the holding period in historical VaR, but it is simulated in Monte Carlo VaR.
Government Note/Bond (Global)	Apply historical/simulated term structure changes to current term structure. Revalue bond using simulated term structure.

Table 25: Simulation Methods (Continued)

Instrument (Market)	Simulation Method
Hedge Fund	Historical/simulated VaR hedge fund returns are estimated using a market beta approach. In summary, each hedge fund is sensitive to one or more markets. The list of markets can be determined by examining the exposure set for the hedge fund. The markets can include equity and fixed income. For equity markets, BarraOne computes the hedge fund's beta with respect to each market. The beta and the market return is used to compute the equity portion of the historical/simulated VaR scenario return. To compute the fixed income portion of the hedge fund return, BarraOne uses STB–KRD conversion.
Inflation Linked Liability	Historical VaR employs full revaluation. Historical realized inflation is used for simulation, while volatility is kept constant (applies to caps and floors). Monte Carlo VaR for inflation-linked liabilities uses the Delta Approximation Method.
Inflation-Protected Bond (Australia, Canada, Euro, New Zealand, South Africa, Sweden, U.K., U.S.)	Apply historical/simulated real term structure changes to current real term structure. Revalue bond using simulated term structure.
Interest Rate Swap	Apply historical/simulated term structure changes to current term structure. Revalue each leg of the interest rate swap. The sum of the value of the two legs is the new market value of the swap.
Mortgage-Backed Security (U.S.)	Apply historical/simulated term structure and spread changes to current term structure. The simulated term structure is supplied as an input to the mortgage prepayment model. The MBS is revalued using the simulated term structure, spread, and new prepayment forecasts. **Note:** The Prepayment Model is not recalibrated in MCVaR.
Municipal Bond (U.S.)	Apply historical/simulated municipal term structure changes to current municipal term structure. Revalue bond using simulated term structure.
Mutual Fund/Unit Trust	The Monte Carlo VaR simulated return of the mutual fund is computed using the beta to the market, where the "market" for a mutual fund is the estimation universe of stocks for the currency of the fund. Actual mutual fund returns are not used, but rather the exposures computed for the mutual fund and the exposures computed for the stocks in the estimation universe are used to compute a correlation (beta) between the mutual fund and the estimation universe. The return of the fund is based on this beta between the mutual fund and the estimation universe. For historical VaR, the following methodology is used: 1.Get the daily returns. 2.If there are gaps in the daily returns, then fill the gaps with approximated returns (computed with beta-to-index, and/or IR-related, and/or FX-related returns). 3.Compute the holding period returns.

Table 25: Simulation Methods (Continued)

Instrument (Market)	Simulation Method
Private Equity	For HVaR, the user should provide returns for Private Equity assets. Otherwise, Historical VaR Simulation will be based upon the betas of these assets to the estimation universe (ESTU portfolio) and the daily returns of the ESTU. For MCVaR, Private Equity is treated as an equity factor asset. Because there are no daily factor returns, it is treated like a hedge fund asset in the short-term covariance matrix.
Private Real Estate	Private real estate is treated like an equity factor asset. Because there are no daily factor returns, the asset is treated like a hedge fund asset when using a short-term covariance matrix.
Structured Products (U.S., EMU): • USD-denominated RMBS (Agency CMO/ REMIC, Whole Loan CMO/REMIC) • USD-denominated ABS (Home Equity, Manufactured Housing, Credit Card, Auto, Equipment, Student Loans) • USD-denominated CMBS • EUR-denominated RMBS, ABS, CMBS	Revalue asset using a "KRD approximation." The change in price is computed as follows: $$\Delta P \approx \sum_{i=1}^{n} (-KRD_i \cdot \Delta r_i) - SpreadDuration \cdot \Delta OAS$$ BarraOne uses user-provided spreads, if available. If prices and spreads are available, BarraOne uses the Price/Spread priority to determine which to use. If there are gaps in the spread and price data available, BarraOne uses its spread calibration methodology.
StructureTool Assets	Apply historical/simulated term structure and spread changes to current term structure. Revalue StructureTool asset using simulated term structure and credit spread. The interest rate volatility for embedded options is held constant over the holding period in historical VaR, but it is simulated in Monte Carlo VaR.
Term Deposit	Apply historical/simulated term structure changes to current term structure. Revalue the term deposit using the simulated term structure.

Sample Reports

Portfolio VaR Overview Report

The Portfolio VaR Overview Report shows basic VaR statistics for a portfolio, including a list of positions in the portfolio that contribute the most (or least) to VaR exposures.

VaR Portfolio/VaR Benchmark % : 95.058	Portfolio	Benchmark
VAR %	4.96	5.21
VAR $	52,665,422	685,119,158,889
NAV	1,062,800,807.78	N/A

Portfolio VaR (% NAV)	4.955
Derivative	0.00
Non-derivative	4.96

Positions: Top 5 by Market Value	Instrument	
EXXON MOBIL CORP	Equity Security	110,819,728.40
GENERAL ELECTRIC CO	Equity Security	84,386,065.85
MICROSOFT CORP	Equity Security	57,140,264.87
CITIGROUP INC	Equity Security	50,978,859.42
BANK OF AMERICA CORPORATION	Equity Security	42,433,687.40

Positions: Top 5 by Component VaR	Instrument	
EXXON MOBIL CORP	Equity Security	12,189,105.95
CHEVRON CORP NEW	Equity Security	4,080,160.58
GENERAL ELECTRIC CO	Equity Security	3,833,540.70
MICROSOFT CORP	Equity Security	3,500,622.63
CITIGROUP INC	Equity Security	2,436,261.15

Positions: Top 5 by Marginal VaR	Instrument	
CORNING INC	Equity Security	1,423,515.78
WYETH	Equity Security	1,332,767.23
BRISTOL MYERS SQUIBB CO	Equity Security	1,218,283.87
EXXON MOBIL CORP	Equity Security	1,168,978.83
CHEVRON CORP NEW	Equity Security	1,158,670.35

Positions: Bottom 5 by Marginal VaR	Instrument	
APPLIED MATLS INC	Equity Security	-399,687.72
PEPSICO INC	Equity Security	-135,706.93
PROCTER & GAMBLE CO	Equity Security	-20,650.96
VERIZON COMMUNICATIONS	Equity Security	49,562.90
JOHNSON & JOHNSON	Equity Security	69,061.73

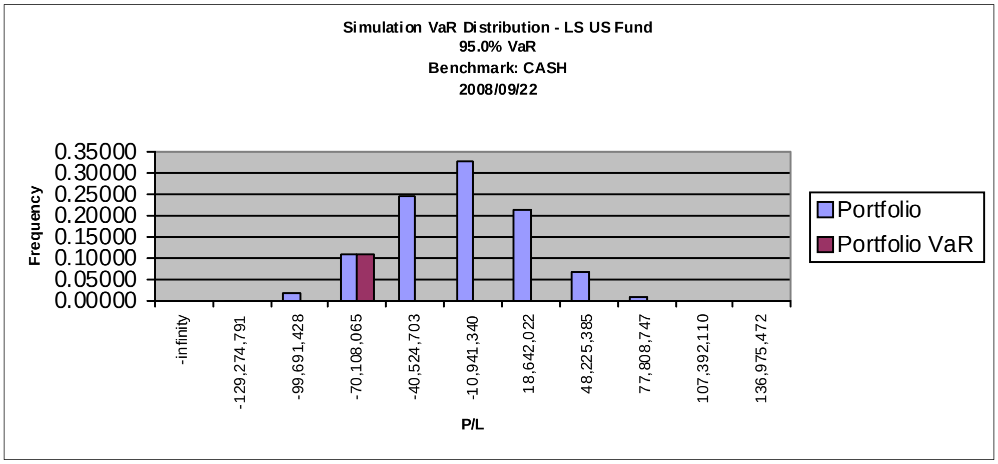
Industry Breakdown Summary Report

The industry summary breakdown shows the contributions of industry groups in the portfolio to various VaR statistics. (An industry breakdown detail report is also available, and it displays this information for each asset within each industry group.)

Grouping: GICS Industry	Mkt Value	MC VaR ($)	Active MC VaR ($)	Component MC VaR	Marginal MC VaR	Expected Shortfall
by: distinct	**1,062,800,807.78**	**52,665,422.12**	**1,852,855.23**	**52,665,422.12**	**N/A**	**59,830,061.05**
Automobiles	2,814,353.00	221,246.15	209,406.16	83,514.68	315,381.45	233,388.04
Beverages	47,002,366.31	944,814.60	554,687.13	7,333.91	1,658.32	970,417.32
Biotechnology	12,931,856.34	852,656.72	641,718.82	781,519.68	642,289.65	1,055,421.26
Commercial Banks	41,132,325.22	2,082,484.46	802,640.78	1,236,850.68	319,584.63	2,890,017.47
Communications Equipment	55,549,124.18	3,681,524.23	3,345,183.76	3,608,700.50	690,439.29	3,694,287.62
Computers & Peripherals	91,339,352.91	3,948,081.69	887,756.08	3,708,216.29	431,478.34	4,083,719.33
Diversified Financial Services	126,562,539.32	7,436,558.73	2,289,561.62	4,591,851.72	385,597.80	8,277,667.48
Diversified Telecommunication Services	50,995,608.16	1,540,514.68	1,433,630.05	735,424.42	153,270.00	1,650,199.72
Hotels Restaurants & Leisure	12,762,003.20	1,017,637.47	402,755.72	826,076.43	687,944.27	1,025,685.30
Household Products	32,000,296.70	501,697.79	285,175.72	-62,178.79	-20,650.96	730,595.10
Industrial Conglomerates	84,386,065.85	4,009,820.63	1,354,557.63	3,833,540.70	482,815.51	4,340,333.52
Insurance	30,311,226.49	2,448,742.58	1,136,955.71	1,902,646.36	667,123.81	2,936,263.97
Media	20,710,719.60	1,194,222.62	427,499.03	1,249,657.67	641,280.07	1,229,660.53
Oil Gas & Consumable Fuels	148,245,368.58	16,820,974.54	8,082,980.64	16,269,266.52	1,166,376.38	16,986,269.99
Pharmaceuticals	138,372,994.92	6,571,733.58	2,366,487.54	6,027,726.74	462,971.32	6,875,523.67
Semiconductors & Semiconductor Equipment	50,530,664.60	1,874,706.96	974,780.65	1,930,349.73	406,006.39	2,013,041.89
Software	72,965,976.99	5,123,387.30	2,250,520.01	4,493,643.21	654,530.76	5,538,286.71
Specialty Retail	15,424,255.56	1,708,423.40	1,564,266.61	1,049,899.03	723,427.81	1,716,704.16
Tobacco	28,763,709.85	1,580,003.67	723,950.99	391,382.63	144,613.40	1,784,496.32

Portfolio P/L Distribution Report

The portfolio P/L distribution shows a histogram of the frequency for the different P/L buckets:



It will also display a table of some VaR statistics:

	VaR ($)	Expected Shortfall	VaR Diversification	Active VaR
Portfolio	$8,651	$12,586	$3,011	$2,192
Benchmark	$6,465	$10,783	$2,834	N/A
	Mean	**Standard Deviation**	**Skewness**	**Kurtosis**
Portfolio	$6,663	$10,376	0.06277	–0.00056
Benchmark	$1,800	$6,225	0.02241	–0.00126

VaR Limits Report

This summary report shows breaches of user-defined limits:

Portfolio Name	Benchmark Name	VaR Limit	Portfolio VaR	Difference	Benchmark VaR
Emerging Markets	MSCI Emerging Markets	$100,000	$110,231	$10,231	$50,000
US Long/ Short	US Long Only	$120,000	$145,302	$25,302	$60,000
Leveraged US Market	S&P500	$80,000	$92,000	$12,000	$40,000

Historical VaR

Accessing Historical VaR

You can use BarraOne's historical VaR feature to define, run, and analyze historical simulations. As with other risk reporting functions in the BarraOne platform, you simply specify the portfolios to be analyzed and the simulation and reporting parameters, and then submit the job for processing.

Using BarraOne's historical VaR feature, you can:

- Assign one or many funds to an historical simulation for processing in batch
- Automatically generate historical VaR reports across multiple funds on a regularly scheduled basis
- Analyze results at the asset, group, or fund level (grouping is supported along numerous dimensions)
- Specify an historical data range
- Select scaled (with sampling period) or consecutive data periods
- Use absolute or relative interest rate shocks
- Calibrate bond spreads
- Use an imported implied volatility term structure
- Decompose VaR according to sources of market risk
- Choose to simulate only certain market risk conditions
- View a complete set of VaR statistics

Limitations of Historical Simulation

Historical simulation has its limitations. One notable limitation is the reliance on a particular set of historical data—and thus the idiosyncrasies of that data set. Historical data may capture periods of extreme volatility or unusually low volatility, and may not accurately represent future outcomes. Another limitation is data availability. One year of data corresponds to only 250 data points (trading days) on average, *i.e.,* 250 scenarios. By contrast, Monte Carlo simulations usually involve over 5,000 simulations (*i.e.,* scenarios). Employing small samples of historical data may leave gaps in the distributions of the risk factors and may tend to under-represent the tails of the distribution, *i.e.,* the occurrence of unlikely but extreme events.

One way to compensate for limitations in risk approaches lies in the combination of multiple techniques. Users of historical VaR in BarraOne can specify various data histories and access the Stress Testing module, as well as the BIM-based parametric VaR approach.

Methodology Overview

The historical simulation approach to VaR is conceptually simple and requires a sufficient set of historical data. In applying historical simulation, three steps are involved:

- Select a sample of actual daily risk factor or price changes over a given period, such as 250 days (*i.e.,* one year's worth of trading days).
- Apply those daily changes to the current value of the risk factors or prices, and revalue the current portfolio as many times as the number of days in the historical sample.
- Construct the histogram of portfolio values, and identify the VaR that isolates the first percentile of the distribution in the left tail, assuming VaR is derived at the 99% confidence level.

To create an historical VaR report, the user selects the risk measures, data range, return horizon and confidence level. Based on the methodology described above, BarraOne uses this information to compute the historical VaR simulation measures.

Based on the user-provided portfolio of instruments (equities, bonds, commodities, *etc.*) for which present and historical values can be determined, BarraOne constructs a series of past price changes over the user's designated interval, or data window. This is done for each asset in the portfolio. In other words, each asset can be associated with a series of price changes that falls within a single (common to all assets) data window.

These asset price changes are applied to the current price of the asset to obtain a simulated new value for the asset. (More precisely, each price return is computed from the historical price series and is applied to the current price of the asset to generate the historically simulated new value of the asset.) When performed for all assets, full revaluation provides a new value for the portfolio. This process is repeated for all the dates in the data window, from the start date of the window to its end date, obtaining a new set of hypothetical portfolio values.

Finally, by running a comparison of these historically simulated portfolio values to the current portfolio market value, BarraOne generates portfolio P&Ls that are ranked to form a simulated profit-and-loss distribution. Thus, for a VaR corresponding to 95% confidence, for example, the particular price change selected is one in which 5% of the changes are worse and 95% are better. The selected price change is the historical value at risk.

Essentially, the steps are:

1. Using historical information about price changes of the assets and market changes, BarraOne generates a set of possible future values for the assets, and then calculates the new value of the portfolio.

2. BarraOne repeats step 1 for each future outcome, and accumulate the distribution of portfolio price changes. From this distribution of price changes, VaR, Expected Shortfall, and other statistical quantities are computed.

To carry out the above procedure, BarraOne uses the following:

1. Historical database of asset price and market data changes. BarraOne maintains a history of daily equity returns, as well as market data, to compute prices/returns to fixed income and derivative securities.

2. A pricing model for fixed income and derivative instruments. These pricing models are summarized in "Valuation Methodology" on page 452.

3. A method of generating possible financial future outcomes using historical returns and current market prices as described below.

Computing Returns

BarraOne uses the following methodology to generate financial future outcomes:

Suppose a portfolio depends on i=1, 2, …, M assets. To perform historical simulation, BarraOne provides a time series of N+1 historical daily prices $\{S_i(t_n) \mid t_0 < ... < t_n < .. < t_N < 0\}$ for each asset, where t_n is an observation date, expressed in days relative to the effective (current) date t=0.

Without loss of generality, an asset's time series is assumed to be the same commensurate length N+1. If that is not the case, then BarraOne can use the intersection of all time series to arrive at a common observation date sequence $t_0 < \ldots < t_n < \ldots < t_N$. If there are missing dates, BarraOne applies proxies to fill the gaps in return history.

To generate future prices for each asset, a time horizon h is selected, expressed as number of days. Next, BarraOne identifies the current market price $S_{i(0)}$ of each asset. Combining this information with the historical time series, the simulated future price $S_{(i)}(t_n)$ for asset i, corresponding to scenario n>0 of observation date t_n, is then

$$S_i^*(t_n) = S_i(0) \times \frac{S_i(t_n)}{S_i(t_n - h)}$$

The above equation defines a set $\{S_i^*(t_n) \mid t_0 < ... < t_n < .. < t_I < 0\}$ of simulated future prices for each of the i=1, 2, …, M assets. I is the number of historical simulations; it is a function of the available historical data, which may include the effect of windowing. Each set is generated from the same observation-date sequence $t_0 < \ldots < t_n < \ldots < t_N$, where if non-overlapping intervals are used, then $I=[N/H]$. For example, if N=11 and h=2, then the number of non-overlapping intervals I=5. If scaled returns are used, then the number of historical simulations is the number of sampling periods.

Refer to "VaR Analytic Definitions" on page 453 for details on how these profit and loss calculations are used to generate VaR statistics.

Equity Returns

An equity return, the historical change in the equity's price, is applied to the equity price as of the analysis date. We use the daily asset return first; we use the beta-adjusted market return when the asset return is not available.

The user should provide returns for Private Equity assets. Otherwise, Historical VaR Simulation will be based upon the betas of these assets to the estimation universe (ESTU portfolio) and the daily returns of the ESTU.

Hedge Fund and Mutual Fund Returns

BarraOne computes holding period returns using daily returns if they are available. If there are gaps in the daily returns, then historical VaR mutual fund returns for the gaps are estimated using a market beta approach. In summary, each mutual fund is sensitive to one or more markets. The list of markets can be determined by examining the exposure set for the mutual fund. The markets can include equity and fixed income. For equity markets, BarraOne computes the mutual fund's beta with respect to each market. The beta and the market return are used to compute the equity portion of the historical VaR scenario return. To compute the fixed income portion of the mutual fund return, BarraOne uses the STB to KRD conversion method.

Hedge funds and mutual funds are similar in their common exposures to the traditional equity and fixed income Barra factors. The only differences between hedge funds and mutual funds are the hedge fund factors. Certain hedge funds are exposed to hedge fund-specific factors, but no market has been identified for these factors. Consequently, neither a beta nor a market return can be computed for the hedge fund factors.

Commodities

If an asset (*e.g.,* Custom Exposure Asset or Mutual Fund) has exposure to only a single commodity, HVaR P&L is calculated as *(total Beta between the asset and the corresponding commodity spot)* × *(return of the commodity Rolling Maturity Future of the shortest term)*.

If an asset (*e.g.,* Custom Exposure Asset or Mutual Fund) has exposures to multiple commodities, HVaR P&L is calculated as Σ[*(partial Beta)* × *(return of the commodity Rolling Maturity Future of the shortest term)*], where partial Beta is calculated between only the commodity factors in the asset and the total commodity spot asset.

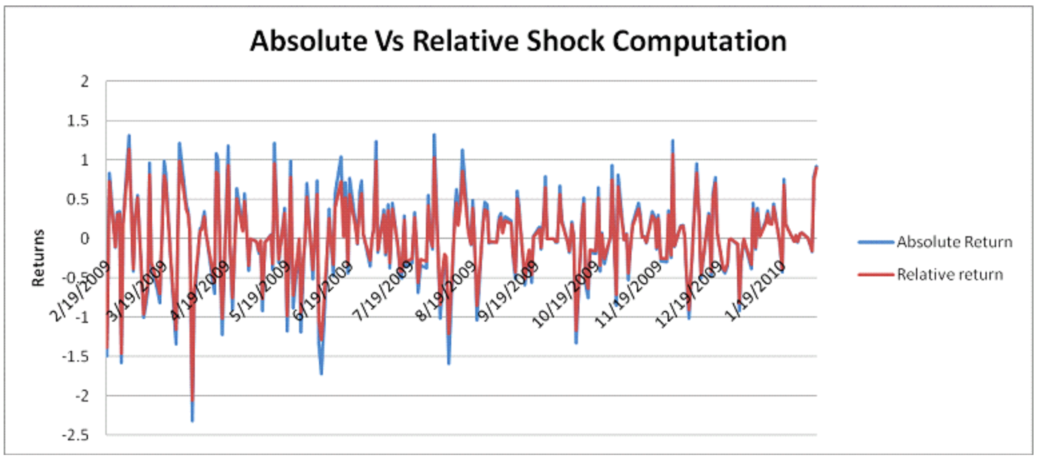
Fixed Income Returns

Historical term structure and spread changes are applied to the current term structure. The bond is revalued using the simulated term structure and credit spread. The interest rate volatility for embedded options is held constant over the holding period.

Absolute versus Relative Shocks

The choice of absolute *vs.* relative shocks for interest rates is contingent on assumptions about the distribution of interest rates. Using absolute shocks implies that interest rates move in accordance with a normal distribution. Using relative shocks implies that the rates move in accordance with a lognormal distribution. Neither distribution adequately explains interest rate movements at all levels.

The absolute shock implementation in BarraOne is consistent with the Barra Integrated Model regarding assumptions about the distribution of interest rates. BarraOne imposes a floor, if necessary, by adjusting the spread such that the at the lowest vertex the interest rate + spread is zero; this adjusted spread is then held constant and applied to all other vertices. For illustration purposes, we compare the absolute *vs.* relative returns for a German government bond.



As can be seen from the above graph, the choice of absolute *vs.* relative shocks does not have a significant impact on the VaR calculations. Moreover, Barra believes that the change from absolute to relative affects a broad range of interest rate instruments.

The following steps outline the algorithm for relative shocks:

1 Compute the shock: (curve on date i) – (curve on date $i + 1$).

2 For each point in the curve, compute the return in percentage terms: (shock at vertex v) ÷ (rate on date i at vertex v). For example, if the shock at the 1-year vertex is 50 bp, and the 1-year rate is 5%, then the return = 0.5/5 = 10%.

3 On analysis date D_0: (new rate on vertex i) × (1 + return)

4 Perform the valuation with the new rate curve computed in this manner.

Bond Spread Calibration

For the simulation of a bond, bond future, bond option, bond future option, and fixed income total return swap, the spread returns are computed. The computed spread returns can be based either on the model spread returns or on the returns of the spread that is calibrated based on the price of the bond. Users can choose either the calibrated bond spread or the model spread.

The price source for which the bond spread is calibrated can vary over the historical period. For cases in which prices from different vendors have a large enough difference, a large spread return can result from just the change from one vendor to the other, rather than from market movements.

Thus, spreads implied by bond prices are used to calculate spread return between two dates only if there are prices on both dates and both prices have the same source. If the prices from the same price source is not available for both dates, then the spread returns implied by the credit model are considered. The total return of an unrated corporate bond is set to zero. For corporate bonds with exposure to one of the detailed credit factors, then the spread return is taken as the corresponding model credit spread factor return.

Summary

If the user chooses not to calibrate bond spreads, spread changes are calculated as:

- Model spread on analysis date (t) minus Model spread on simulation date (t–1)

If the user chooses to calibrate bond spreads, spread changes are calculated as:

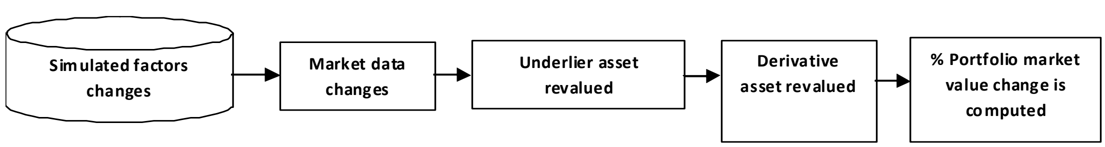
- Implied spread on analysis date (t) minus Implied spread on simulation date (t–1) (if the price is available from the same data source on both dates)
- Model spread on analysis date (t) minus Model spread on simulation date (t–1) (if no price is available from the same data source on either date or both dates)

Composite Returns

The scenario return for a composite is defined as the market-value-weighted average of the composite constituents. However, if the user provides returns for the composite, then BarraOne uses the composite returns to compute historical VaR.

Derivative Returns

The following diagram describes the sequence of steps for revaluing derivative assets:



The following table describes how P&L is calculated for various derivatives.

Table 26: Derivative P&L Calculations

Derivative	P&L Calculation
Bond Future	Compute return of the cheapest-to-deliver bond. Multiply this return by the effective market value of the future to get profit/loss.
Bond Future Option	Compute return of the cheapest-to-deliver bond. Compute the value of the option given the scenario value of the bond.
Interest Rate Swap	Compute the value of each leg of the swap given the scenario interest rate changes.
Equity Future	Compute the return of the underlying equity. Multiply this return by the effective market value of the future to get profit/loss.
Equity Index Future	Compute the return of the underlying equity index. Multiply this return by the effective market value of the future to get profit/loss.
Credit Default Swap Credit Default Swap Basket	Show 0 VaR for the credit default swap and credit default swap basket. Historical VaR is a *market risk* measure – not a *credit risk* measure. Since the credit default swap is a credit instrument we show 0 VaR risk.
Currency Forward	Compute the net present value of the two currency cash flows using the VaR scenario interest rate changes. The scenario profit/loss is the difference between the new and original present value.
Currency Future	Compute the return of the underlying currency. Multiply this return by the effective market value of the future to get profit/loss.
Commodity Future	Historical simulation of commodity futures is obtained by using the return history of the Rolling Maturity Futures associated with the commodity. Compute the return of the underlying commodity. Multiply this return by the effective market value of the future to get profit/loss.
Commodity Index Future	Historical simulation of commodity index futures is obtained by using the return history of the Rolling Maturity Futures associated with the commodity index. Compute the return of the underlying commodity index. Multiply this return by the effective market value of the future to get profit/loss.

Futures

Since futures are marked to market daily, the actual market price of a future is 0 on any given day. The mark-to-market cash flows and base value are needed to compute a return for the holding period.

For historical VaR, the return of the future is computed as:

$$r_h = \frac{P_h - P_A}{P_A}$$

where r_h is the forecasted return of the underlier over the holding period.

The hypothetical profit/loss is:

$$P / L = r_h \cdot EMV_A$$

where EMV_A is the effective market value of the future on the analysis date.

Implied Volatility Term Structures

BarraOne can use a user-supplied implied volatility term structure to calculate historical VaR for equity options, equity index future options, commodity options, commodity future options, FX options, and FX future options (note that Asian and barrier option analysis does not use user-supplied implied volatility term structures). BarraOne transforms the user implied volatility term structure data and stores it as a table with moneyness (a ratio of the underlier price and strike price) and time to maturity.

Assume that the underlier price is 40 in the example below from an implied volatility import template. We can then add a moneyness column.

<underlying id>	<time to maturity>	<strike price>	<volatility>	Moneyness
USMSFT	1M	45	0.11	0.888
USMSFT	1M	50	0.99	0.800
USMSFT	1M	55	0.15	0.727
USMSFT	3M	45	0.17	0.888
USMSFT	3M	50	0.99	0.800
USMSFT	3M	55	0.185	0.727
USMSFT	6M	45	0.21	0.888
USMSFT	6M	50	0.99	0.800
USMSFT	6M	55	0.24	0.727
USMSFT	1Y	45	0.37	0.888
USMSFT	1Y	50	0.99	0.800
USMSFT	1Y	55	0.31	0.727

Assume that the application can retrieve for each underlying $\Sigma(d,n,m)$ where, (n,m) defines the element of the moneyness/maturity matrix, d is a date, and Σ is the volatility. Assume that d spans the set of dates that are consistent with the horizon specified for historical simulation given analysis date D, so that d_1 is the first date preceding D moving backward from D in intervals equal to the horizon, d_2 is the second date, *etc.* Assume there are N dates for which the matrix Σ is specified. Notation-wise, d_0 denotes the analysis date D, and $\Sigma(d_0, n,m)$ might or might not be specified. $(i=0)$ denotes the "instrument volatility" on the analysis date, and the "instrument volatility" priority is 1) from price, 2) from $\Sigma(d,n,m)$, 3) from the user asset.

Historical VaR simulation of a plain vanilla option of maturity T on an underlying for which $\Sigma(d,n,m)$ is defined is performed as follows:

1 On each available date d_1 $(i=1,..,N)$, a volatility is extracted using a Barra function. This function interpolates $\Sigma(d_i, n,m)$ by using the maturity T, the value of the underlying, and the specified choice of moneyness. It thus associates an historical implied vol, $\sigma_{H(i)}$, to the plain vanilla option. Note that T is the maturity of the option as of the analysis date (T is constant across scenarios), while the underlying price depends on the scenario. Notice that, if available, $\sigma_{H(i=0)}$ will not necessarily be equal to the user-specified "instrument volatility."

2 If $\Sigma(d_i, n,m)$ is not specified on a given date d_i, a liner interpolation scheme is used to extract $\Sigma(d_i, n,m)$ from the pair of closest available dates spanning d_i, with flat extrapolation if d_i is outside the range of available dates.

3 The i^{th} scenario $(i=1,..,N)$ is obtained by applying the delta associated to $\sigma_{H(i)}$ to the "instrument volatility" as of the analysis date, *i.e.,* $\sigma_{(i=0)} \rightarrow \sigma_{(i=0)} \times (\sigma_{H(i)}) / (\sigma_{H(i-1)})$, $(i=1,..,N)$, We choose a multiplicative approach instead of an additive one consistent with the fact that implied volatility distributional properties are well represented by a log-normal distribution.

Return Windows

The consecutive and scaled return window approaches are described below.

For a given set of N daily returns a return and holding period h, the holding period return can be computed in two different ways: consecutive return windows, or scaled daily return windows.

Consecutive Return Windows

Holding period returns using consecutive windows are computed as:

$$R_{c1} = (1+r_1)\cdot(1+r_2)\cdot\ldots\cdot(1+r_h)-1$$
$$R_{c2} = (1+r_{h+1})\cdot(1+r_{h+2})\cdot\ldots\cdot(1+r_{2h})-1$$
$$\ldots$$
$$R_{cZ} = (1+r_{(Z-1)h+1})\cdot(1+r_{(Z-1)h+2})\cdot(1+r_{(Z-1)h+3})\cdot\ldots\cdot(1+r_{Zh})-1$$

where:

$\{r_1,\ r_2,\ldots,\ r_N\}$ = daily returns

h = the holding period

R_{c1} = the first holding period return

R_{cZ} = the Z^{th} holding period return

Given N daily returns, one can compute N/h holding period returns:

# of holding period returns using consecutive return window = N/h

The limitation of the consecutive return window approach is the requirement for a long data history. For example, to produce a 1000-return observation set for a five day holding period, a 20-year history of daily returns is required.

The methodology above applies to equities, mutual funds, foreign exchange instruments, and hedge funds.

Fixed income holding period returns are computed by applying term structure and spread changes to the current term structure. The changes using consecutive windows are computed as the sum of the daily absolute spread and rate changes.

Shock Scaling

If shock scaling return window calculations are selected, then BarraOne computes returns based on the selected sampling period days and then scales the returns to the holding period. Holding period returns using scaling windows are computed as:

$$R_{s1} = (r_{t1}) \cdot \sqrt{h/t}$$

$$R_{s2} = (r_{t2}) \cdot \sqrt{h/t}$$

. . .

$$R_{sz} = (r_{tz}) \cdot \sqrt{h/t}$$

where:

$\{r_{t1},\ r_{t2}, \ldots,\ r_{tN}\}$ = sampling period returns

h = the holding period

t = the sampling period $(\text{between 1 and } h)$

R_{s1} = the first scaled sampling period return

R_{sz} = the Z^{th} scaled sampling period return

For fixed income calculations, spread and interest rate changes are computed as:

*Interest rate change for scenario = Historical interest rate change * sqrt (h/t)*

# of holding period returns using scaling return windows = z

The methodology above applies to equities, mutual funds, foreign exchange instruments, and hedge funds.

Fixed income holding period returns are computed by applying term structure and spread changes to the current term structure. The changes using *scaling windows* are computed as the absolute sampling period spread changes multiplied by the square root of the sampling period h/s.

The advantage of the scaling window approach is the number of observations one obtains from a relatively short data history. To produce a 1000-return observation set for a 5-day holding period and a 5-day sampling period, approximately 4 years of data are required. Note that the years must be multiplied by the sampling period days to calculate the required data history, so if the sampling period days are 3, then about 12 years of data history are required in the example above.

Return Scaling

If return scaling return window calculations are selected, then the Sampling Period option is used to scale the VaR output. The Sampling Period menu enables the user to select an integer between 1 and the Holding Period, inclusive. So, if the user has a 22-day holding period, then the user may choose any number from 1 to 22 as the sampling period.

When calculating HVaR with Return Scaling, BarraOne first calculates the HVaR as if the sampling period were the actual holding period, and it then scales the dollar output by the scaling factor α:

$$\textit{Scaling Factor}\ \alpha = \sqrt{\frac{\textit{Holding Period}}{\textit{Sampling Period}}}$$

Thus, the Simulation VaR ($) for each asset is:

$$VaR(\$, scaled) = \alpha \cdot VaR(\$, unscaled)$$

The portfolio-level numbers are computed similarly. The % numbers, *i.e.,* VaR (%) are computed from the scaled $ values.

Treatment of Cash Flows

For historical VaR, cash flows are treated with no accounting for passage of time, and market changes are assumed instantaneous. Historical market data changes are applied to the market data on the analysis date. Securities within the portfolio are then revalued using the modified market data as of the analysis date. This method is appropriate for comparison with parametric VaR.

Instantaneous Return — Bond Cash Flows

The theory behind this methodology is that VaR is a measure of market risk, while.the coupon and principal cash flows are deterministic and considered “income return.” Therefore, coupon and principal payments are not included in the bond return. Including these cash flows in the return calculation could dampen the VaR measure. Thus, the “clean” market return is computed.

Instantaneous Return — Derivative Expiration

A holding period is specified when computing VaR. The holding period defines the future date used to compute the hypothetical loss/gain. In certain cases, a derivative may expire after the analysis date but prior to the future date.

This VaR methodology does not consider the passage of time over the VaR holding period. The VaR scenario return is computed as an instantaneous return on the analysis date. Historical market data changes are applied to the market data on the analysis date. Securities in the portfolio are revalued using the modified market data as of the same analysis date.

If the derivative has expired on the analysis date, then the system will not calculate the VaR of the instrument. BarraOne will assume that the user has accounted for cash flows associated with the derivative expiration (positive or negative) by adjusting a cash position or account somewhere in the system.

VaR Decomposition

Background

The Barra Integrated Model (and structural models in general) provides a set of risk factors based on commonly observable market data. However, historical VaR purposely avoids reliance on a risk model. While this approach reduces reliance on modeling assumptions, one drawback is the limited ability to decompose asset, group, and portfolio VaR into intuitive risk sources.

Overview

VaR Decomposition provides users with further insight into the sources of market risk within BarraOne's historical VaR module. It can be used for risk control, hedging, or simply to enhance insight into risk concentrations by enabling the user to generate a decomposition of historical VaR along the following dimensions for several VaR statistics (see Table 24 on page 461):

- Equity price volatility
- Interest rate volatility
- Spread volatility (bonds, credit default swaps)
- Foreign exchange rate volatility (Treasury, LIBOR, Muni, Real)
- Commodity risk factor return volatility
- Vega (implied volatility for equity, IR, FX, and commodity derivatives)

Refer to Table 27 on page 485 for a list of the market data types relevant for each instrument type.

Note: This approach does not impose a risk model assumption nor provide insight into the comovement (correlation) of risk sources or factors. "Risk Decomposition," including factor interaction and correlation terms, is available via the Factor Risk module in BarraOne using the Barra Integrated Model (BIM), which provides global market coverage and fundamental factors for industry, style, term structure, spreads, FX, and commodities.

Process

VaR Decomposition calculates asset, subportfolio, and portfolio level VaR (and its associated attributes) using the following steps:

1. Each market data category is simulated, while holding others constant, over the historical period.
2. This process is repeated for each asset in the portfolio for each historical scenario (the daily changes in the market data attribute under simulation), to calculate a new value for the portfolio.
3. This process is repeated for all asset returns derived from a given data window, obtaining a new set of hypothetical portfolio values and thus scenario P/Ls.

4 The distribution of these P/Ls is then used to obtain the desired VaR for that simulated market data attribute. Only assets with exposure to the simulated market data category will contribute to the VaR of this scenario. For example, US Treasuries would have no contribution to an Equity VaR.

5 In carrying out the above steps, we arrive at a VaR forecast for an isolated market data category, which we can consider a “risk factor.”

6 The VaR for each category (or risk factor), as well as the Total VaR derived from simulating all market conditions simultaneously, is reported.

7 Portfolio VaR (and its associated attributes) is computed by sequentially simulating the equity, IR, Spreads, FX, commodity, and volatility market data (or risk factors). This sequential simulation provides a VaR for a given risk category that is calculated by simulating the type of market data or risk factors explicitly associated with this category while keeping all other types of market data or risk factors unchanged.

Example

The differentiation between interest rate risk and spread risk enables the user to separate the VaR due purely to term structure movements (Treasury, Real, LIBOR) and the VaR due to changes in spreads (price implied or user supplied). The Treasury curve is used as the reference rate in the valuation of fixed income instruments.

A US corporate bond with a fixed coupon and an A rating will have an IR VaR due to changes in the US Treasury. The spread VaR is computed using the changes in the price implied spread (if available) or the Barra model spread (if the bond does not have a price history).

To compute a 1-day VaR with 5 dates (D1, D2, D3, D4, D5) and an analysis date of D0, BarraOne computes the profit/loss based on "shocked" market conditions (shocked market conditions are defined as market conditions on the analysis date plus the change in market conditions derived from historical data). To compute the Profit/Loss in the simulation, BarraOne will compute the difference in both Treasury rates and spreads separately on successive dates {D1–D2, D2–D3, D3–D4, D4–D5}.

To compute the IR VaR:

- Use the new, “shocked” term structure, computed as *Original TS on D0* + *Delta Treasury.*
- Use the original, calibrated spreads on D0.
- Revalue the bond.
- Compute Profit/Loss as *Value on D0* – *Simulated Value*.

To compute the Spread VaR:

- Use the original term structure on D0.
- Compute a new, “shocked” spread, computed as *Original Spread* + *Delta Spread.*
- Revalue the bond.

- Compute Profit/Loss as *Value on D0 – Simulated Value*.

To compute Total VaR:

- Use the new, “shocked” term structure, computed as *Original TS on D0* + *Delta Treasury.*
- Compute a new, “shocked” spread, computed as *Original Spread* + *Delta Spread.*
- Revalue the bond.
- Compute Profit/Loss as *Value on D0 – Simulated Value*.

This sequence of steps is repeated for the five dates, and the VaR is computed using the distribution of Profit/Loss.

Composites

The scenario return for a composite is defined as the market-value-weighted average of the composite constituents. However, if the user provides returns for the composite, then BarraOne uses the composite returns to compute historical VaR. The aggregated returns for all decomposed VaR simulations are scaled by the ratio of *User-Imported Composite Return* to *Total Aggregated Returns*.

VaR Decomposition Groups

The following table displays the VaR group into which each market condition will be decomposed in VaR Decomposition.

Table 27: VaR Decomposition Groups

Asset type	Market Condition	VaR Group
External Fund (ETF, *etc.*)	Equity Price	Equity
	FX Rate	FX
Equity	Equity Price	Equity
	FX Rate	FX
Equity Future	Underlying Equity Price	Equity
	LIBOR	IR
Equity Index Future	Underlying Equity Index Price	Equity
Equity Options, Equity Index Option	Underlying Equity Price	Equity
	Underlying Equity Volatility	Vega
	LIBOR	IR
	FX Rate	FX

Table 27: VaR Decomposition Groups

Asset type	Market Condition	VaR Group
Equity Index Future Option	Underlying Equity Index Price	Equity
	Underlying Equity Index Volatility	Vega
	LIBOR	IR
	FX Rate	FX
Variance Future, Forward Volatility Agreement	Underlying Equity Index Volatility	Vega
Volatility Swap, Variance Swap, Volatility Option	Underlying Equity Index Volatility	Vega
	FX Rate	FX
Bonds	Corresponding IR Curve (Treasury: Gov, LIBOR: Corp; Muni: Muni; Real: IPB)	IR
	Credit Spread	Spread
	IR Volatility (for Callable/Putable Bonds)	Vega
	FX Rate	FX
Convertible Bonds	Corresponding IR Curve (Treasury)	IR
	Credit Spread	Spread
	IR Volatility (for Callable)	Vega
	FX Rate	FX
	Underlying Equity Price	Equity
	Underlying Equity Volatility	Vega
	Underlying Equity FX Rate	FX
Floating Rate Note (U.S. and Global), Variable Rate Note, Syndicated Loans	Corresponding IR Curve	IR
	Credit Spread	Spread
	FX Rate	FX
Inflation-Linked Liability	Corresponding IR Curve	IR
	Credit Spread	Spread
	FX Rate	FX
Credit Default Swaps, CDS Options	CDS Spreads	Spread
	LIBOR	IR
	FX Rate	FX
ABS	Corresponding IR Curve (Treasury)	IR
	FX Rate	FX
MBS	Corresponding IR Curve (Treasury)	IR
	FX Rate	FX

Table 27: VaR Decomposition Groups

Asset type	Market Condition	VaR Group
Bond Futures	Corresponding IR Curve (Treasury)	IR
	Credit Spread (Affects Underlying Bond Price)	Spread
	IR Volatility	Vega
Bond Options	Corresponding IR Curve (Treasury)	IR
	Credit Spread (Affects Underlying Bond Price)	Spread
	IR Volatility	Vega
	FX Rate	FX
Bond Future Options	Corresponding IR Curve (Treasury)	IR
	Credit Spread (Affects Underlying Bond Price)	Spread
	IR Volatility	Vega
Eurodollar Future	Corresponding IR Curve (LIBOR)	IR
	IR Volatility	Vega
Eurodollar Future Option	Corresponding IR Curve (LIBOR)	IR
	IR Volatility	Vega
IR Swap	Corresponding IR Curve (LIBOR)	IR
	IR Volatility	Vega
	FX Rate	FX
	FX Rate Volatility (for Dual-Currency IR Swap)	Vega
Swaption	Corresponding IR Curve (LIBOR)	IR
	IR Volatility	Vega
	FX Rate	FX
Cash (FX)	FX Rate	FX
FX Forward/Future	Spot FX Rate	FX
	FX Rate Volatility	Vega
	LIBOR	IR
	FX Rate	FX
FX Option	Spot FX Rate	FX
	FX Rate Volatility	Vega
	LIBOR	IR
	FX Rate	FX
FX Future Option	Spot FX Rate	FX
	FX Rate Volatility	Vega
	LIBOR	IR
	FX Rate	FX

Table 27: VaR Decomposition Groups

Asset type	Market Condition	VaR Group
Commodity	Spot Price (N/A)	Commodity
	FX Rate	FX
Commodity Futures	Spot Price	Commodity
	LIBOR	IR
Total Return Swap (fixed income)	Corresponding IR Curves (LIBOR)	IR
	FX Rate	FX
Total Return Swap (equity)	Equity Price	Equity
	Corresponding IR Curves (LIBOR)	IR
	FX Rate	FX
Currency Swap	FX Spot Rates	FX
	Domestic/Foreign Zero Rates	IR
DMBS/ARMS	Corresponding IR Curves (LIBOR)	IR
	FX Rate	FX

VaR Decomposition Statistics

The following table indicates which VaR statistics are computed in VaR Decomposition.

Table 28: VaR Decomposition Statistics

Analytic	HVaR Decomposition
VaR	Yes
Component VaR	Yes
Incremental VaR	Yes
Marginal VaR	Yes
Expected Shortfall/CVaR	Yes
VaR Diversification	No
Active VaR	Yes
Active Component VaR	Yes
Active Incremental VaR	Yes
Active Marginal VaR	Yes
Active VaR Diversification	No
Active Expected Shortfall/CVaR	Yes
Portfolio/Benchmark VaR Ratio	Yes

Sample VaR Decomposition Report

The following sample report illustrates historical VaR decomposition along only the Simulation VaR % dimension:

Asset ID	Simulation VaR (%)							
	Total	Equity	IR	Credit Spread	IR & Credit Spread	FX	Commodities	Vega
16	30.21%	7.56%	17.98%	0.04%	18.02%	11.56%	0.25%	0.00%
UST	3.37%	3.37%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
BONDFUTURE1	3.85%	0.00%	3.85%	0.00%	3.85%	0.00%	0.00%	0.00%
BONDFUTUREOPTION1	19.07%	0.00%	19.07%	0.00%	19.07%	0.00%	0.00%	0.00%
USA89O1	5.77%	5.77%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
HKGCWP1	4.28%	4.31%	0.00%	0.00%	0.00%	0.05%	0.00%	0.00%
COMP_SINGLECOUNTRY_USD	3.43%	3.43%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
CONVERTIBLE_REGULAR_USD_CU	0.16%	0.00%	0.15%	0.31%	0.16%	0.00%	0.00%	0.00%
USAEBJ1	7.20%	7.20%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
EIF_SINGLE_USD	3.43%	3.43%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
EIFO_SINGLE_USD	0.49%	0.49%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
EQOPT_USD_CALLINTHEMONEY	10.94%	11.27%	0.34%	0.00%	0.34%	0.00%	0.00%	0.00%
GOLDFUT_Z09	2.41%	0.00%	0.00%	0.00%	0.00%	0.00%	2.41%	0.00%
GOV1	2.75%	0.00%	2.75%	0.00%	2.75%	0.00%	0.00%	0.00%
IRSWAP_BARRAID_USD	31.74%	0.00%	31.74%	0.00%	31.74%	0.00%	0.00%	0.00%
UNFXFOWARD_EUR	9.31%	0.00%	0.43%	0.00%	0.43%	9.98%	0.00%	0.00%
UNFXOPTION_GBP_EUR	23.15%	0.00%	0.73%	0.00%	0.73%	23.20%	0.00%	0.00%

Simulated Market Condition

Clients who split fund management responsibilities between core and overlay teams (*e.g.*, a team with a separate FX overlay manager) have the freedom to specify which risk factors to simulate and which to hold constant in historical VaR, thus creating custom VaR scenarios. For instance, if the core asset manager does not necessarily care about the VaR of each underlying risk factor, but does care to see the portfolio VaR excluding FX, the user may choose to exclude the FX risk factor from the VaR scenario.

Simulated market condition enables the user to determine which market conditions will be simulated during a VaR analysis. The user may include or exclude the following market conditions (any market condition not selected will remain constant throughout the simulation period):

- Equity price volatility
- Interest rate volatility (Treasury, LIBOR, Muni, Real)
- Spread volatility (bonds, credit default swaps)

- Foreign exchange rate volatility
- Commodity risk factor return volatility
- Vega (implied volatility for equity, IR, FX, and commodity derivatives).

Data Availability

Analysis Date

The earliest analysis date that can be set for historical VaR reports in BarraOne is January 1, 2006. Historical returns are loaded as of January 1, 2003. Thus, an analysis date can be set for any date after January 1, 2006, and any data window from January 1, 2003 to present can be selected.

Equity Data

The following tables indicates the historical equity data that are available in BarraOne going back to January 1, 2003.

Developed Markets

Australia	Austria	Belgium
Canada	Denmark	Finland
France	Germany	Greece
Hong Kong	Ireland	Italy
Japan	Korea	Netherlands
New Zealand	Norway	Portugal
Singapore	Spain	Sweden
Switzerland	United Kingdom	United States

Emerging Markets

Argentina	Bahrain	Brazil
Chile	China	Colombia
Czech Republic	Egypt	Hungary
India	Indonesia	Israel
Jordan	Malaysia	Mexico
Morocco	Nigeria	Oman
Pakistan	Peru	Philippines
Poland	Russia	Saudi Arabia
South Africa	South Korea	Sri Lanka
Taiwan	Thailand	Turkey
Venezuela	Zimbabwe	

Fixed Income Data

The following table displays the historical fixed income data available in BarraOne going back to January 1, 2003. Note that for instruments denominated in European legacy currencies, the local government term structure is used, rather than the EMU term structure.

Table 29: Available Fixed Income Data

Market	Govt Term Structure	Swap Term Structure	Real Term Structure	Municipal Term Structure	Credit Spreads	Emerging Market Spreads	Sector by Rating Credit Spreads
Argentina	✓	✓				✓	
Australia	✓	✓	✓		✓		✓
Austria	✓						
Belgium	✓						
Brazil	✓	✓	✓		✓	✓	
Bulgaria	✓	✓				✓	
Canada	✓	✓	✓	✓	✓		✓
Chile	✓	✓				✓	
China	✓	✓			✓	✓	
Colombia	✓	✓				✓	
Croatia	✓	✓				✓	
Cyprus		✓					
Czech Republic	✓	✓					
Denmark	✓	✓			✓		
Dominican Republic		✓				✓	
Ecuador		✓				✓	
Egypt	✓	✓				✓	
El Salvador		✓				✓	
Euro		✓	✓		✓		✓
Estonia		✓					
Finland	✓						
France	✓		✓				
Germany	✓		✓				
Greece	✓		✓				
Hong Kong	✓	✓			✓	✓	
Hungary	✓	✓				✓	
Iceland	✓	✓					
India	✓	✓			✓	✓	
Indonesia	✓	✓				✓	

Table 29: Available Fixed Income Data (Continued)

Market	Govt Term Structure	Swap Term Structure	Real Term Structure	Municipal Term Structure	Credit Spreads	Emerging Market Spreads	Sector by Rating Credit Spreads
Ireland	✓						
Israel	✓	✓					
Italy	✓		✓				
Ivory Coast		✓				✓	
Japan	✓	✓	✓		✓		✓
Korea	✓	✓			✓	✓	
Latvia		✓					
Lebanon		✓				✓	
Lithuania	✓	✓					
Malaysia	✓	✓			✓	✓	
Mexico	✓	✓			✓	✓	
Morocco		✓				✓	
Netherlands	✓						
New Zealand	✓	✓	✓		✓		
Nigeria		✓				✓	
Norway	✓	✓			✓		
Panama		✓				✓	
Peru	✓	✓				✓	
Philippines	✓	✓			✓	✓	
Poland	✓	✓			✓	✓	
Portugal	✓						
Romania	✓	✓				✓	
Russia	✓	✓				✓	
Serbia		✓				✓	
Singapore	✓	✓			✓	✓	
Slovakia	✓	✓					
Slovenia		✓					
South Africa	✓	✓	✓		✓	✓	
Spain	✓						
Sweden	✓	✓	✓		✓		
Switzerland	✓	✓			✓		✓
Taiwan	✓	✓					
Thailand	✓	✓			✓	✓	
Tunisia		✓				✓	
Turkey	✓	✓				✓	
UK	✓	✓	✓		✓		✓

Table 29: Available Fixed Income Data (Continued)

Market	Govt Term Structure	Swap Term Structure	Real Term Structure	Municipal Term Structure	Credit Spreads	Emerging Market Spreads	Sector by Rating Credit Spreads
Ukraine		✓				✓	
Uruguay		✓				✓	
US	✓	✓	✓	✓	✓		✓
Venezuela		✓				✓	

Mutual Fund Data

The availability of mutual fund data is fund dependent.

FX Data

FX data is available for all markets covered going back to January 1, 2003.

Commodity Data

Commodity returns are not available.

Set of Market Data and Changes

#	Asset Class	Data Type	Description
1	Equity	Daily total asset returns	% daily change of equity price provided by Barra or user.
2	Currency	Daily change in USD exchange rates	% daily change in XXX/USD exchange rate.
3	Bonds (see Absolute versus Relative Shocks below)	Treasury Rate changes	For each rate supported by Barra, either the daily absolute change in rates in basis points, or the relative change. Note that for instruments denominated in European legacy currencies, the local government term structure is used, rather than the EMU term structure.
4		Swap Rate changes	For each rate supported by Barra, either the daily absolute change in rates in basis points, or the relative change.
5		LIBOR Rate changes	For each rate supported by Barra, either the daily absolute change in rates in basis points, or the relative change.
6		Credit Spread changes	For each sector x rating factor, the daily absolute change in spread in basis points.

#	Asset Class	Data Type	Description
7	Derivatives	Implied Volatility - equity, commodity, and FX market	User-supplied implied volatility (volatility surface or schedule); the daily percentage change.
8		Implied Volatility - interest rate	Implied volatility is assumed to be constant over the holding period.
9	Commodity	Daily risk factor returns	Daily risk factor returns.

User-Provided Price Data

Data Type	Used / Not Used	Description
Historical bond prices	Not used, except in bond spread calibration (see Bond Spread Calibration above)	User-provided bond prices are not used in the historical VaR simulation. For historical VaR, interest rate market changes, not bond price changes, are used. Prices are used in bond spread calibration.
Bond price on analysis date	Used	The user-provided bond price on the analysis date is used as the starting point price for the VaR holding period. May also be used in bond spread calibration.
Historical equity prices	Used only in VaR Backtesting	Historical equity prices are used only in VaR Backtesting as a proxy for Barra equity returns. In this case, when Barra equity returns are unavailable, user equity prices are used to compute returns.
Historical option prices	Not used	
Option price on the analysis date	Used	If available and prioritized, the option price on the analysis date is used to calibrate the implied volatility of the option. Option prices on other dates are not used for Historical VaR.
Historical futures prices	Not used	BarraOne uses the price movements of the underlier to compute the theoretical value of the future.
Futures price on the analysis date	Used	BarraOne uses the user-provided futures price on the analysis date.
User-provided asset returns	Used	BarraOne uses user-provided returns above all other data sources.

Missing Data—Filling the Gaps

The historical VaR process requires market data histories to revalue assets. Data histories are not perfect. Assets may have short histories, or data may be missing. When data is missing, BarraOne uses the methods described below to fill the gaps.

Asset Class	Data Type	Gap	Forward Extrapolation	Backward Extrapolation
Equity	Daily total asset returns	Proxy with beta and index return	Proxy with beta and index return	Proxy with beta and index return
Currency	Daily change in USD exchange rates	Reject scenario	Reject scenario	Reject scenario
Bonds	Treasury Rate changes	Zero Return	Zero Return	Zero Return
	Swap Rate changes	Zero Return	Zero Return	Zero Return
	LIBOR Rate changes	Zero Return	Zero Return	Zero Return
	Credit Spread changes	Zero Return	Zero Return	Zero Return
Derivatives	Implied Volatility — equity market	N/A	N/A	N/A
	Implied Volatility — interest rate	N/A	N/A	N/A
Commodity	Daily risk factor returns (N/A — returns are not available for commodity assets)	Linearly interpolate	Zero Return	Zero Return
Market Index Return	Return used for equity proxy	Zero Return	Zero Return	Zero Return

Missing Equity Prices

There are cases where there are gaps in a particular equity's price history. In this case, BarraOne uses market return and asset beta to estimate return.

Daily market returns are used to compute return proxies. Return proxies are required when data is missing (*i.e.,* data gaps or short asset price history). A history of daily market returns is required for all markets where daily factor returns are unavailable. The market is defined by the estimation universe for that market.

Proxy for return of asset A for the period t–1 to t

$$r_t^{\text{Proxy A}} = B_M^A M_t + \varepsilon$$

where

B = asset A's Beta to the Market (beta as of the analysis date)

M = Market Return

ε = idiosyncratic return

For each market, an estimation universe is defined. The data teams provide daily returns for these estimation universes.

Missing Implied Equity Volatility

If BarraOne requires the implied equity volatility for derivative valuation, and if the implied volatility is missing, BarraOne uses the underlying equity's current volatility.

Monte Carlo Simulation

Accessing Monte Carlo Simulation

The user can use BarraOne's Monte Carlo VaR feature to define, run, and analyze Monte Carlo simulations. The current simulation module includes a Stress Testing component (see "Stress Testing in BarraOne," *MSCI Barra Product Insights*, Jan 2007) and Historical VaR component.

As with other risk reporting functions in the BarraOne platform, the user simply specifies the portfolios to be analyzed and the simulation and reporting parameters, and then submits the job for processing.

Using BarraOne's Monte Carlo VaR feature, the user can:

- Assign one or many funds to a Monte Carlo simulation for processing in batch
- Automatically generate VaR reports across multiple funds on a regularly scheduled basis
- Analyze results at the asset, group, or fund level (grouping is supported along numerous dimensions)
- View a complete set of VaR statistics

The first and most crucial step in Monte Carlo simulation consists of choosing a particular stochastic model and the set of factors to be simulated. In BarraOne, the stochastic model uses the forecast, estimated distribution of the factors or prices underlying the Barra Integrated Model (BIM). To generate future factor returns, it is assumed that all the underlying factors follow a geometric Brownian motion. Given that assumption of normality of factor returns, a random normal set of variables is used to simulate factor returns. The PowerVaR methodology described on page 500 relaxes the normality assumption; it allows the use of empirical factor return distributions in Monte Carlo VaR simulations.

The next step in Monte Carlo simulation consists of translating the simulated factor returns into asset returns. This process varies by asset class; equity returns are computed directly using factor returns, while fixed income and derivative instrument returns are computed by revaluing the instruments with simulated market conditions (term structures, spreads, *etc.*).

Advantages of Monte Carlo VaR

There are several advantages to using Monte Carlo VaR in BarraOne:

- Uniformity: The factors used to compute parametric risk are the same as the factors used in Monte Carlo VaR simulations. Parametric VaR and Monte Carlo VaR forecasts are compatible.
- Stability: The factor covariance matrix is stable, leading to stable VaR forecasts.

- Consistency: Correlations are measured over a defined set of factors independent of the number of assets in the portfolio. Compared to an asset-by-asset covariance matrix, the number of spurious correlations is minimized, further increasing the stability of VaR forecasts.
- Scalability: BarraOne's simulation methodology can be applied to all asset classes. VaR forecasts for heterogeneous portfolios and strategies are consistently computed and comparable.

Methodology and Implementation

This section describes the methodology implemented in BarraOne.

Overview

Monte Carlo simulation provides a method of valuing something that depends on the uncertain future state of the world. In the financial context, this could be an equity or a portfolio of investments. The method is simple: many possible future states are randomly chosen using the statistical knowledge of the present; the value of the instrument is then calculated for each of the possible future states; and the probable future value of the object is estimated by averaging the instrument's value in all of the future states.

The Monte Carlo simulation will run over a user-defined number of runs, normally 10,000, although the user can define the number of runs in BarraOne.

The following steps happen during each simulation:

1. Generate starting seed number

   To begin the Monte Carlo VaR simulation process, BarraOne generates a random starting seed number based on the initial simulation parameters that are configured by the user (job name, holding period, start date, etc.).

2. Generate uniformly distributed random numbers

   The starting seed is an input to a random number generator that produces series of uniformly distributed random variables. (The same seed returns the same set of uniformly distributed random numbers, allowing the simulation to be reproduced on a subsequent run if the same seed is provided by the user when the job is scheduled.)

3. Generate normal (Gaussian) random numbers

   The next step transforms the uniformly distributed random numbers generated in the previous step into independent standard normally-distributed (zero expectation, unit variance) random variables.

   To convert the uniformly distributed random numbers into normally distributed random numbers, we use the Box-Muller transformation method. This function enables generating a single sequence of random numbers that have the properties of a normal distribution.

4 Simulate factor returns

To simulate factors consistent with the BIM covariance matrix, we transform independent normal random numbers obtained in Step 3 into correlated random numbers. The Cholesky decomposition of the BIM correlation matrix is used to accomplish this.

First, we extract factor volatilities from the BIM covariance matrix to obtain the BIM correlation matrix. This matrix is decomposed into a product of the lower-triangular Cholesky matrix and the transposed Cholesky matrix. The transposed Cholesky matrix is then applied to the vector of uncorrelated simulated factor returns obtained in Step 3, producing a set of correlated factors with unit standard deviations. Subsequently, volatilities of individual factors are imposed onto the correlated factors.

The standard BIM covariance matrix is defined for a horizon of one month. To obtain factor volatilities corresponding to the user-selected VaR simulation horizon, the monthly factor volatilities are scaled assuming 252 business days in a year. The scaling factor is given by $\sqrt{12h/252}$, where h defines the number of business days in the simulation holding period. As a result, BarraOne produces a vector of factor returns with the covariance properties defined by the BIM covariance matrix scaled to the simulation horizon.

A BIM Daily covariance matrix is available as a user option with a user-selectable half-life and holding period. Refer to “Short-Term Covariance Matrix” on page 532 for details.

5 Convert factor returns into portfolio market returns

The last step in the process is to translate factor returns into market returns. This is done by revaluing assets based on factor returns and assets’ exposures to each factor, as described in “Computing Returns” on page 506.

The calculation of the P&L distribution for equity and fixed income derivatives is performed through full asset reevaluation, except for those assets listed in “Monte Carlo VaR Approximation with Multidimensional Interpolation” on page 513.

PowerVaR: Monte Carlo VaR with Semi-Parametric Extreme Risk

Simulating risk over the horizon of one to ten days can be improved if empirical information about factor return distributions is taken into account. Given the availability of long time histories of returns for many of the fundamental factors used by BarraOne, it is desirable to use such histories effectively to model realistically the possibility of extreme events in a simulation environment. PowerVaR uses a semi-parametric approach to incorporate empirical factor distributions into Monte Carlo risk forecasts, thus going beyond the assumption of jointly normal factor returns used by the standard Monte Carlo approach described in “Overview” on page 499.

(PowerVaR should not be confused with Barra Extreme Risk (BxR) methodology. BxR uses a full non-parametric approach, in which both the marginal distributions of factor returns and the co-movement of factors are determined from an empirical factor return history. First, factor return histories are processed to eliminate the local (in time) linear correlation/volatility structure, while preserving tail dependent features of the multi-factor distribution. Then the correlation/volatility structure on the analysis date is imposed on the factor return history, and the transformed returns are analyzed without resorting to copula modeling. BxR methodology currently covers only equity portfolios. The inclusion of this methodology in BarraOne is contingent on its extension to other asset classes.)

PowerVaR determines non-parametrically, where possible, the probability distribution of factor returns, and it simulates future scenarios that are consistent with such marginal distributions. However, co-movement of the factors is modeled parametrically using copula techniques. Copulas provide a way to specify an arbitrary multi-dimensional probability distribution in terms of the marginal distribution of each factor (*i.e.,* the probability distribution of one factor irrespective of the value taken by other factors) and a prescription (the *copula*) on how to join the marginal distributions. PowerVaR enables the user to choose either a Gaussian copula or one from a Student-T family of copulas. Since marginal distributions are "factored out" in the copula representation of a multivariate probability distribution, copulas provide a useful description of the pure factor-dependence properties of a model.

With a Gaussian copula, the probability of having two factors with extreme (tail) returns conditional on one having an extreme return (the so called tail dependence parameter for the pair) is zero. A T-copula has nonzero tail dependence, but it requires the estimate of a single parameter controlling the behavior of the tail of the distribution. Both choices can be made consistent with correlations specified by the Barra Short Term Factor Covariance Matrix. The default setting uses the Gaussian copula.

Factors in the Barra Integrated Model (BIM) are divided in two groups. The first group includes factors that have a sufficiently long history of daily returns. Other factors are assumed to be normally distributed. The construction of marginal and joint distributions for a one-day horizon is briefly described below.

Each individual factor with a long history of daily returns is described non-parametrically in a way that resembles historical VaR with equal weighting: each historical daily factor return is assumed to be equally probable. However, PowerVaR modifies the history of returns to reflect the changing nature of volatility through time. Each historical factor return is scaled by its historical volatility, and then multiplied by a forecast of today's volatility:

$$\hat{f}_t = f_t \frac{\sigma_T}{\sigma_t}$$

Here, $\hat{f}_t$ is the modified historical factor return on date *t*, σ_T is the forecast volatility of the factor given by Barra Short Term Factor Covariance Matrix (one-day horizon), σ_t is the historical volatility of the factor, and f_t is the raw historical factor return. This scaling normalizes the whole factor history and rescales it in terms of the current volatility climate. The time-series of the historical volatility is computed recursively according to the standard exponential moving average formula for root-mean-squared factor returns:

$$\sigma_t^2 = \lambda \sigma_{t-1}^2 + (1-\lambda) f_{t-1}^2$$

using the same decay factor λ as in the calculation of the short term covariance matrix. The long history of transformed factor returns $\hat{f}_t$ effectively defines an empirical distribution for each factor. When these factor return distributions have fat tails, they are captured by the copula approach.

The Gaussian copula is based on a multivariate normal distribution. Simulation in PowerVaR with a Gaussian copula follows the same Step 1-Step 4 outlined in the Monte Carlo VaR "Overview" on page 499. After Step 4, the factors associated with empirical distributions undergo an additional transformation based on inverse transform sampling.[1] The effect of the transformation is to draw factor returns from their respective empirical distributions, while preserving the linear correlations of the Barra Short Term Factor Covariance Matrix. Note that factors without long histories are treated in the same way as in Monte Carlo VaR.

The T-copula approach is based on a multivariate Student distribution, which takes the number of degrees of freedom (n) as an additional input parameter. In the limit $n \to \infty$, the T-copula is equivalent to the Gaussian copula, but it retains finite tail dependence for finite values of n. Simulation of a multivariate Student distribution follows similar steps as outlined in the Monte Carlo VaR "Overview" on page 499.[2] As with the Gaussian copula, the T-distributed factors undergo an inverse transform to impose the corresponding single-factor distributions on the marginals. Factors with long histories of daily returns are transformed to their empirical distributions, while marginals for other factors use a normal distribution. The default setting for the number of degrees of freedom is n=10.

Joint distributions of factor returns for horizons longer than one day are obtained in a similar manner. Prior to obtaining the factor return empirical distributions, scaled factor returns are aggregated to the corresponding horizon using a bootstrapping procedure.

In addition to empirical factor returns, PowerVaR enables users to select from parametric families of marginal distributions. Parametric choices include either normal or Student-T marginal distributions. All possible choices of marginals and copulas are summarized in Table 30. This table also points out the main difference with respect to the Barra Extreme Risk methodology.

Table 30: PowerVaR Choices of Marginals and Copulas Contrasted with BxR Methodology

Co-Movement Marginals	Gaussian copula	T-copula (n)	Empirical
Normal	Multivariate normal	Stronger tail dependence	N/A
Student-T (n)	Fatter tails	Multivariate Student (n)	N/A
Empirical Factor	Empirical tails, weak tail dependence	Empirical tails, stronger tail dependence	BxR

1 Inverse transform sampling used here assigns a one-to-one correspondence between normal and empirical distributions based on distribution quantiles. For example, a draw from a normal distribution corresponding to a 90% quantile is transformed into a draw from the empirical distribution characterized by a 90% quantile.

2 Step 1-Step 3 are unchanged; Step 4 is augmented in our implementation by the drawing of an independent Chi-Square (with n degrees of freedom) distributed variable for each draw of normally correlated variables ε. We then construct the multivariate T-distribution as $t = \sqrt{n/\chi_n^2}\,\varepsilon$.

When a Gaussian copula is used in conjunction with normal marginals, the resulting multivariate normal distribution is fully consistent with the approach detailed in “Short-Term Covariance Matrix” on page 532. A multivariate Student distribution is implied when the T-copula is used together with the Student-T marginals with the same degree of freedom parameter *n*. The distribution retains the factor volatilities and correlations implied by the short term covariance matrix.[1] Using a Gaussian copula with Student-T marginals enables users to study the effect of identical symmetric fat tails in all factor distributions. On the other hand, marginal normal distributions combined with a T-copula simulate the effect of an increased likelihood of large factor co-movements in the absence of fat tails in individual factor distributions. The most realistic marginal distributions are determined empirically. They can be specified with either a Gaussian or T-copula to account for various degrees of tail dependence. One of the key differences between PowerVaR and BxR is that BxR uses no copulas. Both the marginal distributions and co-movements between factors are determined empirically.

Treatment of Cash Flows

For Monte Carlo VaR, the user has the option to treat cash flows with no accounting for passage of time, in which market changes are assumed instantaneous, or the user can select “passage of time” accounting.

Instantaneous Market Changes

In this method, the simulated market changes are assumed instantaneous in VaR. Simulated market data changes are applied to the market data on the analysis date. Securities within the portfolio are then revalued using the modified market data as of the analysis date. This method is is appropriate for comparison with parametric VaR and for Monte Carlo VaR with short horizons.

Instantaneous Return — Bond Cash Flows

The theory behind this methodology is that VaR is a measure of market risk, while.the coupon and principal cash flows are deterministic and considered “income return.” Therefore, coupon and principal payments are not included in the bond return. Including these cash flows in the return calculation could dampen the VaR measure. Thus, the “clean” market return is computed.

Instantaneous Return — Derivative Expiration

A holding period is specified when computing VaR. The holding period defines the future date used to compute the hypothetical loss/gain. In certain cases, a derivative may expire after the analysis date but prior to the future date.

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1 Multivariate Student and multivariate normal belong to a family of elliptical distributions. One important property of this class of distributions is that the factor correlation matrix is preserved exactly. In the other cases supported by PowerVaR, the short term covariance matrix is used as a starting point, but factor correlations are somewhat changed when marginals are imposed. Factor volatilities are always left unchanged. The resulting multivariate distribution is no longer elliptical in this case.

This VaR methodology does not consider the passage of time over the VaR holding period. The VaR scenario return is computed as an instantaneous return on the analysis date. Simulated market data changes are applied to the market data on the analysis date. Securities in the portfolio are revalued using the modified market data as of the same analysis date.

If the derivative has expired on the analysis date, then the system will not calculate the VaR of the instrument. BarraOne will assume that the user has accounted for cash flows associated with the derivative expiration (positive or negative) by adjusting a cash position or account somewhere in the system.

Passage of Time

The passage of time methodology is an option that is appropriate for holding periods of greater than ten days. When passage of time is taken into account in the return calculation, assumptions must be made about reinvestment, derivative underliers must be valued on the expiration date, and derivative cash flows must be calculated. Profit and loss value in this method is defined as the difference between the asset price at the end and beginning of the simulation holding period, plus the difference in accrued interest, plus the asset-generated cash flow P&L within the holding period (coupons, *etc.*)

There are two basic use cases: the first one captures assets that are expiring or maturing within the simulation holding period; the second captures the cash flows that are scheduled to be paid within the simulation holding period (bonds, swaps, caps). For purposes of describing the methodology, imagine that we sort all assets in the simulation portfolio by their maturity or expiration date. Then, for an n-day holding period, we create n subportfolios, assigning all assets expiring on day one to the first portfolio, on day two to the second portfolio, and so on. Most assets will be assigned to last portfolio, since it will contain all assets maturing on day n and beyond.

All n portfolios are simulated based on the same factor returns set, which is scaled to the simulation horizon. The P&L of each portfolio is discounted forward to the end of holding period using the simulated risk-free rate. The first use case has a special exception: the calculation of P&L through the use of exposure approximation (MBS, convertibles, *etc.*). These assets will not take into account the cash flow paid within holding period, and the factor returns are scaled to the simulation horizon. These assets are always assigned to the n^{th} portfolio.

For the second use case (cash flow paid within holding period), each cash flow is considered as an additional cash position for the portfolio that corresponds to its payment day. This synthetic cash position ensures the proper calculation of the portfolio P&L at the end of holding period (*i.e.,* it is added to the portfolio simulated value on each path).

Bonds that mature within the holding period are converted to par and reinvested at the underlying reinvestment rate in that run to the end of the holding period. Derivatives that expire are exercised and accrued to the end of the holding period at the underlying reinvestment rate.

For options expiring during the holding period, the moneyness of the option must be determined at expiration in order to determine whether a cash payment is made or whether the option will expire without being exercised. As an example, let us consider an equity option expiring on day 5 of a 10-day holding period simulation, BarraOne will value the option using the shocked underlier price and discount rate. These shocks are computed using the monthly factor volatilities scaled down to a 5-day volatility corresponding to the 5 days from the simulation start date to the option expiration. Note that the implied volatility of the equity underlier is held constant during the simulation. If the option is in the money at expiration, BarraOne assumes it will be exercised, and the profit (*i.e.,* Spot Price – Strike Price) is reinvested for the remaining days of the holding period at the shocked LIBOR reinvestment rate. If the option is at-the-money or out-of-the-money, the value of the option is assumed to be 0, and the full loss will be recorded.

Reinvestment rate:

- Current LIBOR rate (default)
- Treasury rate (if LIBOR is not present or cannot be calculated)
- 5% rate (if none of the above are available)

Special Cases

Reset Rates

For a Floating Rate Note, IR Swap, or IR Cap that pays a coupon within the holding period, the value of the next reset rate is undefined. For instance, consider the situation where the next reset rate date is in the beginning of the holding period and therefore has to be simulated. If the holding period is long, then using the shocked interest at the end of the holding period will result in an unreasonably large variation of the reset rate and can introduce a discontinuity in the bond VaR estimation when the starting date of the holding period is gradually moved to the reset rate date. To avoid this issue, BarraOne derives a simulated reset rate by interpolating between the index value at the beginning and the end of holding period.

Path-Dependent Options

For the valuation of a Barrier option with a given factor scenario, it is necessary to consider the option payoff cancelation condition based on the simulated underlying asset value in each scenario. Since the underlying asset path is not simulated, it is assumed that the option is still active if the cancelation condition is not breached at the end of holding period. For an option expiring within the holding period, it is important that the underlying asset price is calculated based on factor returns scaled to the expiration date (instead of the end of holding period). Since an option payoff is expected to be computed through full revaluation, the cancelation condition is considered by the Barrier option valuation model.

For an Asian option (an option on average value of underlying asset price), the calculation is complicated by the necessity to approximate the simulated average value of the underlying asset price for each factor scenario. Let us denote an average asset price at time t as:

$$A_t = \frac{1}{n}\sum_{i=1}^{n} S_{t_i}$$

where index i enumerates averaging intervals, and n corresponds to a number of historically observed asset prices by time t. The expected value of the average asset price at the end of the holding period can be approximated as follows:

$$E\left(A_{t+h} \mid S_{t+h}\right) = \frac{A_t n + n_h S_t + \left(S_{t+h} - S_t\right)(n_h + 1)/2}{n + n_h}$$

where nh is the number of average intervals in the holding period. Note that the number of average intervals within the holding period nh depends on average frequency.

Computing Returns

Equity Returns

Common factor equity asset returns are based on the sum of the product of factor exposure and factor return.

$$\frac{\vec{P}_S}{P_0} = \max\left\{10^{-4}, 1 + \vec{e}_S \times F_\delta + \sigma_S \times \vec{\varepsilon}_S\right\}$$

where P_0 refers to a stock (or equity index) price at the beginning of holding period; $\vec{e}_S$ is the stock factor exposures vector; σ_S is the asset-specific risk volatility scaled to the VaR holding period; $\vec{\varepsilon}_S$ is an M-size vector of normally (mean=0, σ =1) distributed random numbers. $\vec{\varepsilon}_S$ should be uncorrelated with F_δ. Then $\vec{P}_S$ represents the vector of simulated stock prices for M scenarios at the end of VaR holding period t_h, and the histogram of $\Delta \vec{P}_S = \vec{P}_S - P_0$ represents the distribution of the asset P&L. The *max{...}* function ensures that we will not have a negative stock price after aggregation of simulated factor returns. Note that if you opt not to simulate asset-specific risk in Monte Carlo VaR simulations, then $\vec{\varepsilon}_S$ is set to zero.

Drift in Equity Distribution

The equation above assumes zero drift in the distribution of equity prices. Since information about future divided payments is not expected to be available, the best assumption about the future stock price is its current market value.

Equity Price Adjustment for FX Rate Return

The asset price P_0 in the equation above is assumed to be expressed in its local currency; in cases in which it is different from the numeraire, the currency exposure is not included in the asset exposure vector $\vec{e}_S$. Instead, the perturbed stock price $\vec{P}_S$ is converted into numeraire currency using the simulated exchange rate (see “FX Rate Return” on page 510).

Hedge Fund and Mutual Fund Returns

For hedge funds and mutual funds, the simulation is based on the simulation of hedge fund and mutual fund factors.

$$\frac{\vec{P}_S}{P_0} = \max\left\{10^{-4}, 1 + \vec{e}_S \times F_\delta + \sigma_S \times \vec{\varepsilon}_S\right\}$$

where P_0 refers to a fund price at the beginning of holding period; $\vec{e}_S$ is the fund factor exposures vector; σ_S is the asset-specific risk volatility scaled to the VaR holding period; $\vec{\varepsilon}_S$ is an *M*-size vector of normally (mean=0, σ =1) distributed random numbers. $\vec{\varepsilon}_S$ should be uncorrelated with F_δ. Then $\vec{P}_S$ represents the vector of simulated fund prices for *M* scenarios at the end of VaR holding period t_h, and the histogram of $\Delta \vec{P}_S = \vec{P}_S - P_0$ represents the distribution of the asset P&L. The *max{...}* function ensures that we will not have a negative fund price after aggregation of simulated factor returns. Note that if you opt not to simulate asset-specific risk in Monte Carlo VaR simulations, then $\vec{\varepsilon}_S$ is set to zero.

Fixed Income Returns

The relation between fixed income (FI) market data (interest rate, spread, volatility, prepayment parameter) and corresponding factor returns is complicated, because asset price change is derived from observed market data changes through a specific asset valuation model. The valuation model, together with the definition of factor exposure, determines the sign conventions for the aggregation of factor returns with asset exposures. These sign conventions might be counterintuitive compared to the aggregation of equity factor returns. However, the following generic rule can be applied: a positive factor return, together with a positive exposure, should correspond to a positive asset excess return. For instance, let us consider the return of the interest rate Shift factor. It is an approximately parallel shock of the interest rate term structure, and it is estimated based on a set of treasury bonds that all have positive exposure to this factor (exposure to the Shift factor is deemed as bond effective duration). Thus, a positive return in this factor should correspond to a decline in the level of the underlying bond term structure in order to explain positive bond excess return. This implies that the Shift factor return should be subtracted from the current term structure in the computation of an interest rate shock.

Bond P&L

In general, if we denote by $\vec{P}_h(F_\delta)$ the vector of simulated bond dirty prices at the end of simulation horizon *h* computed through the full evaluation of an asset with stressed market data, then the bond P&L vector can be computed as follows:

$$\vec{P}_{P\&L} = \left(\vec{P}_h(F_\delta) + P_0 \times \sigma_S \times \overrightarrow{\varepsilon_S}\right) \times \mu_h + \sum_t \left\{\frac{1}{DF_{t,h}} \times CF_t\right\} - P_0$$

where μ_h is a fraction of the remaining principal for each simulation scenario; σ_S is the asset-specific risk volatility scaled to the VaR holding period; $\overrightarrow{\varepsilon_S}$ is the vector of normally (mean=0, σ=1) distributed random numbers; CF_t is the expected value of cash flow payments paid at time $t \le h$; $DF_{t,h}$ is the forward discount factor from t to h; and P_0 is a bond dirty price at the beginning of the holding period. The rules for applying FI factor returns F_δ to the underlying bond market data are specified in the following sections. Note that the calculation of a cash flow expected value CF_t should be done once, at the holding period start date, by the bond valuation model. Note that if you opt not to simulate asset-specific risk in Monte Carlo VaR simulations, then $\vec{\varepsilon}_S$ is set to zero.

Applying Shift, Twist, Butterfly (STB) Factor Shocks

Barra STB factors capture the return of Treasury, Real, and U.S. Municipal term structures. For each term structure type, we have a specific set of STB shapes (principal components) used to estimate corresponding factor returns. Given the matrix of three column vectors G^{STB} of STB shapes and three-by-M matrix F_δ^{STB} of simulated STB factor returns, the M column vector matrix of term structure shocks can be defined as follows:

$$\mathbf{f}^{STB} = G^{STB} \times F_\delta^{STB}$$

where $\mathbf{f}^{STB}$ represents the semiannually compounded rate shocks for M simulation scenarios. The estimation of STB factor returns is based on a linear regression of bond price excess returns. It can be written as follows:

$$\vec{f}^{STB} = \left(D_{STB}^T \times D_{STB}\right)^{-1} \times D_{STB}^T \times \vec{r}_{ex}$$

where $\vec{r}_{ex}$ is a vector of treasury bonds excess returns, and D_{STB} is a Shift, Twist, Butterfly bond estimation universe exposure matrix. This equation imposes a linear dependency between the STB factor returns and the bond price excess returns. Since a zero coupon bond price is exponentially proportional to an interest rate of a corresponding maturity $(P_B(t) = exp(-r_t \times t))$, it can be derived that in order to maintain linear dependency between price excess returns and STB factor returns, the simulated adjustments to STB factor shocks F_δ^{STB} should be applied to the continuously compounded term structure rates as follows:

$$r_s(t_i) = r_0(t_i) - \frac{1}{t_i}\ln\left(\max\left\{10^{-4}, 1 + t_i \cdot f^{STB}(t_i)\right\}\right)$$

where $r_0(t_i)$ represents the unperturbed continuously compounded forward rate of term t_i. Taking into account only the first order component of a Taylor series expansion for the *ln* function in the previous equation simply defines the subtraction of simulated factor returns from the underlying term structure rates. However, for longterm bonds, it ensures zero drift in the distribution of simulated bond prices. If the number of STB terms in the G^{STB} matrix is different from the number of rates in the $\vec{r}_0$ vector, then to equalize the size, the missing elements can be computed with linear interpolation between the two nearest terms (or assuming constant extrapolation). The *max{...}* function in the previous equation simply ensures that the natural logarithm can be computed. The simulated interest rate vector $\vec{r}_S$ can still end up with some negative values, and unlike equity prices, they are not required to be constrained.

Swap Term Structure Shock

In the context of the Barra Fixed Income Factor Model, the return of the Swap term structure is associated with the following two components: STB factor return and Swap Spread factor return. Unlike nominal rates, the swap term structure is currently delivered as quoted money market and swap rates, and their compounding conventions are different from one market to another. More specifically, money market (sometimes called cash) rates are quoted on an annual basis, and swap rates assume the compounding of the corresponding treasury bond yield. Thus, these market rates have to be converted into continuously compounded rates and then into forward rates. The following formula defines the calculation of swap rates for one simulation scenario $\vec{f}^{STB}$:

$$r_{S,L}(t_i) = r_{0,L}(t_i) - \frac{1}{t_i} \ln\left(\max\left\{ 10^{-4}, 1 + t_i \cdot f^{STB}(t_i) + t_i \cdot f^{Swap} \right\} \right)$$

where $r_{S,L}(t_i)$ defines the unperturbed continuously compounded LIBOR forward rate of term t_i.

Bond Option-Adjusted Spread (OAS) Shock

The Fixed Income Factor Model captures the risk associated with the change of credit spreads over the swap curve for corporate bonds through the set of Sector/Rating spread factors. However, the total return of bond OAS, as spread over the nominal curve, should be computed as the sum of the market swap spread factor return f^{Swap} and the individual bond Sector/Rating spread factor return $f^{S/R}$. Thus, the adjustment of bond OAS due to simulated credit factor returns can be defined as follows:

$$OAS_S = OAS - f^{Swap} - f^{S/R}$$

Note that spread factor returns are subtracted from OAS for the same reason that the STB return is subtracted from the IR term structure. In addition to the Sector/Rating factors, the FI model has spread factors associated with Agency, Foreign Governments, Municipal, and MBS issues. Their returns should be applied to bond OAS in the same way as the Sector/Rating spread factor return in the previous equation.

Exception: U.S. Municipal bonds are not exposed to the swap spread factor, and therefore municipal bond OAS should be affected only by Municipal Sector/Rating spread factor return.

Prepayment Speed Shock

The U.S. Prepayment Speed factor is estimated based on the absolute return of the *REFI_SCALE* parameter of the MBS prepayment model. The shocked prepayment speed (*REFI_SCALE* parameter of the model) is computed according to the following formula:

$$REFI\_SCALE_S = \max\left\{ 0, REFI\_SCALE_0 - f^{REFI\_SCALE} \right\}$$

where $REFI\_SCALE_0$ refers to the unperturbed prepayment parameter.

IR Volatility Shock

The IR Implied Volatility factor is estimated based on the logarithm of the market-implied volatility of the 10-year yield. Thus, the simulated return of this factor represents the absolute change in the *ln(σ)*, where σ refers to the volatility of the Gaussian term structure model (Hull-White model). This return should be applied to the term structure volatility as follows:

$$\sigma_S = \sigma_0 \times \exp\left(f^{IMP\_VOL}\right)$$

where f^{IMP_VOL} refers to the IR Implied Volatility factor return.

FX Rate Return

The BIM covariance matrix is estimated from the perspective of a U.S. investor. The local country factors are estimated based on the asset returns computed in their local currency, while the exchange rate return for non-U.S. assets is captured in a separate currency covariance block. For instance, the return of an asset denominated in a currency different from USD, considered in the USD numeraire, can be specified as follows:

$$r_{C/\$} - r_{IR}^{\$} \simeq r_C - r_{IR}^{C} + ex_{C/\$} + r_{IR}^{C} - r_{IR}^{\$}$$

where $r_{C/\$}$ is the return in USD of the asset denominated in some other currency *C* different from USD; $r_{IR}^{\$}$ is the USD IR risk-free rate; r_C is the asset return in home currency; $ex_{C/\$}$ is the currency *C* to \$ spot exchange rate return; and r_{IR}^{C} is the risk-free rate in currency *C*. The $r_C - r_{IR}^{C}$ terms represent the estimation of local equity factors and the $ex_{C/\$} + r_{IR}^{C} - r_{IR}^{\$}$ term represents the estimation of exchange rate factors. For the purpose of the simulation of equity asset return in its local currency, we do not take into account the r_{IR}^{C} risk-free rate. For FI assets, r_{IR}^{C} is taken into account.

Taking the money-market account as the choice of numeraire, it can be shown that under the assumption of deterministic economy the expected value of future exchange rate $ex_{C/\$}$ at the end of holding period is equal to its forward value given by $ex_{C/\$} + r_{IR}^{C} - r_{IR}^{\$}$ terms in the previous equation. Then, the vector of shocked exchange rates for $r_{IR}^{C} - r_{IR}^{\$}$ currency *C* over \$ can be defined as follows:

$$\vec{R}ex_{C/\$,S} = Rex_{C/\$,0} \times \max\left\{10^{-6}, 1 + \vec{F}_0^{ex}\right\}$$

where $Rex_{C/\$,0} = Rex_{C/\$,Spot} \times \exp\left(\left(r_{IR}^{C} - r_{IR}^{\$}\right) \times t_h\right)$ defines the forward exchange rate at the end of holding period t_h.

Instantaneous Shocks

The simulation that does not account for the passage of time in the calculation of the perturbed asset price at the end of the holding period, the return of exchange rate factors in the previous equation should be applied directly to the spot exchange rate $Rex_{C/\$,Spot}$.

Cross-Currency Exchange Rates

Once currency C over \$ exchange rates are simulated according to the previous equation, the simulated exchange rate for currency $C1$ over currency $C2$ can be computed as the ratio of corresponding exchange rates over \$:

$$\vec{Rex}_{C1/C2,S} = dot\left\{ \vec{Rex}_{C1/\$,S}, \frac{1}{\vec{Rex}_{C2/\$,S}} \right\}$$

Future Contract Currency Conversion

All exchange-traded futures contracts should be excluded from the simulated exchange rate adjustment, because futures positions are assumed to have no currency exposure due to the daily settlement of the margin account. Therefore, if the portfolio includes a futures contract position denominated in a currency different from the numeraire currency, its P&L values should be converted into the numeraire currency using the $Rex_{C/\$,0}$ forward exchange rate).

Accounting for Interest Rate Drift

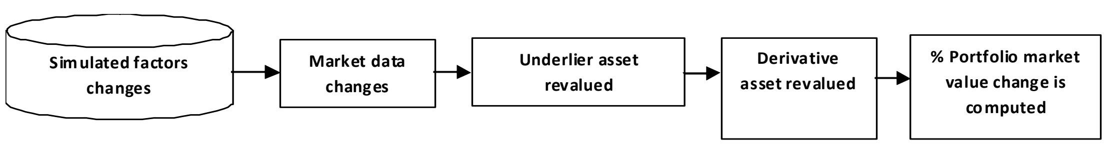
For the Monte Carlo VaR implementation that takes passage of time into account, the shocks to the term structures described in "Applying Shift, Twist, Butterfly (STB) Factor Shocks" on page 508 and "Swap Term Structure Shock" on page 509 are applied to forward interest rates. The transformation of the continuously compounded spot rate of term T to the continuously compounded forward rate of the same term at the end of the holding period t_h can be defined as follows:

$$r\left(t_h, T\right) = \frac{1}{T}\left(r\left(0, t_h + T\right)\left(t_h + T\right) - r(0, t_h)t_h\right)$$

where $r(t_h, T)$ defines the forward rate from t_h to $t_h + T$, and $r(0, t_h)$ defines the spot rate of term t_h at the beginning of the simulation holding period.

Derivative Returns

The following diagram describes the sequence of steps for revaluing derivative assets:



Derivative Specific Risk

The equation in "Equity Returns" on page 506 defines the specific risk adjustment for a stock price return. For an option return written on an equity asset and directly recalculated based on the simulated stock price, no further specific risk adjustment is necessary. However, for fixed income derivatives such as bond options, bond futures, option on bond futures, and CDS that have specific risk exposure, the calculation of the specific risk adjustment in simulation is more complex. The equation in "Bond P&L" on page 507 simplifies a bond's return specific risk adjustment as a Gaussian uncorrelated random vector $\vec{\varepsilon}_S$ scaled by a bond specific risk volatility σ_S. For details about Barra's bond specific risk model refer to the *Barra Risk Model Handbook*.

Note that we have the following two bond specific risk models:

Heuristic Model:

$$\sigma_s(T_h) = D(b + cS)\sqrt{T_h}$$

Transition Matrix Based Model:

$$\sigma_s(T_h) = \sqrt{\left(D^2 a_{rating} + b_{rating}\right)T_h}$$

In the formula above, D is bond spread duration, S is option-adjusted spread, b, c, a_{rating}, and b_{rating} are periodically estimated model parameters, and T_h is a simulation holding period. Note that σ_S depends on bond spread duration D. Thus, an accurate estimation of σ_S for a given holding period requires a multi-step simulation to capture the change in bond duration. Since this is not practical, we approximate the change in the bond specific risk variance by linearly scaling it with the following function:

$$f\left(\frac{T_h}{T_m}\right) = \begin{cases} 1 - \dfrac{T_h}{T_m}, & if\ T_h \le T_m \\ 0, & if\ T_h > T_m \end{cases}$$

where T_h and T_m define the length of the holding period and time to bond maturity measured from the beginning of the holding period. Then, the bond specific risk in the equation in "Bond P&L" on page 507 is computed as follows:

Heuristic Model:

$$\sigma_s = D(b + cS)\sqrt{T_h f(T_h / T_m)}$$

Transition Matrix Based Model:

$$\sigma_S = \sqrt{\left(D^2 a_{rating} f\left(\frac{T_h}{T_m}\right) + b_{rating}\right)\min\left[T_h, T_m\right]}$$

Note that for an option written on a bond, unlike for an equity option, the specific risk is calculated as the delta-adjusted underlying asset specific risk multiplied by the Gaussian uncorrelated random vector ε, because in this case the bond option valuation model does not allow for explicitly adjusting the simulated underlying bond price with its specific risk exposure.

Monte Carlo VaR Approximation with Multidimensional Interpolation

The calculation of portfolio Value at Risk (VaR) using Monte Carlo simulation requires the reevaluation of each asset in the portfolio for each simulated market scenario. When the portfolio contains computationally complex derivatives, the estimation of VaR can therefore be very expensive. The problem can be described as follows: suppose an asset is exposed to n risk factors, and $V(f_1, .., f_n)$ is the return of the asset corresponding to a factor scenario return vector $(f_1, .., f_n)$. Monte Carlo simulation easily generates the factor scenarios, but if the calculation of $V(f_1, .., f_n)$ requires the evaluation of complex embedded options, the estimation of asset returns required for the VaR calculation will be time consuming.

The BarraOne approach to approximation is to replace the full revaluation of $V(f_1, .., f_n)$ with an approximation based on multidimensional interpolation. This approach differs from the common practice of approximating $V(f_1, .., f_n)$ using first- or second-order Taylor series expansion, which requires estimating delta and gamma (first- and second-order partial derivatives) for each risk factor. An expansion limited to delta terms, *i.e.,* representing asset return in terms of linear risk exposures, can be used for assets with linear payoff functions, but it fails to capture VaR correctly for derivatives with a significant curvature in the payoff. Accounting for gamma effects improves accuracy, but it requires the magnitude of the underlying risk factor returns to be relatively small. The delta-gamma approximation may thus fail for large simulation horizons, typically on the order of one month or more, because many of the simulated factor returns will be too large to justify the use of a second-order Taylor series expansion. An additional practical issue is that gamma estimates can be inaccurate when the valuation model for $V(f_1, .., f_n)$ also requires simulation methods, thus limiting the applicability of the delta-gamma approximation.

The model used for the multidimensional interpolation of $V(f_1, .., f_n)$ in BarraOne overcomes the limitations of the delta-gamma approximation by using a general interpolation scheme based on radial basis functions[1]. The BarraOne approach satisfies the following criteria:

- It is meshless, in that it does not require any particular geometry of sample points to build the interpolation
- It is exact, in that it precisely reproduces the known values at the sample points
- It is efficient, in that it requires a fraction of the sample points out of total number of simulation scenarios
- It is generic, in that it accurately approximates general nonlinear functions, and it is therefore applicable to all types of derivatives

1 See A. Iske, "Radial Basis Functions: Basics, Advanced Topics and Meshfree Methods for Transport Problems." Rend. Sem. Mat. Univ. Pol. Torino, Vol. 61, 3 (2003).

The construction of the interpolator requires the careful selection of the sample points used to cover the space of factor return scenarios $(f_1, .., f_n)$ generated by the simulation job. This is achieved by evaluating the space covered by the factor returns for each instrument through a principal component analysis of the covariance matrix. The result is an interpolation that is accurate regardless of the simulation horizon or the magnitude of the risk factor volatilities. Our testing results, with up to ten thousand simulated scenarios, show that VaR estimated through the full reevaluation of $V(f_1, .., f_n)$ *vs.* multidimensional interpolation of $V(f_1, .., f_n)$ is within the simulation error threshold for a broad set of asset types (MBS, CMO, complex floaters with embedded options, convertibles) and simulation horizons of up to one year.

The following instrument types are evaluated with this methodology by default; all others use the full valuation method. When an asset class is configured to use the full valuation method, and if it takes more than 20 milliseconds per valuation, BarraOne evaluates the asset using the approximation approach.

Table 31: Asset Types Subject to Radial Approximation

ARM	Certificate/Tracker	Structured Asset
Bond Option	Bond Future Option	Bond Future
CDS (single name, index, CLN, *etc.*)	MBS, Danish MBS	Convertible Bond
CMO/ABS	Fix To Float (Variable Rate)	Floater
Equity Option	Swaption	FX Option

Note: If a single valuation exceeds 4 seconds, BarraOne reduces the sample points to 16. For valuations between 1 and 4 seconds, BarraOne uses fewer than 128 sample points(64 or 32, depending upon the valuation time).

Scaling

If *Use Scaling* is selected, then BarraOne first calculates the MCVaR as if the scaling period were the actual holding period, and it then scales the dollar output by the scaling factor α:

$$Scaling\ Factor\ \alpha = \sqrt{\frac{Holding\ Period}{Sampling\ Period}}$$

Thus, the Simulation VaR ($) for each asset is:

$$VaR(\$, scaled) = \alpha \cdot VaR(\$, unscaled)$$

The portfolio-level numbers are computed similarly. The % numbers, *i.e.,* VaR (%) are computed from the scaled $ values.

All dollar-based simulation VaR values are scaled:

- Active Component Simulation VaR ($)
- Active Expected Shortfall ($)
- Active Incremental Simulation VaR ($)
- Active Marginal Simulation VaR ($)
- Active Simulation VaR ($)
- Component Simulation VaR ($)
- Expected Shortfall ($)
- Incremental Simulation VaR ($)
- Marginal Simulation VaR ($)
- Simulation VaR ($)
- Simulation VaR Diversification ($)

Simulation VaR (%), Active Simulation VaR (%), and Standard Deviation of Simulated Returns are also scaled.

The following value is not scaled:

- Portfolio/Benchmark Simulation VaR

Chapter 5

VaR Backtesting

This chapter is dedicated to the treatment of VaR Backtesting in BarraOne.

Introduction

BarraOne VaR Backtesting is used to test the accuracy and predictive power of BarraOne Monte Carlo simulation, historical VaR, and parametric Value at Risk. It enables users to compare these calculated VaR values with the hypothetical P&L of the portfolio or asset over a period and thereby to check whether the hypothetical returns are consistent, at a given confidence level, with the corresponding VaR produced by each model.

There are many possible sources of error in a VaR calculation, both random and systematic. Correlations and volatility estimates might be wrong, risk factors might be omitted, and pricing models might be inaccurate. VaR Backtesting enables users to provide regulatory evidence of the applicability and credibility of their internal VaR models approach, and as such it is a vital part of regulatory oversight on the sell side and risk oversight within the buy side.

The problems and regulatory requirements have motivated the development of backtesting theory and approaches to VaR. Backtesting is important to discover incorrect structural and distributional assumptions in VaR methods, to test the method in different settings, and to evaluate the method’s capability to produce accurate forecasts for expected losses.

Backtesting of Value at Risk improves market risk management and leads to more accurate VaR methods. The improved accuracy and market risk management can release capital and work resources for core business operations, because the capital requirement against market risk is set by the regulators on the basis of reported VaR.

Backtesting of VaR models helps to identify the advantages and disadvantages in each model, and it can be used to detect incorrectly specified VaR models and sources of inaccuracy in VaR forecasts. Value at Risk models and their accuracy can be compared through backtesting to select adequately accurate models in market risk management.

Backtesting is also required by the regulatory bodies, as the Basel Committee has set up standards for the quality of VaR data in the backtesting framework.

Basel Committee (1996a) recognizes that the backtests in their framework have a limited power to distinguish an accurate model from an inaccurate model. The reason for the use of the number of exceptions as a basis for classification in the backtesting process is the simplicity and straightforwardness of the method. This approach necessitates the assumption that each day’s outcome in backtests is independent of the outcome on any other day.

The different types of errors in backtesting must be acknowledged to be able to avoid them. Conventionally, error types are associated to hypothesis tests, but they are readily generalized to backtesting as a whole. If back tests are accurate and systematically specified to detect the accuracy of a VaR model, they categorize an inadequate VaR model as inaccurate and incorrectly specified. An accurate and adequately specified VaR model is classified as a well-defined model.

The classification of a valid VaR model as an invalid model based on the backtests constitutes a Type I decision error. The categorization of an invalid VaR model as a valid model constitutes a Type II decision error. These two error types are used in backtesting process to evaluate the goodness of the back test.

An important element in backtesting implementation is the formulation of backtesting to a process. The process design ensures the overall control and sustainable development of functional market risk management. In addition to the improvement and control of the quality of risk measures, market risk management often improves through reliable trading, P/L calculation, the use of accurate positions in VaR calculation, and improvements in the overall organization culture (Jorion, 2001).

The type of P/L must be acknowledged in the backtests, because it has a tremendous effect on the backtests. Generally, P/L can be divided into three categories, each of which can be used in backtesting. The different types are referred to as theoretical P/L, hypothetical P/L, and real P/L. Jorion (2001) defines theoretical P/L as the returns entirely generated from a statistical model, hypothetical P/L as the returns generated from a static portfolio of assets with real market risk factor movements, and real P/L as the returns, which include all profit and loss components. Hypothetical P/L should primarily be used in backtesting and real P/L in regulatory reporting (Jorion, 2001).

Regulators stipulate that backtesting should be performed daily. In addition, an institution must identify the number of times that its net trading losses, if any, for a particular day exceeded the corresponding daily VaR. As BarraOne is capable of generating three forms of VaR (Monte Carlo, historical, and parametric), the expert buy-side practitioner should compare hypothetical P&L against all three forms in order to track the relative performance of his risk measures and understand better the non-linear risks associated with his portfolio.

When backtesting is employed in relation to regulatory capital requirements, the backtests must compare VaR measures calibrated to a movement in rates and prices over a specified holding period and a specified (one-tailed) confidence level, against two measures of the profit & loss (P&L):

- "Dirty" backtesting: The actual net trading P&L for the holding period, and
- "Clean" backtesting: The hypothetical P&L, also called "static P&L," that would have occurred had the position at the close of the business day been carried forward over the holding period (captured with BarraOne VaR Backtesting).

Assumptions and Prerequisites

VaR is usually computed at the close of the trading day, and it is based on the market positions reported at that time, *i.e.,* the VaR methodology does not take into account the next day's trading. It assumes unchanged positions and calculates P&L due strictly to market price movements.

For any instruments that will mature or expire during the holding period, BarraOne applies the holding period's price movement but sets the valuation date to the maturity date. Stock splits and other corporate actions are handled by Barra without any client intervention.

Methodology

VaR Backtesting evaluates the same set of portfolios or assets at two points. First, it values the selected portfolio or asset using market data at the portfolio date. Then, it values the selected portfolio or asset with market data at a selected later date. The difference between the dates represents the holding period of the portfolio or asset.

The difference between these two portfolio/asset values is called hypothetical P&L, or the return on the portfolio that would have occurred if the portfolio/asset had been held over the specified holding period (*e.g.*, 1, 10, or 22 days). BarraOne VaR Backtesting stores hypothetical P&Ls to compare with the VaR figures generated from parametric VaR and each Monte Carlo and historical VaR job.

Equities versus Bonds and Derivatives

Equities are generally evaluated based upon returns.

- If corporate-action-adjusted returns (realized and unrealized) over the holding period are available, these returns are used to compute P&L.
- If corporate-action-adjusted returns are missing, the difference between *prices x holdings* at T and $T+n$ are used to compute returns (users are expected to adjust their holdings to reflect corporate actions).

If bonds have available returns, then the returns will be used to calculate P&L. Otherwise, bonds are evaluated based upon market conditions; the bond is evaluated with holdings as of T using market data as of $T+n$.

On the other hand, derivatives are always evaluated based upon market conditions. The interest rate derivative, equity derivative, or foreign exchange derivative is evaluated with holdings as of T using market data as of $T+n$.

Asset-Level VaR Backtesting Methods

The following table describes how hypothetical P&L is calculated for different asset types.

▷ **Note:** Where prices are used in backtesting calculations, any supplied price will have priority over a model-calculated price.

Table 32: Backtesting P&L Methods

Instrument (Market)	Backtesting P&L Method
Agency Bond (U.S.)	Apply realized term structure changes to current term structure. Revalue bond using realized term structure. Compute profit/loss based on the change in value of the bond.
Bond Future (Australia, Canada, U.K., Euro, Germany, Japan, Korea, Spain, Sweden, Switzerland, U.S.)	Apply realized term structure changes to current term structure. Revalue the deliverable bonds using realized term structure. Compute the profit/loss of the future based on the change in value of the underlying bonds.
Bond Future Option	Apply realized term structure changes to current term structure. Revalue the deliverable bonds using realized term structure. Compute the profit/loss of the future option based on the change in value of the underlying bonds.
Bond Option	Apply realized term structure changes to current term structure. Revalue the underlying bond using realized term structure. Revalue the bond option using the Crank-Nicholson algorithm. Compute profit/loss based on the change in value of the bond option.
Commercial Paper	Apply realized term structure and spread changes to current term structure. Revalue commercial paper using realized term structure and credit spread. Compute profit/loss based on the change in value of the commercial paper.
Commodity	Realized change in the price of the commodity.
Commodity Future Commodity Index Future	Realized change in the user-provided price of the commodity (index) future, obtained by using the return history of the Rolling Maturity Futures associated with the commodity.
Commodity Future Option	Realized change in the underlying commodity's price is applied to the commodity price as of the analysis date, obtained by using the return history of the Rolling Maturity Futures associated with the commodity.
Composite of Barra-supplied index or the user's own portfolio	Realized composite returns.
Convertible Bond (U.S. and Global)	Apply realized term structure and spread changes to current term structure. Revalue bond portion of the security using realized term structure and credit spread. Apply realized equity price changes to the underlying equity and revalue the conversion option. The value of the convertible is computed as the sum of the value of the bond portion and the value of the option. Compute profit/loss based on the change in value of the convertible bond.
Corporate Bond (U.S. and Global)	Apply realized term structure and spread changes to current term structure. Revalue bond using realized term structure and credit spread. Compute profit/loss based on the change in value of the bond.

Table 32: Backtesting P&L Methods (Continued)

Instrument (Market)	Backtesting P&L Method
Credit Default Swap	Apply realized credit spread changes to current CDS spread. Use the new CDS spread to revalue the instrument. Compute profit/loss based on the change in value of the CDS.
CDS Option	Requires access either to Markit CDS curve data or user-imported curve data.
Currency	Realized changes in exchange rates are applied to the current exchange rate. The currency is marked to market with the realized exchange rate. Compute profit/loss based on the change in value of the currency.
Currency Forward	Realized term structure changes are applied to the current term structure. Realized currency exchange rates are applied to current exchange rates. The realized term structure and exchange rates are used to compute the net present value of the two legs of the currency forward. Compute profit/loss based on the change in value of the currency forward.
Currency Future	Realized term structure changes are applied to the current term structure. Realized currency exchange rates are applied to current exchange rates. The realized term structure and exchange rates are used to compute the holding period profit/loss for the currency future.
Duration Proxy	Realized returns are calculated from user-provided prices.
Equity (Global)	Realized change in the equity's price.
Equity Future Equity Index Future	The realized P/L($) at the asset level on day t = user price on day t * user return (%) on day t+1 * contract size * holdings. If a user-provided return does not exist, then user prices are used to calculate return. For VaR Backtesting purposes, this return is computed as the realized change in the user-provided price of the equity (index) future: $$r_h = \frac{P_h - P_A}{P_A}$$ where r_h is the forecast return of the equity (index) future over the holding period. The hypothetical profit/loss is: $$P / L = r_h \cdot EMV_A$$ where EMV_A is the effective market value of the future on the analysis date. (Since futures are marked to market daily, the actual market value of the future is 0 on any given day.) If the price currency and base currency are different, then FX rates are incorporated in the analysis.
Equity Index (Selected Global)	Realized change in the equity index's price.
Equity Option	Realized change in the underlying equity's price is applied to the equity price as of the analysis date. The realized change in the applicable term structure is applied to the current term structure. The realized equity price and realized term structure is used to revalue the equity option. Compute profit/loss based on the change in value of the equity option.

Table 32: Backtesting P&L Methods (Continued)

Instrument (Market)	Backtesting P&L Method
Eurobond (Global)	Apply realized term structure changes to current term structure. Revalue bond using realized term structure. Compute profit/loss based on the change in value of the eurobond.
Exchange-Traded Fund	Realized change in the price of the ETF.
Floating Rate Note (U.S. and Global)	Apply realized term structure and spread changes to current term structure. Revalue the FRN using the realized term structure and spread. Compute profit/loss based on the change in value of the FRN.
Government Note/Bond (Global)	Apply realized term structure changes to current term structure. Revalue bond using realized term structure. Compute profit/loss based on the change in value of the bond.
Hedge Fund	Realized change in the price of the hedge fund.
Inflation Linked Liability	User-supplied returns for inflation-linked liabilities are not accepted in VaR Backtesting. These instruments are evaluated using realized market conditions.
Inflation-Protected Bond (Australia, Canada, Euro, New Zealand, South Africa, Sweden, U.K., U.S.)	Apply realized real term structure changes to current real term structure. Revalue bond using realized term structure. Compute profit/loss based on the change in value of the bond.
Interest Rate Swap	Apply realized term structure changes to current term structure. Revalue each leg of the interest rate swap. The sum of the value of the two legs is the new market value of the swap. Compute profit/loss based on the change in market value of the swap.
Mortgage-Backed Security (U.S.)	Apply realized term structure changes to current term structure. The realized term structure is supplied as an input to the mortgage prepayment model. The mortgage backed security is then revalued using the new prepayment forecasts. Compute profit/loss based on the change in value of the MBS.
Municipal Bond (U.S.)	Apply realized municipal term structure changes to current municipal term structure. Revalue bond using realized term structure. Compute profit/loss based on the change in value of the bond.
Mutual Fund/Unit Trust	Realized change in the price.
Private Equity	Realized change in the user-provided price.
Structured Products (U.S., EMU)	Realized change in the market value.
StructureTool Assets	Apply realized term structure and spread changes to current term structure. Revalue StructureTool asset using realized term structure and credit spread. Compute profit/loss based on the change in value of the StructureTool asset.
Term Deposit	Apply realized term structure changes to current term structure. Revalue the term deposit using the realized term structure. Compute profit/loss based on the change in value of the term deposit.

- **Note:** All assets are also subject to currency P&L when the asset currency differs from the reporting currency: Realized changes in exchange rates are applied to the current exchange rate. The currency is marked to market with the realized exchange rate. Profit/loss is computed based on the change in the value of the currency.

Evaluating the Results

The VaR Backtesting results should be less than the VaR results within the confidence level. Assuming that the risk factors are correctly modeled and the markets behave accordingly, the number of times that the VaR Backtesting loss exceeds the predicted Value at Risk should not be more than one minus the confidence level. Thus, the absolute value of hypothetical P&L over the last 250 days is expected to be greater than the calculated VaR figure on only two and one-half days on average (*i.e.*, three days in practice, given our 99% confidence level).

Treatment of Data Issues

There are a few potential data issues that if left unresolved could cause erroneous P&L calculations. This section outlines those issues and the ways that they are handled in VaR Backtesting.

The implementation is similar to that of historical VaR simulations, in that the time series of prices is processed for each holding period (*e.g.,* 1 day, 10 days) to generate a return. When the VaR Backtesting job is run, it tries to find the return for the holding period for that asset in order to compute the P&L over the holding period (*T+n* in the table below).

Table 33: Data Issues and BarraOne Solutions

Data Issue	BarraOne Solution
Equity returns are missing between *T* and *T+n*.	If corporate-action-adjusted returns (realized and unrealized) over the holding period are available, these returns are used to compute P&L. If corporate-action-adjusted returns are missing, the difference between *prices x holdings* at *T* and *T+n* are used to compute returns (users are expected to adjust their holdings to reflect corporate actions).
There is a stock merger at *T+n*.	All equity returns are corporate action adjusted.
A dividend or split occurs between *T* and *T+n*.	
A bond matures between *T* and *T+n*.	Not applicable. The bond is evaluated with holdings as of *T* using market data as of *T+n*.
An interest rate derivative has expired prior to *T+n*.	
An equity derivative or foreign exchange derivative has expired prior to *T+n*.	
Portfolio contains futures.	VaR Backtesting uses effective market value for futures (same as Historical VaR).

Sample Reports

BarraOne provides the following VaR Backtesting reports:

- Summary Report
- Raw Data Report
- Error Report

Summary Report

The summary report includes the following information:

- Confidence interval
- Start and end dates of the backtest period
- Total number of data points
- Number of realized exceptions
- Number of expected exceptions
- Maximum underprediction

	A	B
1		
2	Porfolio Name	Comp_Single_USD
3	Confidence Interval	95.0
4	Start Date	09/09/2007
5	End Date	10/08/2007
6	Total Number of Data Points	6
7	Number of Realized Exceptions	0
8	Number of Expected Exceptions	0
9	Maximum Underprediction	N/A

Raw Data Report

The raw data report provides the following for each data point:

- Realized P/L
- Hist VaR

- Whether the difference is an exception (loss > 0 and ≥ HVaR)

	A	B	C	D
1	Date	Realized P/L	Hist VaR	Exception (Y/N)
2	09/28/2007	0.37	0.60	N
3	09/29/2007	0.37	0.60	N
4	09/30/2007	0.37	0.60	N
5	10/01/2007	10.00	0.14	N
6	10/02/2007	10.00	0.34	N
7	10/03/2007	-0.11	1.19	N

Error Report

The following information is provided with the error report:

- Dates for which VaR forecasts are missing
- If portfolio's net value has changed since the VaR forecast was generated (for example, if the portfolio's holdings, prices, or other market conditions have changed). Depending on the magnitude of the change, you might want to regenerate the VaR forecast report to ensure the backtest results will be valid.

	A	B	C
1	Date	Type	Message
2	10/02/2007	Error	Net Value of the portfolio has changed from 100.0 to 50.0 USD
3	10/03/2007	Error	Net Value of the portfolio has changed from 100.0 to 60.0 USD
4	09/09/2007	Warning	HVaR testing results are missing
5	09/10/2007	Warning	HVaR testing results are missing

Chapter 6

Miscellaneous Analytics

This chapter is covers miscellaneous analytics and methodologies in BarraOne.

- **Multiple Model Support**
- **BIM301XL**
- **Macro Factor Models**
- **BIM with Global Equity Factors**
- **Factor Correlations Report**
- **Month-End Reporting**

Multiple Model Support

Users have the option of selecting either the Barra Integrated Model—BIM301L; a short-term model based on BIM—see below; a long-term variant of BIM—BIM301XL—see “BIM301XL” on page 534; or a combination of BIM and global equity factors—BIM301L (with GEM2Lfactors)—see “BIM with Global Equity Factors” on page 540.

Short-Term Covariance Matrix

The short-term covariance model was developed to forecast risk over a horizon that is measured in one to ten days. The model provides accurate risk forecasts for this short-term horizon using the same set of risk factors as in the Barra Integrated Model (BIM). We refer to this shorter horizon as the “reporting horizon” to keep it conceptually distinct from the investment horizon targeted for BIM estimation. The model is estimated based on daily factor returns (DFRs), and it consistently outperforms BIM in forecasting daily horizon VaR.

For detailed information regarding the short-term covariance model estimation and testing refer to the *Modeling Value at Risk with Factors* white paper.

The short-term model can be used for all analysis reports (with the exception of Optimization), as well as Monte Carlo VaR simulation. The short-term covariance matrix is used in both Monte Carlo VaR simulations and parametric risk calculations for holding periods of one to ten days. The BIM covariance matrix is used for holding periods of greater than ten days.

Short-term Monte Carlo VaR uses the same process previously outlined for Monte Carlo VaR, except that rather than scaling the monthly BIM covariance matrix to the simulation horizon, the short-term covariance matrix is constructed on the fly from daily data (daily factor and asset returns) where such data is available. Daily factor returns are available for all currency models, all fixed income models, and all equity models except the following:

- CZE1: Czech Republic Equity Model
- HUE1: Hungary Equity Model
- PLE1: Poland Equity Model
- SKE1: Slovakia Equity Model

These DFRs are weighted using a decay factor (an exponentially weighted moving average) determined by a user-specified half-life parameter, enabling the user to give more importance to the most recent history of factor returns. The history of factor returns used in estimating the short-term covariance matrix is also limited to six times the half-life period. Barra has found that a 21-day half-life provides the best trade-off between the responsiveness and noisiness of the risk forecast, and for this reason has chosen this value to be the default for this input. Note that specific return variances are estimated in the same way as for the investment horizon models (see the Barra Risk Model Handbook) and then scaled to a VaR estimation horizon proportional to the number of days in the simulation horizon.

Short-term Covariance Matrix Blocks

The short-term covariance matrix has the following distinct blocks estimated according to different methodologies:

Daily Factor Return Block

For the Daily Factor Return (DFR) block of the short-term covariance matrix, all factor variances and covariances are updated on a daily basis according to the standard recursive formula for covariances computed via an exponentially weighted moving average. All fixed income, currency, and equity factors with available DFRs are grouped in one large block, which is entirely recalculated based on DFRs and a user-specified half-life. This daily block is then scaled into the original (investment horizon) BIM matrix.

Non-DFR Markets Equity Block

Data from non-DFR market equities is insufficient to extract high-frequency correlations between factors. Therefore, when constructing the short-term covariance matrix, the factor correlations within the Non-DFR Markets Equity block are left unchanged from their monthly values in the BIM covariance matrix.

The following is list of the non-DFR market equity models for which a reliable daily index can be constructed based on individual asset returns.

- CZE1: Czech Republic Equity Model
- HUE1: Hungary Equity Model
- PLE1: Poland Equity Model
- SKE1: Slovakia Equity Model

To construct the daily market index for a particular country, we select all stocks from the estimation universe of that country for which daily returns are available. The weight of each stock in the index is proportional to the respective market cap on the first business day of the month. During the month, stock weights are adjusted to account for daily asset returns (equivalent to holding a fixed number of shares of each stock for the entire month).

The historical, exponentially weighted volatility of the index is computed using the same half-life parameter used for the DFR block. Then, we estimate the volatility of the estimation universe index portfolio using the investment horizon BIM covariance matrix and scale it to the simulation horizon. By adjusting the volatility of each factor by the ratio of the historical short-term volatility to the BIM volatility of the market index, we increase the responsiveness of the risk forecast corresponding to the reporting horizon.

Other Blocks

In local models where both DFRs and daily indexes are unavailable, the daily variances and covariances for these factors are computed from their respective monthly values by dividing them by 21 (the average number of trading days in a month). These blocks include commodity and hedge fund factors.

BIM301XL

A stable, long-horizon variant to BIM, called BIM301XL, complements the BIM301L variant of the Barra Integrated Model. The XL variant of the Barra Integrated Model is built with an 8-year half-life over an expanding window return history. A 6-month history of covariance matrices is available for analysis dates prior to the release date of BarraOne 3.7.

In this variant, the component covariance matrix blocks, global factor covariance matrix, and local-global exposures are re-estimated with equal weights from the same factor returns as BIM301L. The blocks for private assets (hedge funds, private real estate, and private equity) are not fully re-estimated. Most of the 2,800 factors have a return history spanning the full 10 year history

BIM301XL is useful for clients who require an equally weighted covariance matrix for Solvency II requirements, or for asset owners who are interested in a long-horizon model.

Users can choose this model for use in the following areas of BarraOne:

- Analysis tab (Reports and MPC)
- Simulation tab (Setup > MCVaR Profile, Reports)
- Portfolio Optimization
- Portfolio Admin tab
- Data Admin tab (Attributes, Factors, Screen, and User Assets)
- Import
- Export Sets (Portfolio Analysis, Multiple Portfolio Comparison, Stress Test Simulation, and Monte Carlo VaR)
- Accounts (My Profile)

That the following areas of BarraOne are not supported by this model:

- Returns Calculator
- Performance Attribution
- BIM Daily
- Historical VaR
- VaR Backtesting

Notes:

- Attributes for both versions of BIM301 are identical
- Exposures are identical for fixed income assets, factor assets, hedge fund assets, and mutual fund assets
- Intex and StructureTool assets inherit the model selection from the batch jobs that are run to process their exposures

Macro Factor Models

Subject to user licensing, BarraOne supports macro factor model options in BIM301L. Macro factor models attribute the risk of the Barra Integrated Model to a far smaller set of factors. At the highest level, we use just six factors, representing the primary drivers of total risk and return for a global, multi-asset class portfolio that reduces the number of factors in an integrated factor model by creating single factors, otherwise known as macro factors, from selected groups of factors. For instance, the Tier 1 Macro Factor Scheme has only six factors:

- Equity: Global public and private equity
- Interest Rates: Sensitivity to global interest rates
- Credit: Sensitivity to global credit spreads
- Inflation: Sensitivity to breakeven inflation
- Real Assets: Real Estate and Commodities
- Pure Alternatives: Investment strategy return of Private Equity and Hedge Funds, net of traditional public factor returns

Macro factors enable users to focus their investment analysis and decision-making on the important aspects of their strategies, while providing precise estimates and risk forecasts that use the full detail of the Barra Integrated Model. Multiple tiers of granularity enable investors to "zoom" in and out to the level of detail desired.

Regardless of the level of detail, the macro factors are exactly consistent with the underlying Barra Integrated Model. Factor Residuals capture the components of risk and return of the Barra Integrated Model factors net of the macro factors, so that all risk forecasts are exactly consistent. The factor residuals can be included with the factor groups of the standard Barra Integrated Model factors, or rolled up into a single Factor Residual component.

Macro factors have the same capabilities as standard factor models, including exposures, factor returns, and risk and return contributions. Unlike groups of factors, macro factors enable well-defined and intuitive factor exposures. These exposures represent the primary dimensions the investor can control, which the macro factor models relate to the portfolio risk and return.

Note: The Beta estimation of macro factors is floored at zero to avoid negative correlations.

A research white paper on macro factors in BarraOne is available here.

Macro Factor Schemes

BarraOne provides predefined macro factor schemes, but customization may be possible in the future. The macro factor schemes currently available are detailed in spreadsheets available here, numbered in order of increasing granularity.

Portfolio Strategy Settings

Users may assign a macro factors scheme to each portfolio, tree, or node. The macro factors scheme is selected as part of the profile settings, and it is reflected in the portfolio strategy. The user can edit the strategy settings in either Data Admin > Strategies or Portfolio Admin > Settings.

Import templates for portfolio and trees that reflect this option are available here. For trees, note that different factor schemes may be selected for different nodes of a tree, and there is no inheritance of the schemes from other tree levels.

A global default macro factors scheme for each user may also be selected in Accounts > My Profile > General Settings > Default Macro Factors Scheme.

The scheme selected here will be overridden by any setting selected in a Portfolio Strategy. For instance, if the scheme selected here is "Tier 3," and if the scheme selected in Portfolio Admin > Settings is "None," then the portfolio's scheme will be Tier 3. However, if in this case the scheme selected in Portfolio Admin > Settings is "Tier 1," then the portfolio's scheme will be Tier 1.

Reporting

The following reports can make use of the macro factors model:

- The Positions Report displays the asset-level exposure and contribution to each macro factor. Open the Customize Positions Report window, and mark the *Enable Macro Factors* checkbox to view and select the macro factor columns to display. *Risk Model* > *BIM301 Factors* now reads *BIM301 (<Macro Factors Scheme>) Factors*, and the factors themselves are under *Macro Factors Detail*.

  Note that macro factors in the current macro factors scheme only may be selected, and that grouping using macro factors is not supported in BarraOne.

  In addition to the macro factors under *Macro Factors Detail*, the following related columns are available:

  #### *Portfolio Risk*

  - %CR to Macro Factors Risk
  - MC to Macro Factors Risk
  - Macro Factors Contribution
  - Macro Factors Correlation
  - Macro Factors MCTR
  - Macro Factors Risk

Active Risk

- %CR to Active Macro Factors Risk
- Active Macro Factors Contribution
- Active Macro Factors Correlation
- Active Macro Factors MCTR
- Active Macro Factors Risk
- MC to Active Macro Factors Risk

Notional Analytics

- MC to Macro Factors Risk (Notional)
- Macro Factors Risk (Notional)

Active Notional Analytics

- Active Macro Factors Risk (Notional)
- MC to Active Macro Factors Risk (Notional)

The following relationships hold at the asset level in the Positions Report:

- Common Factor Risk Contribution = Macro Factors Risk Contribution + Residual Factor group risk contribution.
- Macro Factor Risk Contribution = Sum of contributions from all macro factors. (This can be computed from the Risk Decomposition Report or the Factor Exposure Breakdown Report.)

Note: If the user changes the macro factors scheme after selecting a column from another macro factors scheme, the previously defined column will display "N/A."

- The Factor Exposure Breakdown Report displays macro factors. Open the Customize Factor Exposure Breakdown Report window, and mark the *Enable Macro Factors* checkbox to view the rows of macro factors in the report.
- The Risk Decomposition Report displays macro factors. Open the Customize Risk Decomposition Report window, and mark the *Enable Macro Factors* checkbox to view the rows of macro factors in the report.

The macro factors will be displayed in the *Common Factor Risk* group (the Tier 1 scheme is illustrated below). Factors that are not part of the selected macro factor scheme are displayed in the *Factor Residual Risk* node of the *Risk Source* tree.

If "Enable Macro Factors" is not selected in the **Customize Risk Decomposition Report** window, then only the group-level BIM Common Factor Risk numbers are displayed; whereas if "Enable Macro Factors" is selected, then both group-level and factor-level *Common Factor Risk* numbers are displayed for both macro factors and BIM factors.

Regardless of whether "Enable Macro Factors" is selected, the portfolio factor exposure to each BIM factor is the same, as is the Total Risk; however, the volatility of these factors decreases with the selection of "Enable Macro Factors."

The following columns are available in the Risk Decomposition Report for macro factor scheme analysis:

- The Risk Decomposition Report offers the following optional columns for use in analysis with macro factor schemes:
- Exposure (exposure of the portfolio to a factor)
- Benchmark Exposure (exposure of the benchmark to a factor)
- Active Exposure (active exposure to a factor)
- Factor Risk (this is the risk when exposure is equal to 1)
- Factor Correlation with Portfolio Risk (this is equal to Portfolio Correlation X sign of the Exposure)
- Factor Correlation with Active Risk (this is equal to Active Correlation X sign of the Active Exposure)

Note: Factor Risk is defined here using total exposures, rather than active exposures; thus, this does not enable clean x-sigma-rho analysis for active risk.

Notes:

- Macro factors are not available in the Data Admin > Attributes tree.
- Factor grouping on macro factors is not supported, and macro factors are not displayed in the Data Admin > Factors tree.
- Performance Attribution and Stress Testing do not support macro factors.
- Currencies are not part of any macro factor, but total exposure to foreign currencies is added to the Risk Decomposition Report.

BIM with Global Equity Factors

Background

The Barra Integrated Model (BIM) has roughly 2000 factors. The risk forecasts from the BIM model provide the best possible information to explain portfolio risk; the granular factors of the BIM model help to make the risk forecast more accurate. However, the multitude of factors imposes a cost on clients trying to aggregate the information into a hierarchical, top-down structure, and clients often will struggle with the granularity of BIM.

Solution

Users can access a version of BIM in which the single-country equity factors are replaced with the global equity factors based on the GEM2L model. This model enables clients to report on risk with GEM2L factors for equity and BIM for other asset classes. This helps users to reduce the number of factors for equities, instead of using all of the factors in each single-country model.

Note: GEM2L is Barra's Global Equity Model Long-Term. (The long-term designation highlights the covariance matrix half-life, which is 52 weeks for variances and 156 weeks for correlations in the long-term version of the model, versus 18 weeks and 104 weeks, respectively, for the short-term version of the model.) Details about GEM2L are available on the MSCI Client Support website

BarraOne has the following model types:

- BIM301L: This is the standard Barra Integrated Model that uses single-country equity (industry and style) factors.
- BIM301L (with GEM2L factors): This model option uses BIM301L factors for non-equity assets and GEM2L factors for equity assets. Assets that may have exposures to both equity factors and non-equity factors will have GEM2L factors for equity exposures and BIM301L for non-equity exposures. For example:
    - Private Equity
    - Hedge Funds
    - Mutual Funds
    - Convertible Bonds
    - Certificates
    - StructureTool assets

  Equity assets with exposures in GEM2L have GEM2L exposures; equity assets not covered in GEM2L are rejected. All non-equity assets have the same exposures in both BIM301L and BIM301L (with GEM2L factors).

  The history of BIM301L (with GEM2L factors) extends to February 2012.

Risk forecasts are different between BIM301L and BIM301L (with GEM2L factors). The differences in risk reporting are illustrated below:

US Energy	BIM301L	BIM301L (with GEM2L factors)
Total Volatility	9.03	7.05
Specific	0.58	0.44
Total Factor	8.45	6.61
Pure Local Factor		
Global Factor		6.61
World Contribution		2.81
World Exposure		1.00
US Contribution		0.07
US Exposure		1.00
Energy Contribution		3.23
Energy Exposure		1.00

The following portions of BarraOne are not supported for BIM301L (with GEM2L factors), and the user will be able to select only BIM for these modules and report types.

- Optimization
- Monte Carlo VaR
- Historical VaR
- VaR Backtesting
- Performance Attribution
- Returns Calculator
- Asset Valuation
- Local Market Risk Breakdown report

Note: If the user's default model is BIM301L (with GEM2L factors), then the default model for these portions of BarraOne will revert to the first available system model in the model list.

Factor Groups

Factor groups are derived directly from the underlying models. The factor group structure for GEM2L factors in BIM301L is as follows:

- The GEM2L factor group is used for equity assets
- All other asset classes inherit the BIM301L factor group
- Currency factor groups are derived from BIM301L
- Industry and Style factor folders are absent from the single country factor folder

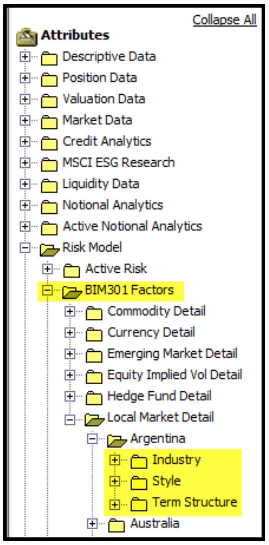


Figure 27: BIM301L Risk Attributes

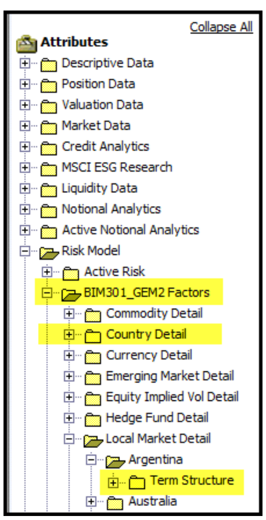


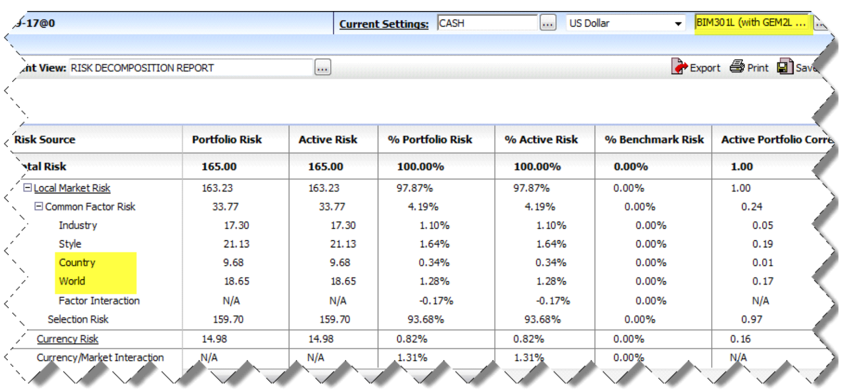
Figure 28: BIM301L (with GEM2L factors) Risk Attributes

Grouping Schemes

The grouping schemes are as follows:

- GEM2L Industry and Style factors are added to the existing factor list for industry and style.
- Country factors are added as a new factor group in the Data Admin tab.
- The World factor is added to the groupings for Factor attributes.

Figure 29: BIM301L (with GEM2L factors) Factor Groups

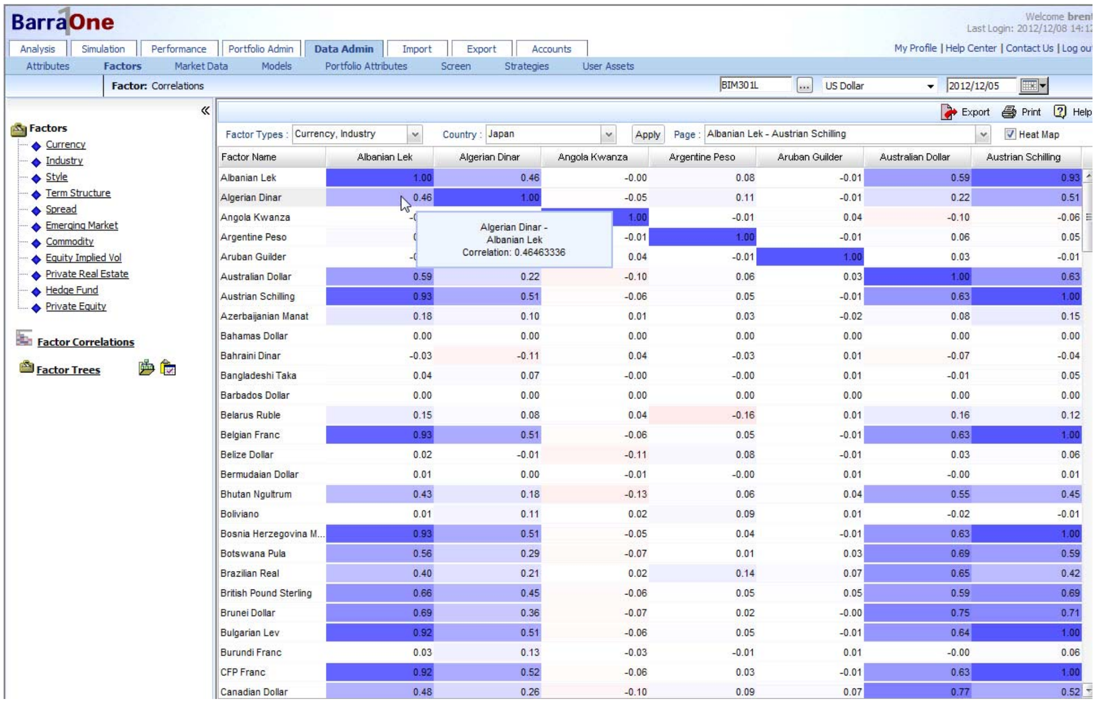


Risk Source	Portfolio Risk	Active Risk	% Portfolio Risk	% Active Risk	% Benchmark Risk	Active Portfolio Corre
tal Risk	165.00	165.00	100.00%	100.00%	0.00%	1.00
Local Market Risk	163.23	163.23	97.87%	97.87%	0.00%	1.00
Common Factor Risk	33.77	33.77	4.19%	4.19%	0.00%	0.24
Industry	17.30	17.30	1.10%	1.10%	0.00%	0.05
Style	21.13	21.13	1.64%	1.64%	0.00%	0.19
Country	9.68	9.68	0.34%	0.34%	0.00%	0.01
World	18.65	18.65	1.28%	1.28%	0.00%	0.17
Factor Interaction	N/A	N/A	-0.17%	-0.17%	0.00%	N/A
Selection Risk	159.70	159.70	93.68%	93.68%	0.00%	0.97
Currency Risk	14.98	14.98	0.82%	0.82%	0.00%	0.16
Currency/Market Interaction	N/A	N/A	1.31%	1.31%	0.00%	N/A

Figure 30: Risk Decomposition with GEM2L Factors

Factor Correlations Report

The Factor Correlation Report under Data Admin tab > Factors shows a snapshot of factor return correlations from the underlying covariance matrix of the selected model for the selected analysis date.



Month-End Reporting

The user can choose how to handle month-end reporting in BarraOne. The choices available are "As Delivered" or "Month End."

To understand the background of the reporting options, it is necessary to understand the model dating conventions used by Barra risk models and data release timing. Monthly risk models for both equity and fixed income are computed using returns through the end of the month. The risk models are then intended to provide a risk forecast for the following month. However, as it takes time to acquire and process the data needed to build the risk models, there is a lag between the end of the month and the date at which the model is released and loaded into BarraOne.

Example:

The table below shows the monthly data deliverables used when selecting an analysis date of 31 August 2008.

Table 34: Model Dating and Risk Forecasts

Data Type	Description	Target Release Date	Data Based on Returns Through
BIM Covariance Matrix	BIM factor variance-covariance matrix	12th Calendar Day	31-Jul-08
Equity Risk Exposures	Equity Asset Risk Data	1st to 5th business day	31-Jul-08
FI Research Data	Barra Research Data (risk factors, credit risk parameters, specific risk parameters, and Japan issuer driven spread factor mappings)	8th business day	31-Jul-08
Mutual Fund Exposures	Mutual Fund Asset Risk Data	15th-18th calendar day	31-Jul-08
Time-dimensional FI Market Conditions	Index Rates (market index level data, such as constant maturity Swap Rates, fed. funds, CPI)	3rd business day	31-Jul-08

“As Delivered” Option

For any given analysis date, BarraOne uses the risk model data that was available in the system on that date. This enables the paradigm of “as-of” reporting such that for any historical date, a user can regenerate a risk report just as it would have been generated on that date simply by changing the Analysis Date field within BarraOne. The risk models used for the selected analysis date are those that were loaded in the system as of that date.

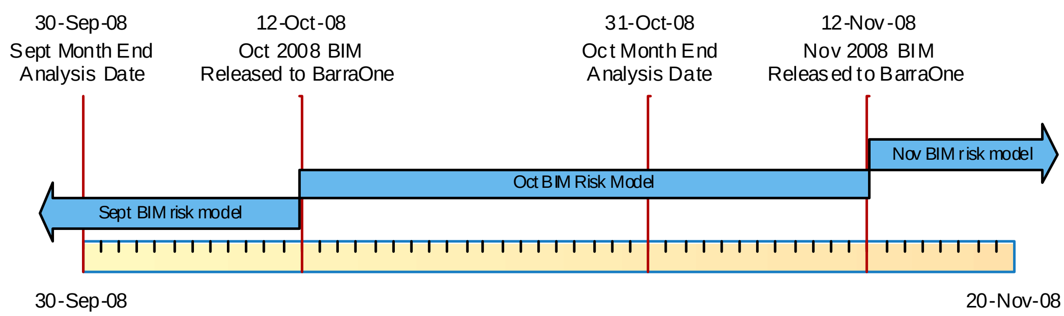


Figure 31: As Delivered Reporting Option

For month-end-reporting users who want to report forecasted risk for the upcoming month using the forward looking risk models, this methodology presents a problem due to the lag in risk model updates. Selecting a later analysis date when the risk model is available could result in inappropriate instrument pricing and valuation for month-end reporting requirements. For example, options that expire or bonds that mature between the month-end date and the date at which the finalized monthly data is available would be rejected or show as matured and have no value.

“Month End” Option

While the “As Delivered” option enables the replication of historical reports, there a number of cases in which the ability to disjoin the fixed link between the analysis date and the underlying model data used for analysis is desirable. With the “Month end” option, the user can run a month-end forecast (*ex-ante*) risk report using a forward-looking (updated) risk model for upcoming month. The updated risk model data option is applicable to any analysis date from the last business date of the previous month, defined as the last calendar date if the date falls on a Monday through Friday, or the last Friday of the previous month if the last calendar date falls on a Saturday or Sunday.

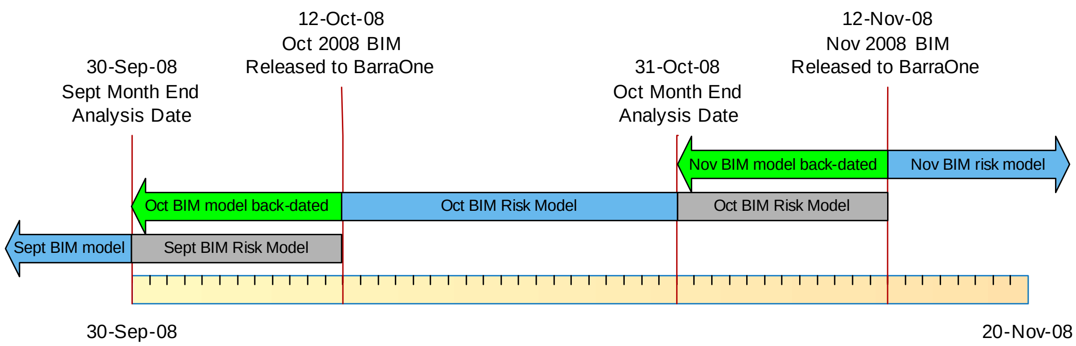


Figure 32: Month End Reporting Option