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Scenario Analysis

Bloomberg

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SCENARIO ANALYSIS

Bloomberg's Portfolio & Risk Analytics solution for investment professionals provides you with the tools necessary to successfully implement optimal investment portfolio strategies. Our platform will help you make quicker, more informed decisions by enabling you to easily and accurately measure portfolio risk and return.

Fully integrated with the Bloomberg Professional® service at no additional cost, our Portfolio & Risk Analytics platform provides end-to-end perspective for your portfolios—past, present, future—thus streamlining your overall investment management workflow.

The Scenarios Tab in PORT <GO> allows you to stress test (crash test) your portfolio to see how it is impacted. We offer two approaches for scenario analysis in PORT. Full Valuation is primarily relevant for fixed income instruments. However, for multi-asset portfolios, Bloomberg's multi-asset risk factor model is more useful because it incorporates the correlation of different asset classes for a given scenario.

Scenarios can be run using two different methodologies:

FACTOR-BASED SCENARIOS

» Returns are estimated by mapping instruments to factors in the Bloomberg Risk Model and then stressing those underlying factors

» Users can choose to isolate factors or propagate moves in one factor to all other factors in the model

FULL-VALUATION SCENARIOS

» Spreads are calculated for instruments in the portfolio, then the underlying curve is shifted and the instrument is repriced

» Full valuation only works for instruments that can be priced using a model

FULL-VALUATION MODEL

Calculations

General Assumptions – For current market analysis, Bloomberg assumes all securities settle on the current date. For analysis at a horizon date, Bloomberg assumes securities settle on the horizon date. Bloomberg does not apply conventional settlement date lags at any time during the analysis.

Benchmark Yield Curve – Bloomberg prices all securities off the government or swap curve associated with the underlying security.

Reinvestment Rates – All cash is reinvested from its receipt date to the next horizon date at prevailing rates per the government curve under the scenario as of the cash flow receipt date.

PRICING METHODOLOGY FOR FIXED/ FLOATING RATE GOVERNMENT, CORPORATE & MUNICIPAL SECURITIES

OAS Method

First, Bloomberg calculates the current OAS versus the security's mapped curve using the current market price, current mapped curve levels, default exercise premium, volatility and mean reversion assumptions. Bloomberg then steps forward through time to handle cash flows and test, where appropriate, to determine whether any market-driven corporate actions affect the security, for example, whether the security is called. Finally, Bloomberg calculates the price of the security at each horizon date on which the security is still outstanding by calculating the OAS price for the security and using the current OAS and current interest rate levels, volatility and mean reversion of the mapped curve at that horizon date under the scenario.

PRICING METHODOLOGY FOR MORTGAGE SECURITIES

Conventional Yield Method

First, Bloomberg calculates the current yield spread of the security. The current yield spread is the difference between the security's yield, calculated at the current market price by assuming cash flows consistent with the current market Mortgage Defaults Function (MDF) prepayment speed assumptions, and the term yield to the Weighted Average Life (WAL) of the security according to the mapped curve. Bloomberg next generates cash flows for the scenario using the MDF prepayment speed assumptions given a parallel shift in interest rates corresponding to the selected yield curve shift. Bloomberg then steps forward through time to handle cash flows. Finally, Bloomberg calculates the price of the security at each horizon date on which the security is still outstanding by using the cash flows generated for the scenario and the term yield to the WAL of the security according to the mapped curve as the yield at the horizon date, plus the calculated current yield spread of the security.

OAS Method

First, Bloomberg calculates the current OAS versus the security's mapped curve by using the current market price, current mapped curve levels, prepayment model, prepayment models scaling, volatility and mean reversion assumptions per the settings on the Mortgage Defaults function (MDF). Bloomberg next generates cash flows for the scenario using the prepayment model and prepayment model scaling per the settings on the MDF. Bloomberg then steps forward through time to handle cash flows and test, where appropriate, to determine whether any market-driven corporate actions affect the security, for example, whether the security is called. Finally, Bloomberg calculates the price of the security at each horizon date on which the security is still outstanding by calculating the OAS price for the security using the current OAS and using interest rate levels, volatility and the mean reversion of the mapped curve at that horizon date under the scenario.

PRICING METHODOLOGY FOR DERIVATIVE SECURITIES

For derivative securities, Bloomberg first completes a scenario analysis on the underlying security and then uses the results to determine the return on the derivative security. The specific methods for different types of derivatives are as follows:

CTD Futures

Bloomberg calculates the net basis of the current cheapest price to deliver the security using the futures contract's current market price and the current market price of all deliverables. Bloomberg assumes that this current CTD net basis declines linearly to zero at the last delivery date for the contract. To price the contract at any horizon date up to the last delivery date, Bloomberg uses the then-current net basis and the horizon price of all of the deliverable bonds to determine the horizon price of the futures contract using the delivery factors for the various bonds to determine which bond is cheapest at the horizon date under the scenario. For a horizon date after the last delivery date, Bloomberg prices all the deliverable bonds under the scenario at the last delivery date, calculates the futures price based on those deliverable prices and assumes the position is cash-settled against that futures price. Cash is then reinvested to the horizon date and the total return is calculated.

Short-Term Interest Rate (STIR) Futures

Bloomberg calculates the implied forward rate for the relevant deposit period, then applies the appropriate adjustments to turn this forward rate into a futures price. Bloomberg determines the difference between the calculated futures price and the actual futures price and considers this value to be an error term. Bloomberg assumes that the error term converges to zero at the cash settlement date of the contract. To price the contract at any horizon date up to the cash settlement date, Bloomberg calculates the implied forward rate for the relevant deposit period and adjusts this forward rate to calculate the contract price—applying the remaining error term if the horizon date is before the cash settlement date. For a horizon date after the cash settlement date, Bloomberg prices the contract at the cash settlement date and assumes the position is cash-settled at that price. Cash is then reinvested to the horizon date and the total return is calculated.

Options

For a horizon date prior to option expiration, Bloomberg prices the option using the current implied volatility and the price of the underlying security at the horizon according to the scenario. For a horizon date after option expiration, Bloomberg prices the option at the expiration date and assumes the position is cash-settled at that price. Cash is then reinvested to the horizon date and the total return is calculated.

TOTAL RETURN CALCULATION

The steps to determine the Total Return on a fixed income security out to the final horizon in scenario analysis are as follows:

» Based on the current security pricing, determine the current OAS, yield spread or discount margin of the security versus government curve. Start a cash account for cash flows received from the security. The initial value of the cash account is zero.

» Next, step forward through time from the initial date to the final horizon date to perform the following actions as needed:

– If a cash flow is due to the security holder on a date, determine the date and amount of the actual cash flow as per the scenario. Add the cash flow amount to the security's cash account and invest/borrow the cash amount to the next horizon date at prevailing rates per the mapped curve under the scenario as of the cash flow receipt date.

» If a bond is callable/puttable on a date, determine if that call/put is exercised by pricing the security under the scenario on that date. If exercised, invest/borrow the cash as above.

» On the horizon date, price the security and determine sensitivities under the scenario. Reinvest the cash account to the next horizon date, if any.

» The total return on the security to any horizon date is calculated based on an initial investment equal to the initial value of the security position (including any accrued interest) and a final value equal to the security's horizon value (including accrued interest), plus the value of the cash account, which is equal to the cumulative cash flow plus cumulative reinvestment.

Horizon Value Calculation – Horizon Value = Principal + Accrued Interest + Cash Flow + Reinvestment Income

FACTOR MODEL

In the course of creating scenarios for stress testing, we often want to propagate stresses from some variables to others based on statistical relationships. Using the new Scenario Editor in PORT <GO>, we are able to demonstrate the anticipated move in equity prices when, for example, the price of oil is shocked by a given percentage (say, up 20%).

The variables that we stress explicitly are referred to as the independent variables; the other variables, to which these explicit stresses are to be propagated, are the dependent variables.

The Scenarios tab in the PORT <GO> function is powered by the Bloomberg's factor models. Out of the total *N* factors available in the Bloomberg risk model, the user can stress any *K* factors independently by desired magnitudes (refer to these as the independent variables) and then has a choice to propagate these stresses to the remaining *N* − *K* factors (refer to these as the dependent variables). We assume that the covariance matrix fully determines the relationship between the independent and dependent variables. Two propagation methods are supported:

» the built-in covariance matrix (the default method)

» a date range–based covariance matrix (the user specifies the dates)

The first method is more robust since it benefits from the extensive covariance matrix cleaning that is built into the Bloomberg production system. The second method utilizes the user-specified time period to calculate the correlations and variances between variables. Since stress propagation involves matrix inversion operation, we apply a small amount of shrinkage to the correlation matrix to improve the robustness of the inversion.

We calculate the expected moves in the dependent *N* − *K* variables as follows. Order the variables so that the independent *K* variables come first and let Σ be the *N x N* covariance matrix of all the variables. Then we can write:

$$\Sigma = \begin{bmatrix} \Sigma_{11} & \Sigma_{12} \\ \Sigma_{21} & \Sigma_{22} \end{bmatrix}$$

where Σ_{11} is the *K x K* covariance matrix between the independent variables, Σ_{12} is the

K x (N − K) covariance matrix between the independent and dependent variables, Σ_{21} is its transpose and Σ_{22} is the *(N − K) x (N − K)* covariance matrix between the dependent variables given by the factor model. We assume that the *unconditional* expected return on every dependent variable is zero, so the vector *v* of *conditional* expected returns on the

N − *K* dependent variables is given by

$$v = \Sigma_{21}\Sigma_{11}^{-1}s$$

where *s* is the vector of shocks to the independent variables. Notice the use of the inverse operation on Σ_{11}, this is why it is very important that Σ_{11} is actually invertible and this is why we apply the shrinkage operation mentioned above.

As an example, suppose we shock only a single factor *(K = 1)*, so s_1 represents percentage move in this factor. Then Σ_{11}^{-1} is a single number (the inverse of the factor variance

$\Sigma_{11} = \sigma_{11}^2$), and Σ_{21} represents the covariance between this factor and the other *N* − *1* risk factors. Then, the propagation equation reduces to:

$$v_k = \rho_{k1}\frac{\sigma_{k1}}{\sigma_{11}}s_1$$

If we regroup it as follows:

$$\frac{v_k}{\sigma_{k1}} = \rho_{k1}\frac{s_1}{\sigma_{11}}$$

then you can see the intuitive result that it leads to: if the independent factor moves by *x* sigmas, the other factors move by $\rho_{k1}\,x$ sigmas, so, for example, a 2 sigma move in the USD 1-year sovereign curve factor would lead to 0.9 sigma move in the USD 10-year sovereign curve factor since the correlation between the two is ~45%.

To illustrate further the effect of factor propagation on a portfolio return, suppose we would like to shock a well-diversified U.S. equity portfolio such as the S&P 500 index fund by a 10% upward move in the oil factor. This portfolio has a high positive exposure to the U.S. equity market factor and the Energy factor (because of the large Energy sector weight in the portfolio) and the U.S. Size factor. Other factor exposures are smaller by comparison, so we will disregard them in this example.

If the beta of the U.S. market factor to oil over the most recent one-month period is

negative at −30% and portfolio exposure to the U.S. market factor is 1.0 then a +10% oil shock would translate into

$$-0.3*1.0*(+10\%) = -3\% \text{ return}$$

However, this is partly offset by exposure to the Energy factor, which is positively correlated to oil. If the portfolio Energy factor exposure is 0.13 and Energy beta to oil is +40%, then a +10% oil shock translates into

$$+0.4*0.13*(+10\%) = +0.56\% \text{ return}$$

U.S. Size factor exposure is +0.47, but its beta to oil is close to zero, therefore, it does *not* contribute to portfolio return. The total impact of a +10% oil shock is then simply:

$$-3\% + 0.56\% = -2.44\%.$$

So the portfolio value should drop by 2.44%.

LEARN MORE

To learn more about Bloomberg's Portfolio & Risk Analytics solution, press the <HELP> key twice on the Bloomberg Professional service or go to bloomberg.com/portfolio-risk.

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