FINMASON FACTORS AND STRESS TESTING

DEFINITIONS, SOURCES, TRANSFORMATIONS AND FACTOR SHIFTS

OVERVIEW

Factor-based stress testing and scenario analysis is a popular technique for visualizing and estimating risk and reward in a portfolio. Even when considering historical scenarios, factor-based analysis can be helpful considering that (1) some assets may not have been in existence during the historical period in question and (2) the asset may have been in existence, but is fundamentally different than it was during the historical period. The workflow is as follows:

1. Select a set of factors that drives the performance of an asset.
2. Find a source for the daily history of those factors.
3. When necessary, transform the factor from its raw form into a form suitable for regressions.
4. Measure the sensitivity of each asset to each of the factors by performing a multi-variate linear regression of the historical total return of the asset against the historical factor set.
5. Determine the movement of each of the factors during a stress scenario.
6. Multiply the factor shifts for the scenario by the sensitivities of each asset to each factor to estimate the return of that asset in that scenario.
7. Aggregate the performance of each asset up to the portfolio level using its weight in the portfolio.

The following will describe these steps in more detail.

THE GLOBAL MULTI-ASSET FACTOR SET

Choosing a factor set is an important consideration when performing any sort of factor-based analysis. We allow clients to choose from a large number of factor sets and we will create custom factor sets at a client's request. Below is a list of the factors in our standard Global Multi-Asset Factor Set. This is the default factor set we use when we are performing scenario analysis or stress testing. Clients are allowed to select other factor sets, depending on their goals and preferences. Our factors generally break down into 4 categories: Global Equity Factors, Currency Factors, Interest Rate Factors and Commodity Factors. Details on these factors are set forth below.

GLOBAL EQUITY FACTORS

FinMason currently employs five geographically-based broad equity market indices representing the largest national/regional equity markets globally: the US, Europe, Japan, China and Emerging Markets. All of these equity index factors are defined using month-end data and transformed as month-on-month percent changes in the underlying index. Currently, all equity market factors are sourced from Thomson Reuters and are measured on a total return basis in US dollar terms. The specific indices currently in use at FinMason are as follows:

- <u>US equity market:</u> S&P 500 Total Return Index.
- <u>European equity market:</u> S&P Euro 350 EUR Index (USD).
- <u>Japanese equity market:</u> S&P Topix 150 Market Index (USD).
- <u>Chinese equity market:</u> FTSE China 50 Index (USD).
- <u>Emerging Markets equities.</u> MSCI EM Index (USD).

Equity index factor shifts for scenarios are calculated as the maximum drawdown or change in the factor observed during each particular scenario, measured as the cumulative percentage change over the course of that scenario. Given that asset markets do not all adjust simultaneously in response to a shock, the exact period over which a drawdown or change is measured may differ somewhat across factors. For example, in the crash of 2008 episode, US equity markets did not peak until October of 2007, whereas a number of other markets – most notably US mortgage securities and US money markets – began adjusting much earlier.

FAMA-FRENCH US EQUITY MARKET FACTORS

FinMason's factor set includes two factors reflecting benchmark returns for two US equity market factors defined by Eugene F. Fama and Kenneth R. French in their seminal research paper, "Common risk factors in the returns on stocks and bonds," *Journal of Financial Economics* (1993). These two factors are the performance of small stocks relative to big stocks (SMB, or Small Minus Big), and the performance of value stocks relative to growth stocks (HML, or High Minus Low). These factors are calculated from US corporate financial data obtained from the Thomson Reuters WorldScope Fundamentals database.

We calculate benchmark returns to Fama-French size (SMB) and value (HML) factors using the same methodology described in Fama-French (1993) and on the website of Kenneth French. Our dataset includes all firms incorporated in the US with ordinary common equity listed on the NYSE, Amex or NASDAQ. This methodology can be summarized as consisting of the following steps:

- Find the median market value/capitalization (in dollars) each quarter of all firms listed on the NYSE
- Construct quarterly rankings of all firms in the database by size (capitalization)
- Using median NYSE figure as breakpoint, define/populate a size field for all firms as Small or Big, calculated separately each quarter
- Define book-to-market ratio, for latest quarter, as BMR = [Book value] / [Market cap]
- Populate the BMR field
- Define a subset of NYSE firms solely for ranking purposes (not for calculating FF returns)
- Exclude from this subset all firms with negative book value for the most recent observation
- From the NYSE subset of firms, identify the 70th and 30th percentile breakpoints for BMR
- Define a value field for all firms (not just those in the NYSE subset)
- Populate the value field as Low (BMR<30%), Medium (30%<BMR<70%) or High (70%<BMR), calculated separately for each quarter

- Construct 6 portfolios, resorted and rebalanced quarterly, based on the quarterly size and value fields, as follows:
    - Small/high (value)
    - Small/medium (neutral)
    - Small/low (growth)
    - Big/high (value)
    - Big/medium (neutral)
    - Big/low (growth)
- Individual firms in each portfolio are weighted by market value
- Calculate monthly returns for each of the 6 portfolios above
- Calculate returns for SMB and HML factors using the returns to the 6 portfolios, as follows:
    - SMB = 1/3 (Small/value + small/neutral + small/growth) – 1/3 (big/value + big/neutral + big/growth)
    - HML = 1/2 (small/value + big/value) – 1/2 (small/growth + big/growth)

Factor shifts are defined as cumulative scenario returns (calculated as the sum of monthly percentage returns) to these factors over the course of the scenario.

US TREASURY YIELD CURVE FACTORS

A core component of our fixed income factors is US Treasury Curve Yields. Constant Maturity Treasury Yields are provided by the Board of Governors of the Federal Reserve System, which publishes daily interest rate data in its H.15 Release. We use several points on the curve as factors: 3 month, 1 year, 5 year, 10 year and 30 year. Selecting many points on the curve allows us to more closely match a particular factor to a bond's duration, which improves fit. It also allows us to capture the effects of non-parallel shifts, such as when the curve steepens or flattens.

Yields on Treasury nominal securities at "constant maturity" are interpolated by the U.S. Treasury from the daily yield curve for non-inflation-indexed Treasury securities. This curve, which relates the yield on a security to its time to maturity, is based on the closing market bid yields on actively traded

Treasury securities in the over-the-counter market. These market yields are calculated from composites of quotations obtained by the Federal Reserve Bank of New York. The constant maturity yield values are read from the yield curve at fixed maturities, currently 1, 3 and 6 months and 1, 2, 3, 5, 7, 10, 20 and 30 years. This method provides a yield for a 10-year maturity, for example, even if no outstanding security has exactly 10 years remaining to maturity. The Federal Reserve Bank of St. Louis also maintains these data series for public use on its "FRED" website (https://fred.stlouisfed.org/), which is the source of the data used by FinMason.

The FED publishes Constant Maturity Treasury Yields as % Yield to Maturity. We convert these interest rates into % return for the purposes of using in our regression models. Essentially, we use the day-to-day change in Treasury yields, as published by the FED, to estimate the return to a holder of a particular Treasury, had that person held the bond from the close of one day to the close of the next. To do this, we make a few assumptions: (1) that the holder does not trade the bond for the entire period; (2) that the maturity of the bond is exactly the stated maturity period for the bond, i.e. the 10 Year Constant Maturity Treasury matures in exactly 10 years; (3) that the next interest payment is exactly 6 months away, except for the 3 month, which is exactly 3 months away; (4) that the bonds have no early termination provisions such as calls, puts or sinking funds; and (5) that the bond is initially priced at 100 and that represents the Present Value of all future cash flows discounted back at the stated yield. Our general method is to use the old yield as the coupon of the bond and then calculate the present value of all future cash flows discounted back at the new yield. Since a bond's price is simply the present value of all future cash flows, we calculate the percent holding period return from the old price (100) and the new price (present value of cash flows at the new yield). The exact math is as follows:

$$\left(100 - \sum_{i=1}^{T\times 2} (y_1 \times 100) \div (1 + \frac{y_2}{2})^i\right) \div 100$$

Note that, beginning February 18, 2002, the Federal Reserve ceased publication of the 30-year constant maturity series, and the series was reintroduced on February 9, 2006. However, the US Treasury Department publishes a Treasury 20-year Constant Maturity rate for this period along with an extrapolation factor that can be added to the 20-year Constant Maturity to obtain an estimate for a theoretical 30-year rate. FinMason uses this estimated 30-year rate to create a continuous series during the period when no constant maturity yield was published.

Similar to the methodology for international equity market factors, FinMason uses month-end data to calculate month-on-month yield changes, in basis points, which are then transformed into monthly total returns as described above. Factor shifts for scenarios are calculated in the same manner, starting with maximum changes in yields over the course of the scenario in question.

OTHER FACTORS

- US corporate bond yield spread. The US corporate bond spread is represented by the BofA Merrill Lynch US Corporate BBB Index Effective Yield minus the 10-Year Treasury Yield. This index represents a subset of the BofA Merrill Lynch US Corporate Master Index tracking the performance of US dollar denominated investment grade rated corporate debt publicly issued in the US domestic market. The subset includes all securities with a given investment grade rating BBB. FinMason uses the spread, in basis points, between the published effective yield on the BBB Index and the US Treasury 10-Year Note Constant Maturity yield. Both series are sourced from FRED (see above). After calculating the basis point change in the spread over the course of a scenario (or a month), this yield change is transformed into a total return using the same methodology as used for Treasury securities, which represents the actual factor shift used.
- Oil Prices. Wholesale spot crude oil prices for the West Texas Intermediate benchmark traded in Cushing, Oklahoma are sourced from the US Energy Information Administration, published daily. FinMason obtains these prices from FRED (see above). Using month-end data, the factor is defined as the month-on-month percentage change in the price index,

and factor shifts in scenarios are defined as the maximum cumulative percentage change over the course of the scenario.

- US Dollar Index. The US Dollar Major Currency Index, calculated and published weekly in the H.10 Release by the Federal Reserve Board, is a trade-weighted weighted average of the foreign exchange value of the US dollar against currencies of the Euro Area, Canada, Japan, UK, Switzerland, Australia and Sweden. The Federal Reserve recalculates and revises trade shares and the resulting index weights on an annual basis. FinMason obtains these rates from FRED (see above). Using month-end data, the factor is defined as the month-on-month percentage change in the index, and factor shifts in scenarios are defined as the maximum cumulative percentage change over the course of the scenario.
- Gold Price. Gold prices are represented by the ICE Benchmark Administration Limited (IBA), Gold Fixing Price 3:00 P.M. (London time) in London Bullion Market, based in US Dollars. FinMason obtains these prices from FRED (see above). Using month-end data, the factor is defined as the month-on-month percentage change in the price, and factor shifts in scenarios are defined as the maximum cumulative percentage change over the course of the scenario.

EXAMPLE: CALCULATION OF THE RETURN ON A SINGLE ASSET, CRASH OF 2008 SCENARIO

(Note: All calculations are approximate, for illustration only, and may not match FinRiver data.)

Return on Exxon Mobil Corporation (XOM)

Factor Model with Estimated Factor Sensitivities (Betas) for Exxon Mobil:

XOM = Constant + Beta1 * SP500 + Beta2 * OIL + Residual

Estimated Factor Sensitivities:
Constant = 0.004651
Beta1 = 0.539978
Beta2 = 0.078203

Calculation of Factors and Factor Shifts, Crash of 2008 Scenario (SP500 and Oil)

SP500, Oct 2007 = 2423.7
SP500, Feb 2009 = 1188.8
SP500 Crash 2008 Factor Shift = 1188.8/2423.7-1 = -50.9%

Oil price, June 2008 = 133.93
Oil price, Feb 2009 = 39.16
Oil price Crash 2008 Factor Shift = 39.16/133.93 -1 = - 70.8%

<u>Estimated Return for Exxon Mobil, Crash of 2008 Scenario</u>

Estimated XOM Return = 0.004651 + 0.539978 * (-50.9%) + 0.078203 * (-70.8%) = - 33.0%

Actual XOM Return, Dec 2007 through Apr 2009= -27.1%