BlackRock Solutions®

Static and Option-Adjusted Risk Sensitivities: An Overview of Methodologies

Introduction

BlackRock Solutions® (BRS) employs a bottom-up approach to risk, providing static and option-adjusted risk measures at a security level. Results are aggregated to compute portfolio and ultimately enterprise risk. All securities are valued based on market standard cash flow and option pricing models. Based on these core valuations, BRS calculates a wide range of risk measures, including option-adjusted risk sensitivities. Option-adjusted risks are calculated by shifting individual risk factors contributing to an instrument's price (e.g., interest rates, volatility, spreads, etc.) in isolation and revaluing the instrument. The difference in price reflects the sensitivity of the instrument to the specific risk factor. Option-adjusted risk measures include effective duration, convexity, volatility duration, and spread duration.

Yield and Static Measures

Nominal Yield

The Nominal Yield is the internal rate of return of the security based on the given market price. It is the single discount rate that equates a security price (inclusive of accrued interest) with its projected cash flows.

For callable bonds, the nominal yield represents the "yield to worst." For mortgages, it represents the yield given base prepayments for a given yield curve environment. For futures, the yield denotes the carry and is included in the calculation for aggregate yield of a portfolio, weighted by the notional value of the future. Nominal Yield is not applicable for options, swaps, and other derivative instruments where the term is not expressly defined.

Yield-to-Worst

Lowest yield possible for a security given the current price, taking into account both call dates and maturity.

Modified Duration

This is the approximate percentage change in price for a hundred basis point change in yield assuming that cash flows are fixed as rates change.

Weighted Average Life

The Weighted Average Life (WAL) of a security denotes the weighted average time in years to receipt of principal. For bonds with bullet maturities, the WAL is the years to maturity. For amortizing bonds, the WAL is principal weighted by time and will give an average time to receipt of a one dollar of principal.

For mortgage products the average life is computed assuming base case prepayments. For callable bonds, the average life provided is the "average life to worst". The WAL is often used to determine which Treasury yield will be the benchmark for pricing the security.

Zero Volatility Spread or Zero Volatility OAS (ZVO)

Single spread over the appropriate yield curve implied by the market price, using cash flows derived by assuming interest rates follow the forward curve.

Option-Adjusted Measures

Option-Adjusted Spread

Option-Adjusted Spread (OAS) is the average spread of a security, quoted in basis points, over the entire Treasury curve after factoring out the value of embedded options.

OAS = Zero Volatility Spread - Option Cost

OAS is used as an indicator of the relative value of a security. For non-callable securities, the OAS will equal the Zero Volatility Spread (ZVO). For callable bonds, the OAS will be less than the ZVO. The option value is determined by various option models, whether through a lattice for callable bonds or a Monte Carlo simulation for mortgages. OAS is not applicable for futures, options, swaps, and other derivatives where the term is not expressly defined. Base case OAS is imputed from market prices and held constant when calculating most other option-adjusted risk sensitivities.

Effective Duration

Effective Duration is the Option-Adjusted Duration (OAD). OAD measures the sensitivity of market price to parallel shifts in the yield curve (1st derivative of price with respect to yield) assuming the OAS stays constant as the curve shifts.

Unlike Modified Duration, the OAD does not assume that cash flows are constant as interest rates change.

The effective duration measures the percentage change in price for a 100 bps parallel shift. Positive duration means that as rates rise, the price decreases, and negative duration means that as rates rise, the price increases.

Change in Price = Change in Yield Curve * -1 * (OAD/100) * (Price + Accrued Interest)

The OAD is computed in the following manner:

1. Compute base case OAS with the given market full price (P[0])

2. Holding the OAS constant, compute the Option Adjusted Value (OAV) for the security when shifting the yield curve up and down X basis points in parallel

(re-price the security in the +X basis points and –X basis points scenarios, using the base case OAS, to derive P[-X] and P[+X])

3. Calculate the OAD by determining the change in value of the security by shocking the yield curve as a fraction of the original full price, scale by the shock size to normalize to a 100 bp shock, and multiply by 100 to express as a percentage of price:

OAD = ((P[-X] - P[+X]) / (P[0])) * 100/2X * 100

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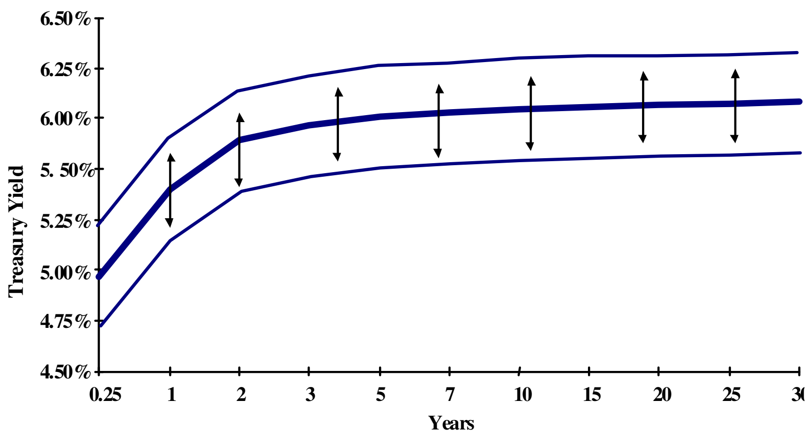
As shown graphically below, conventional OAD is computed by shocking the entire curve up and down in parallel.

Chart 1: Option-Adjusted Duration Methodology



Effective Convexity

Effective Convexity is the Option-Adjusted Convexity (OAC); it measures the sensitivity of price to parallel yield curve shifts unaccounted for by duration (i.e., it is a 2nd order approximation).

OAC = 100 * (P[-X] + P[+X] – 2 * P[0])/((X/100)^2 * P[0])

Positive convexity indicates that the security will outperform what duration alone predicts; negative convexity indicates that security will underperform what duration alone predicts. Negative convexity usually indicates the presence of a short embedded option in instruments such as callable bonds and mortgages. Non-callable bonds will typically have positive convexity.

Interest rate shift sizes used by BRS in OAD/OAC calculations vary based on security type. The security types and their corresponding default OAD/OAC shifts are listed in Table 1. Notably, all durations are normalized to a 100 bp shift for portfolio level reporting.

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Table 1: Shift Sizes by Security Type

Security Type	Shift (bp)
Generic Bonds	20
Treasuries	20
Corporates	20
Callable Bonds	50
Agencies	20
Mortgage Backed Securities	50
CMBS	20
ARMs	50
IO/PO	50
CMOs	50
ABS	20
Futures	10
Index Futures	50
Options on Treasury Futures	Underlying OAD uses 50, then option delta is used to scale Option OAD
Options and Eurodollar Futures	10
Swaptions	10
Caps and Floors	10
Generic Swaps	20
Currency Swaps	1

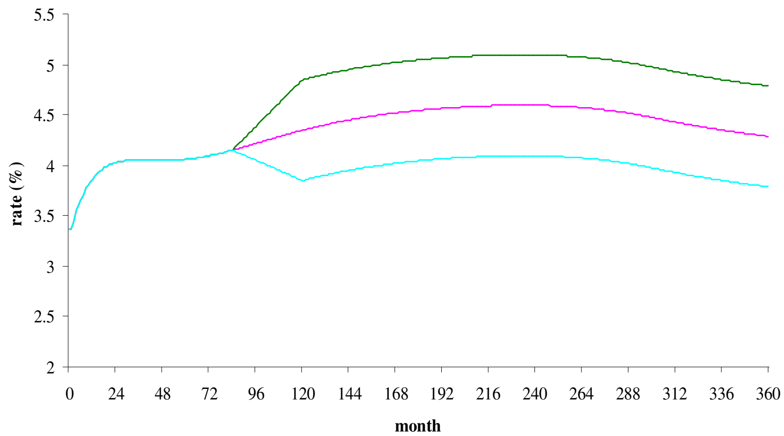
BlackRock Solutions uses the same shock size for both the option adjusted duration (OAD) and option adjusted convexity (OAC) calculations. When determining the appropriate shock size for an instrument, we need to consider many factors (such as the discrete nature of our lattice) to find a balance between the accuracy and stability of these option adjusted metrics. While the effective duration described in the previous section will converge to the true instantaneous first derivative as shock size is reduced to zero, this results in unstable day-over-day convexity numbers. Reducing the shock size also increases the dispersion of the distribution of option adjusted metrics (like OAD and OAC) across simulated interest rate paths or scenarios.

Thus, BRS has chosen to use shock sizes that provide accurate option adjusted metrics while ensuring their day-over-day stability in order to prevent constant rehedging for small market moves.

Key Rate Durations

Key rate durations are based on the notion of partial interest rate shifts, which when aggregated, represent a parallel shift in the spot curve. Key rate durations measure the price sensitivity of a security or a portfolio to rate changes in different parts of the yield curve. In order to compute these analytics, we first calculate sensitivities to wave shocks, called wave key rate durations (WKRDs), by shocking the curve beyond a given key rate. Chart 2 shows an example of wave shocks that would be used to estimate the 10 year wave key rate duration. A WKRD is calculated by holding the option adjusted spread (OAS) constant and then valuing the security under both the positive and negative wave scenarios.

Chart 2: Up and Down 10 year Wave Shocks



Once we have calculated WKRDs, to deduce the exposure to a given point on the curve, i.e. a KRD, one must take the difference between two sequential WKRDs. The first key rate duration is estimated by taking the difference between the OAD and the second WKRD. The last KRD is the same as the last WKRD. All intermediate KRDs can be calculated as WKRDi-WKRDi+1. Thus, by construction, the sum of KRDs calculated in this fashion always equals the OAD.

For example, Chart 3 illustrates two consecutive wave shocks for the 10 and 15 year points. One can observe that the difference of these shocked curves is equivalent to a triangular shock at the 10 year point, as shown in Chart 4. Let us denote the WKRD that is calculated as a result of the shock that starts at year P and linearly increases until year P+1 as $WKRD_{P\_P+1}$. The 10 year KRD calculated using wave shocks in this case is equal to $WKRD_{7\_10} - WKRD_{10\_15}$.

Chart 3: Up and Down 10y and 15y Wave Shocks

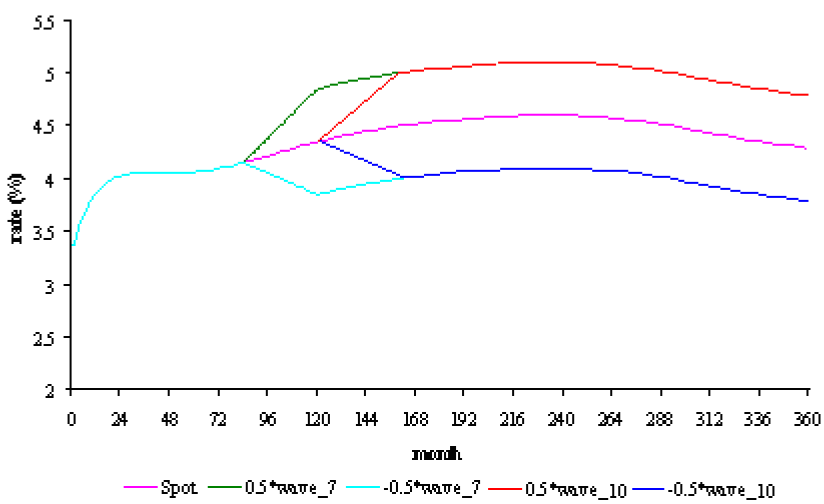
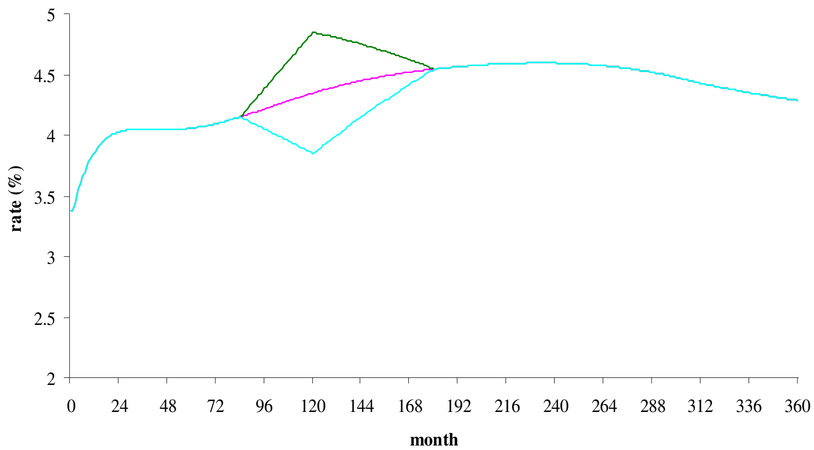


Chart 4: Up and Down 10 Year Key Rate Shocks



Volatility Duration

Volatility Duration measures the sensitivity of market value to changes in implied volatility; this measure is only applicable to securities with optionality (either options themselves or securities with embedded options).

When calculating volatility duration, shift sizes differ depending on the interest rate model employed. When utilizing a lognormal interest rate model such as Black-Karasinski (BK), volatility duration is calculated by applying a +/-1% parallel shift to the lognormal volatility surface. However, when employing normal models (such as Hull-White (HW) or Shifted Lognormal (SLN) interest rate models, it is calculated by applying +/-10 bp shift to the normal volatility surface.

- Negative volatility duration indicates that value will increase with an increase in volatility. Positive volatility duration indicates that value will decrease with an increase in volatility.
- Portfolio volatility duration has similar characteristics as an option's vega.
- Volatility duration allows portfolio managers to manage the exposure of the portfolio to changes in implied volatility.

Prepayment Duration

Prepayment duration measures the risk associated with prepayment speeds being systematically slower or faster than those predicted by the prepayment model for MBS or CMO securities. BRS prepayment duration computation is defined as the price sensitivity to an increase/decrease of 25% in prepayments versus what the model is currently projecting. Specifically, each Single Monthly Mortality (SMM) returned by the prepayment model is scaled up/down, cash flows are recomputed, and the OAV for each interest rate path is computed holding the base case OAS constant.

Spread Duration

Spread Duration measures the sensitivity of a security's price to changes in its Option-Adjusted Spread (OAS). Spread duration measures a security's exposure to changes in its market spread to a discount curve without changes to other economic data; consequently, BRS measures spread duration by shocking only OAS, and thus discounting, while keeping the cash flows consistent in all cases.

Mortgage Rate Basis Duration

Mortgage Rate Basis Duration measures the sensitivity of a security's value to changes in the spread between current coupon MBS (the "par coupon", the coupon of a theoretical TBA priced at par) and a blend of swap rates, and is only applicable for securities that use the BRS prepayment model (MBS and CMO products). The BRS model uses the mortgage rate basis in order to project future mortgage rates in the primary market and determine homeowners' incentive to prepay; shocking this basis thus changes homeowner incentives and behavior in the model, changing cash flow profiles without impacting discount functions.

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Option Cost

This is the value of embedded interest rate options in a security, which is defined as the difference between the OAS and ZVO.

Implied Volatility

The volatility produced from an option pricing model given the market price of the option.

OTC Option Sensitivities

Delta

Delta represents the expected change in option premium given a nominal shift in the underlying (yield, rate, price, etc.). Mathematically, delta is the first derivative of the option price relative to the underlying price. Delta is an absolute change measured in units of currency. For example, an option with a delta of .5 is expected to change in value 50 cents for every $1 change in the underlying. Delta values range from 0 (for deep out-of-the-money options) to 1 (for deep in-the-money options).

Gamma

Gamma reflects anticipated changes in delta given shifts in the underlying (yield, rate, price, etc.). Mathematically, gamma is the second derivative of the option premium relative to the underlying.

Vega

Vega captures expected changes in the option premium due to isolated, nominal changes in implied volatility. Mathematically, vega is the first derivative of the option premium with respect to volatility.