Methodologies Used in the Interactive Smart Beta Tool

Expected Returns Model

We find that valuation ratios are inversely proportional to subsequent excess returns of equity factors and smart beta strategies. This effect is robust across different factors and strategies, across varying time horizons, and across regions. Our expected returns model assumes a continuation of that relationship, forming expectations based on historical returns and valuations. The model is calibrated using historical data but employs methods such as pooling and shrinking parameter estimates to avoid overfitting the model to the data, which is known to produce suboptimal out-of-sample performance.

Expected returns are modeled with an inverse relationship between the log of the factor or strategy's valuation ratio and its subsequent return. (Valuation ratio is defined for strategies as the price to fundamentals of the strategy divided by the price to fundamentals of the market benchmark, and for factors as the price to fundamentals of the long side divided by the price to fundamentals of the short side.) When a factor or strategy is expensive relative to its historical norms, its expected return is low and vice versa. At neutral valuation, the expected return is its structural alpha, which is defined as historical return net of any trend in valuations, and is defined in the next section.

The Expected Returns model is as follows:

$$E(r)_{P,R,T} = \alpha_{struct,P} + avg(\beta_P, \beta_{group}) \times z\left(\ln\left(val\ ratio_{P,R,T}\right)\right)$$

The first step is to compute valuation ratios:

$$val\ ratio_{P,R} = \left[\left(\frac{P/B\ ook_{strat}}{P/B\ ook_{market}}\right)\left(\frac{P/5\ yrSales_{strat}}{P/5\ yrSales_{market}}\right)\left(\frac{P/5\ yrEarn_{strat}}{P/5\ yrEarn_{market}}\right)\left(\frac{P/5\ yrDiv_{strat}}{P/5\ yrDiv_{market}}\right)\right]^{\frac{1}{4}}$$

for Strategy P in Region R, and for Factor P in Region R.

$$val\ ratio_{P,R} = \left[\left(\frac{P/B\ ook_{long}}{P/B\ ook_{short}}\right)\left(\frac{P/5\ yrSales_{long}}{P/5\ yrSales_{short}}\right)\left(\frac{P/5\ yrEarn_{long}}{P/5\ yrEarn_{short}}\right)\left(\frac{P/5\ yrDiv_{long}}{P/5\ yrDiv_{short}}\right)\right]^{\frac{1}{4}}$$

Valuation ratios are then *Z*-scored to frame valuations in terms of historical observations:

$$z\left(\ln\left(val\ ratio_{P,R,T}\right)\right) = \frac{\ln\left(val\ ratio_{P,R,T}\right) - avg_T \ln\left(val\ ratio_{P,R,t}\right)}{stdev_T \ln\left(val\ ratio_{P,R,t}\right)}$$

When the valuation ratio of a strategy or factor is at its historical average, this *Z*-score equals zero and the expected return is equal to the structural alpha, defined in the next section.

Next, we compute $\beta_{P,R}$ as the coefficient for a factor or strategy in a given region according to the following regression:

$$Excess\ Return_{P,R,t..t+5} \sim \alpha_{P,R} + \beta_{P,R} * z\left(\ln\left(val\ ratio_{P,R,t}\right)\right) + \epsilon_{P,R,t}$$

Then take the average coefficient for a given factor or strategy across all regions, weighted by the number of unique data points available in each region:

$$\beta_P = avg\left(\beta_{P,r1}, \beta_{P,r2}, \beta_{P,r3}, \dots\right)$$

These betas can be interpreted as the excess return gained per unit of valuation *Z*-score. For example, a β of -2% means that we expect a headwind of -2% excess return when the strategy is valued one standard deviation above its historical mean, and a tailwind of +4% excess return when it is valued two standard deviations below its historical mean, etc. Betas are averaged across regions for a given factor or strategy to take advantage of longer data samples in certain regions and increase confidence in betas in regions with little data such as emerging markets.

Finally, compute the average coefficient across the group of all strategies or all factors:

$$\beta_{group} = avg\left(\beta_{p1}, \beta_{p2}, \beta_{p3}, \dots\right)$$

This average across all strategies or across all factors is the shrinkage target toward which we will shrink individual factor- or strategy-level coefficients. $avg\left(\beta_P, \beta_{group}\right)$ in the expected returns model shrinks the portfolio-level coefficient β_P halfway toward the average of all factor or all strategy coefficients. This shrinkage allows for differing levels of mean-reversion assumptions for different factors and strategies according to the data, but avoids overfitting any one factor or strategy that has a particularly strong or weak relationship between valuations and subsequent returns.

$\alpha_{struct,P}$ is the Structural Alpha of strategy or factor P. It is computed as the weighted-average Structural Alpha of strategy or factor P across all regions:

$$\alpha_{struct,P} = avg\left(\alpha_{struct,P,r1}, \alpha_{struct,P,r2}, \alpha_{struct,P,r3}, \dots\right)$$

Structural Alpha is the historical return of a strategy or factor net a trend in valuation. This is the model's expectation of future excess returns from neutral starting valuations. It is defined in more detail in the next section.

Structural Alpha and Revaluation Alpha

Equity strategies and factors sometimes deliver a premium by getting more expensive or suffer a loss by getting cheaper. It might not matter to the bottom line whether past returns came from an increase in valuations, but for the purpose of estimating what returns to expect going forward, what matters is the portion of the return that is repeatable. If a strategy earns a 100% excess return by doubling in valuation, we should not expect that strategy to continue that performance (i.e., doubling in valuation again and again and again in the future).

We deconstruct the returns of long/short factors and the excess returns of smart beta strategies into two components: Structural Alpha and Revaluation Alpha.

$$Excess\ Return = Structural\ Alpha + Revaluation\ Alpha$$

Revaluation Alpha is the component of return that comes from changing valuations. It is defined as the trend in valuation ratio over the sample, computed as the coefficient $\widehat{\beta_{P,R}}$ according to

$$Revaluation\ Alpha = \beta_{P,R}$$

according to

$$val\ ratio_{t,P,R} \sim \widehat{\alpha_{P,R}} + \widehat{\beta_{P,R}} * t + \varepsilon$$

where t is measured in years. Structural Alpha is then simply the excess return net of Revaluation Alpha:

$$Structural\ Alpha = Excess\ Return - Revaluation\ Alpha$$

Structural Alpha can be interpreted as the return of a strategy or factor net of changes in valuation. This would be the expectation of excess returns an investor would have if they were valuation indifferent or if they were forming expectations for average returns over several decades (which could include many valuation cycles), or if the excess return expectation was derived from neutral valuation levels. Structural Alpha of Portfolio P in Region R $(\alpha_{struct,P,R})$ is used as the expectation at historical neutral valuation in the expected returns model above.

Trading Cost Model

Trading costs often go unnoticed by the end investor because they arise from the temporary price impact created when buying and selling the underlying securities. When an index performs its annual, quarterly, or monthly rebalance, the resulting transactions temporarily drive up the price of shares that are bought and drive down the price of shares that are sold. This price impact is proportional to the percentage of daily volume occurring for that stock at a rate of 0.30% transaction cost for every 10% of average daily volume (ADV) traded (Aked and Moroz, 2015).

To estimate the trading cost of a smart beta strategy, the transactions generated by that strategy's rebalancing are computed assuming $10B in AUM for US and Developed strategies, and $1B for Emerging Markets. Volume on rebalance days is assumed to be the maximum of the prior 30-day ADV and prior 90-day ADV and is aggregated across all relevant exchanges. Maximum price impact per trade is capped at 2%. Price impacts of individual stock transactions are aggregated up to the portfolio level and annualized.

Benchmark

LARGE CAP BENCHMARK

Large Cap Benchmark selects the top 500 stocks by market cap (US) and all stocks in the Large + Mid Cap starting universe (Developed and EM), then weights by market capitalization, rebalancing annually in the US and semi-annually in Developed and EM.

1) Starting Universe
    - A. *Depth*
        - i. US: Top 500 by market cap
        - ii. Developed and EM: Large + Mid Cap
    - B. *Notable exclusions*
        - i. None

2) Rebalancing Frequency
    - A. *US: Annually, end of June*
    - B. *Developed and EM: Semi-annually, end of June and December*

3) Relevant Individual Stock Variables Calculation Procedure
    - A. *None, only requires market cap and free float.*

4) Selection Procedure
    - A. *Select all stocks in the starting universe.*

5) Weighting Scheme
    - A. *Weight by market cap * free float.*

Value

GEN-1 VALUE – ALL REGIONS

The Gen-1 Value simulation selects stocks from the starting universe according to a composite value score calculated using Book/Price, five-year sales per share growth, and two-year earnings per share growth. Stocks are weighted by the product of this score and market capitalization, and rebalanced annually.

1) Starting Universe

A. *Depth*

i. US: Top 1,000 stocks by market cap

ii. Developed and EM: Large + Mid Cap

B. *Notable exclusions*

i. None

2) Rebalancing Frequency

A. *Annually*

B. *End of June*

3) Relevant Individual Stock Variables Calculation Procedure

A. *Calculate Value Score as percentile rank within nation for Book/Price ratio.*

B. *Calculate Growth Score as average of percentile rank within nation for five-year sales per share growth and two-year earnings per share growth. Note that the score is inverted such that value companies have the highest score.*

C. *Calculate Composite Score (X) as average of Value Score and Growth Score.*

D. *Calculate cumulative market-cap weight ordered by Composite Score (X). Stocks with missing values get the average score for the industry. Get break points for 25th, 50th, and 75th percentiles (X_L, X_M, X_U, respectively).*

E. *Calculate probability of being a value company as*

$$P(X) = \begin{cases} 1 & if\ X_U < X \\ \dfrac{1}{1+\exp\left(\frac{5X_M - X}{X_U - X_M}\right)} & if\ \ X_M < X < X_U \\ \dfrac{1}{1+\exp\left(\frac{5X_M - X}{X_M - X_L}\right)} & if\ \ X_L < X < X_M \\ 0 & if\ X < X_L \end{cases}$$

F. *Apply 5% rule that makes P = 1 if P ≥ 0.95 and P = 0 if P ≤ 0.05.*

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4) Selection Procedure

A. *Count/Coverage*

i. Targets a number of securities that cover 50% of the starting universe by market cap for each nation.

5) Weighting Scheme

A. *Weight stocks by P(X) * market cap * free float.*

CONCENTRATED VALUE – ALL REGIONS

The Concentrated Value simulation selects companies from the Large + Mid Cap universe based on a value score, calculated using Price/Book, Price/Earnings, and Enterprise Value/ Cash Flow from Operations. Stocks are weighted by market cap times value score and are rebalanced semi-annually.

1) Starting Universe
   - A. *Depth*
     - i. Large + Mid Cap
   - B. *Notable exclusions*
     - i. None

2) Rebalancing Frequency
   - A. *Semi-annually*
   - B. *End of June and December*

3) Relevant Individual Stock Variables Calculation Procedure
   - A. *Price/Book Value*
     - i. Company Market-Cap/Book Value
   - B. *Price/Earnings*
     - i. Company Market-Cap/Earnings
   - C. *Enterprise Value/Cash Flow from Operations*
     - i. Enterprise Value/Cash Flow from Operations
   - D. *Calculate Z-scores for these three variables.*
   - E. *Value_Z = average (PB_Z, PE_Z, EVCFO_Z) unless the stock is a financial company, then Value_Z = average (PB_Z, PE_Z)*
     - i. If any variables are missing, take the average of the nonmissing variables.
   - F. *Calculate Z-scores within each industry from Value_Z, and call it Rel_Value_Z.*
   - G. *Calculate a value score for each stock as*

$$Value\ Score = \begin{cases} 1 + Rel\_Value\_Z, & x > 0 \\ (1 - Rel\_Value\_Z)^{-1}, & x < 0 \end{cases}$$

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4) Selection Procedure

A. *Count/Coverage*

i. This index targets a fixed number of securities that cover 25–30% of the starting universe by market cap, rounded to the nearest appropriate number ending in 0 or 5.

B. *Selection Order*

i. Stocks are ranked and selected by value score. Stocks currently in the portfolio are given precedence to avoid excess turnover.

01. This index uses a fixed security buffer algorithm of 50%.

*a. For example, if the count is 200, the first 100 companies (50% * 200 = 100) ranked by the value score are added. The existing constituents ranked between 101 and 300 (150% * 200 = 300) are added until 200 constituents have been selected. If 200 are not yet selected, add constituents until 200 are selected.*

5) Weighting Scheme

A. *The weight is calculated as*

i. Value Weight = Value Score * Market Cap * Free Float.

ii. This index additionally uses a turnover buffer of 50%.

01. For example, if the rebalance results in the weight of a security changing from a to b, then the new change in weight will be

a. New Weight = a + (a − b)/2.

b. This is not performed on deletions.

iii. Weights are capped at 5%.

FUNDAMENTALLY REWEIGHTED – ALL REGIONS

The Fundamentally Reweighted simulation weights all companies in the starting universe according to four fundamental measures of company size: book value, sales, earnings, and cash earnings. The index is rebalanced semi-annually.

1) Starting Universe
   - A. *Depth*
     - i. Large + Mid Cap
   - B. *Notable exclusions*
     - i. None

2) Rebalancing Frequency
   - A. *Semi-annually*
   - B. *End of June and December*

3) Relevant Individual Stock Variables Calculation Procedure
   - A. *Book weight: The ratio of the stock's book value to the cumulative sum of the book values of all companies in the starting universe.*
   - B. *Sales weight: The ratio of the stock's previous three-year average sales value to the cumulative sum of the three-year average sales values of all companies in the starting universe.*
   - C. *Earnings weight: The ratio of the stock's previous three-year average earnings to the cumulative sum of the three-year average earnings of all companies in the starting universe.*
   - D. *Cash earnings weight: The ratio of the stock's previous three-year average cash earnings to the cumulative sum of the three-year average cash earnings of all companies in the starting universe.*
   - E. *Calculate the composite fundamental weight by taking the average of the preceding four fundamental weights.*

4) Selection Procedure
   - A. *Count/Coverage*
     - i. Use all stocks in the Large + Mid Cap universe.

5) Weighting Scheme
   - A. *Weight stocks by composite fundamental weight * free float.*

RAFI FUNDAMENTAL INDEX – ALL REGIONS

The RAFI™ Fundamental Index™ simulation selects and weights companies according to four fundamental measures of company size: book value, cash flow, dividends + buybacks, and adjusted sales. Four tranches are each rebalanced annually for a quarterly staggered rebalance.

1) Starting Universe

   A. *Depth*

      i. Top 86% by fundamental weight from each of the following six regions: US, UK, Europe ex UK, Japan, Other Developed, and EM.

   B. *Notable exclusions*

      i. None

2) Rebalancing Frequency

   A. *Annual construction at the end of June implemented using QSR method in June, September, December, and March.*

3) Relevant Individual Stock Variables Calculation Procedure

   A. *Book weight: The ratio of the stock's book value to the cumulative sum of the book value of all companies in the starting universe.*

   B. *Adjusted Sales weight: Adjusted Sales value is the stock's previous five-year average sales value scaled by average book value divided by average asset value. Adjusted Sales weight is the ratio of the stock's adjusted sales value to the cumulative sum of the adjusted sales values of all companies in the starting universe.*

   C. *Cash Flow weight: The ratio of the stock's previous five-year average cash flow to the cumulative sum of the five-year average cash flows of all companies in the starting universe.*

   D. *Dividends + Buyback weight: The ratio of the stock's previous five-year average dividend + average buybacks to the cumulative sum of the five-year average dividends + average buybacks of all companies in the starting universe.*

   E. *Calculate the composite fundamental weight by taking the average of the preceding four fundamental weights. If dividends weight is zero, take the average of the other three.*

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4) Selection Procedure

A. *Count/Coverage*

i. All companies in universe (i.e., top 86% by fundamental weight from each major region)

5) Weighting Scheme

A. *Weight stocks by fundamental weight * free float.*

B. *Apply liquidity constraint to the weights such that the weights cannot exceed four times their volume weight in portfolio of same constituents.*

RAFI VALUE FACTOR – ALL REGIONS

The RAFI Value Factor simulation selects the top quarter of large companies by fundamental-to-price ratios and weights by fundamental measures of company size. Four tranches are each rebalanced annually for a quarterly staggered rebalance.

1) Starting Universe

   A. *Depth*

      i. Top 86% by fundamental weight from each of the following six regions: US, UK, Europe ex UK, Japan, Other Developed, and EM.

   B. *Notable exclusions*

      i. None

2) Rebalancing Frequency

   A. *Annual construction at the end of June implemented using QSR method in June, September, December, and March.*

3) Relevant Individual Stock Variables Calculation Procedure

   A. *Calculate fundamental-to-cap ratio defined as Fundamental Index weight divided by market capitalization.*

   B. *Calculate fundamental weight as explained in Fundamental Index.*

   C. *Calculate momentum as total return of the stock over the prior 12 months, excluding the most recent month.*

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4) Selection Procedure

A. *For each region (US, UK, Europe ex UK, Japan, Other Developed, and EM) select the top 25% by cumulative fundamental weight of the companies with the highest fundamental-to-cap ratio.*

   i. Apply banding such that companies in the top 90% by portfolio weight stay in the index after rebalancing.

   ii. Rank the trades from current to target portfolios by momentum. Companies in the top 25% of fundamental weight ranked by momentum get higher of current and target weights (do not sell high momentum companies); companies in the bottom 25% of fundamental weight ranked by momentum get lower of current and target weights (do not buy low momentum companies).

5) Weighting Scheme

A. *Weight stocks by fundamental weight * free float.*

B. *Apply liquid constraint to the weights such that the weights cannot exceed four times their volume weight in portfolio of same constituents.*

Income

HIGH DIVIDEND – US

The High Dividend simulation selects 100 stocks by dividend yield from the US Large + Mid + Small Cap universe, after applying screens for dividend growth and dividend coverage. Stocks are weighted by indicated dividend yield and rebalanced annually.

1) Starting Universe

   A. *Depth*

      i. Large + Mid + Small (All Cap)

   B. *Notable exclusions*

      i. Excludes REITs and non-dividend-paying companies.

2) Rebalancing Frequency

   A. *Annually*

   B. *End of June*

3) Relevant Individual Stock Variables Calculation Procedure

   A. *Five-year DPS Growth Rate*

$$5\ year\ DPS\ Growth\ Rate = \frac{DPS_t}{average(DPS_t,\ DPS_{t-1}, DPS_{t-2}, DPS_{t-3}, DPS_{t-4})} - 1$$

   B. *Five-year Dividend Coverage Ratio*

$$5\ year\ div.cov.ratio = Average\left(\frac{EPS_t}{DPS_t}, \frac{EPS_{t-1}}{DPS_{t-1}}, \frac{EPS_{t-2}}{DPS_{t-2}}, \frac{EPS_{t-3}}{DPS_{t-3}}, \frac{EPS_{t-4}}{DPS_{t-4}}\right)$$

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4) Selection Procedure

A. *Count/Coverage*

i. 100 stocks

B. *Requirements to enter portfolio*

i. Positive past fiscal year earnings

ii. Five-year DPS Growth Rate ≥ 0%

iii. Five-year Dividend Coverage Ratio > 167%

iv. Paid dividends in previous five years

v. Free-float market cap > $1B

C. *Requirements to remain in the portfolio*

i. Free-float market cap > $750M

ii. Paid dividends in previous five years

D. *Selection Order*

i. Stocks currently in the portfolio are given precedence to avoid excess turnover.

ii. Rank stocks by indicated dividend yield (DY)

01. If currently in the portfolio and DY rank ≤ 200, select.

02. Select names not currently in the portfolio by top DY until 100 total names are selected.

5) Weighting Scheme

A. *Weight stocks by indicated dividend yield.*

B. *Cap weights at 10%.*

HIGH DIVIDEND – DEVELOPED

The High Dividend simulation selects 100 stocks by dividend yield from the Developed Large + Mid + Small Cap universe, after applying screens for dividend growth and dividend coverage. Stocks are weighted by indicated dividend yield and rebalanced annually.

1) Starting Universe

   A. *Depth*

      i. Large + Mid + Small (All Cap)

   B. *Notable exclusions*

      i. Excludes REITs and non-dividend-paying companies.

2) Rebalancing Frequency

   A. *Annually*

   B. *End of June*

3) Relevant Individual Stock Variables Calculation Procedure

   A. *Five-year average dividends per share (DPS)*

$$5\ year\ average\ DPS = average(DPS_t, DPS_{t-1}, DPS_{t-2}, DPS_{t-3}, DPS_{t-4})$$

   B. *Five-year Dividend Coverage Ratio*

$$5\ year\ div.cov.ratio = Average\left(\frac{EPS_t}{DPS_t}, \frac{EPS_{t-1}}{DPS_{t-1}}, \frac{EPS_{t-2}}{DPS_{t-2}}, \frac{EPS_{t-3}}{DPS_{t-3}}, \frac{EPS_{t-4}}{DPS_{t-4}}\right)$$

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4) Selection Procedure

A. *Count/Coverage*

i. 100 stocks

B. *Requirements to enter portfolio*

i. Positive past fiscal year earnings

ii. Five-year avg. DPS ≥ current DPS

iii. Five-year Dividend Coverage Ratio > 167% for US and European companies, >125% for all other countries

iv. Free-float market cap > $1B

v. Three-month average daily volume > $3M

C. *Requirements to remain in the portfolio*

i. Free-float market cap > $750M

D. *Selection Order*

i. Stocks currently in the portfolio are given precedence to avoid excess turnover.

ii. Rank stocks by indicated dividend yield (DY)

01. If currently in the portfolio and DY rank ≤ 200, select.

02. Select names not currently in the portfolio by top DY until 100 total names are selected.

5) Weighting Scheme

A. *Weight stocks by indicated dividend yield.*

B. *Cap weights at 10%.*

HIGH DIVIDEND – EM

The High Dividend simulation selects 100 stocks by dividend yield from the Emerging Market Large + Mid + Small Cap universe, after applying screens for earnings and continuous dividend payment. Stocks are weighted by indicated dividend yield and rebalanced annually.

1) Starting Universe
    - A. *Depth*
        - i. Large + Mid + Small (All Cap)
    - B. *Notable exclusions*
        - i. Excludes REITs and non-dividend-paying companies

2) Rebalancing Frequency
    - A. *Annually*
    - B. *End of June*

3) Relevant Individual Stock Variables Calculation Procedure
    - A. *None*

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4) Selection Procedure

A. *Count/Coverage*

i. 100 stocks

B. *Requirements to enter portfolio*

i. Positive past fiscal year earnings

ii. Must have paid dividends in each of the past three years

iii. Free-float market cap > $250M

iv. Three-month average daily volume > $2M

C. *Requirements to remain in the portfolio*

i. Three-month average daily volume > $500,000

D. *Selection Order*

i. Stocks currently in the portfolio are given precedence to avoid excess turnover.

ii. Rank stocks by indicated dividend yield (DY)

01. If currently in the portfolio and DY rank ≤ 200, select.

02. No more than 30 stocks can be selected from a single country.

03. Select names not currently in the portfolio by top DY until 100 total names are selected.

5) Weighting Scheme

A. *Weight stocks by indicated dividend yield.*

B. *Nation weights are capped at 25%.*

DIVIDEND GROWTH – US

The Dividend Growth simulation selects all stocks from the top 1,500 by market cap that had stable or increasing dividends every year for the last 20 years. The stocks are weighted by indicated dividend yield, and the portfolio is rebalanced quarterly.

1) Starting Universe

   A. *Depth*

      i. Top 1,500 by market cap

   B. *Notable exclusions*

      i. None

2) Rebalancing Frequency

   A. *Quarterly*

   B. *End of June, September, December, and March*

3) Relevant Individual Stock Variables Calculation Procedure

   A. *Number of Continuous Years of Increasing or Stable Dividends*

      i. If total dividend payout increased or decreased by less than 15%, count the year. Cumulatively count the number of years this occurs for each stock, and reset the count to zero if the condition is violated.

4) Selection Procedure

   A. *Count/Coverage*

      i. No coverage or count requirement

   B. *Requirements to enter portfolio*

      i. If year = 1968, require 15 years of increasing or stable dividends.

      ii. If 1968 < year < 1985, require 17 years of increasing or stable dividends.

      iii. If year ≥ 1985, require 20 years of increasing or stable dividends.

      iv. If year ≥ 1999, stocks must also have $1B market cap and $4M average daily volume.

   C. *Selection Order*

      i. Select all companies that meet the requirements to enter the portfolio.

5) Weighting Scheme

   A. *Weight companies by indicated dividend yield.*

DIVIDEND GROWTH – DEVELOPED

The Dividend Growth simulation selects 100 stocks from the Developed Large + Mid + Small Cap universe that had stable or increasing dividends every year for the last 10 years, along with screens for earnings and dividend payout ratio. The stocks are weighted by indicated dividend yield, and the portfolio is rebalanced quarterly.

1) Starting Universe
   - A. *Depth*
     - i. Large + Mid + Small Cap
   - B. *Notable exclusions*
     - i. Non-dividend-paying companies

2) Rebalancing Frequency
   - A. *Semi-annually*
   - B. *End of June and December*

3) Relevant Individual Stock Variables Calculation Procedure
   - A. *Dividend Payout Ratio = Dividends / Earnings*

4) Selection Procedure
   - A. *Count/Coverage*
     - i. 100 stocks
   - B. *Requirements to enter portfolio*
     - i. Dividend Payout Ratio < 100%
     - ii. Positive EPS
     - iii. Stocks must have $1B market cap and $5M average daily volume.
     - iv. Stocks must have 10 years of increasing or stable dividends.
       - 01. This is relaxed if it would result in less than 100 stocks in the portfolio. This requirement is lowered by one year until 100 stocks pass all of the requirements for entry.
   - C. *Requirements to remain in the portfolio*
     - i. Positive EPS
   - D. *Selection Order*
     - i. Rank all companies that meet the requirements by indicated dividend yield, and select top 100 companies with highest indicated dividend yield.

5) Weighting Scheme
   - A. *Weight companies by indicated dividend yield.*

DIVIDEND GROWTH – EM

The Dividend Growth simulation selects 100 stocks from the Emerging Market Large + Mid + Small Cap universe that had growing earnings and high dividend yields. The stocks are weighted by annual dividend yield, and the portfolio is rebalanced semi-annually.

1) Starting Universe
    - A. *Depth*
        - i. Large + Mid + Small Cap
    - B. *Notable exclusions*
        - i. Non-dividend-paying companies

2) Rebalancing Frequency
    - A. *Semi-annually*
    - B. *End of June and December*

3) Relevant Individual Stock Variables Calculation Procedure
    - A. *Three-year earnings growth = annual earnings three years ago minus most recent annual earnings.*
    - B. *Annual dividend yield*
        - i. Previous 12 months of paid dividends/current price

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4) Selection Procedure

A. Count/Coverage

i. 100 stocks

B. Requirements to enter portfolio

i. Stocks must have a float-adjusted market cap of $300M, total market cap of $1B, and average daily volume of $1M.

ii. Positive EPS

iii. Positive three-year earnings growth

C. Requirements to remain in the portfolio

i. Positive three-year earnings growth in one of last two years

ii. Stocks must have a float-adjusted market cap of $300M, total market cap of $1B, and average daily volume of $1M

D. Selection Order

i. Rank stocks by annual dividend yield (ADY).

01. If currently in the portfolio and DY rank ≤ 200, select.

02. Select names not currently in the portfolio by top ADY until 100 total names are selected.

5) Weighting Scheme

A. Weight companies by annual dividend yield.

B. Cap weights at the minimum of 3% or average daily dollar volume/$750M.

C. Cap sector and nation weights at 25%.

RAFI EQUITY INCOME – ALL REGIONS

The RAFI Equity Income simulation selects the top 50% of stocks by dividend yield from the top 98% of stocks by fundamental weight, screening out the bottom quintiles by growth (return on assets), distress (debt coverage ratio), and conservative accounting (net operating assets). Stocks are weighted by the product of fundamental weight and dividend yield, and are rebalanced annually.

1) Starting Universe

   A. *Depth*

      i. Top 98% by fundamental weight from each of the following six regions: US, UK, Europe ex UK, Japan, Other Developed, and EM.

2) Rebalancing Frequency

   A. *Annually*

   B. *End of June*

3) Relevant Individual Stock Variables Calculation Procedure

   A. *Dividend Yield*

      i. Accumulation of trailing 12-month dividend, divided by one-year daily average price.

      ii. Dividend yield winsorized within each region and industry basket at 95th percentile.

   B. *Minimum Robustness Rank (MRR)*

      i. Minimum of the percentile ranks of ROA, NOA, and DCR. The ranking is done within region and industry baskets.

   C. *Calculate fundamental weight by the method explained in Fundamental Index with the following fundamentals: book, sales, cash flow, and dividends. If dividends are zero, then the composite weight is the average of the other three fundamentals.*

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4) Selection Procedure

A. *Count/Coverage*

i. Remove 50% of companies with lowest yields within region and industry baskets.

ii. Independently remove companies with MRR less than 20%.

B. *Banding*

i. Dividend yield and MRR percentile ranks for existing holdings are given a 20% boost (e.g., PR = 40% is treated as 48%).

5) Weighting Scheme

A. *Weight securities by dividend yield * fundamental weight * free float.*

B. *Weights are within 5% and 10bps, not exceeding four times the weight in a reference portfolio of the same holdings weighted by ADV.*

Low Volatility

MINIMUM VOLATILITY – ALL REGIONS

The Minimum Volatility simulation employs a constrained optimization on the Large + Mid Cap universe to minimize volatility. Constraints include minimum and maximum constituent, country, and sector weights, and turnover. The optimization is recomputed semi-annually.

1) Starting Universe
   - A. *Depth*
     - i. Large + Mid Cap
   - B. *Notable exclusions*
     - i. None

2) Rebalancing Frequency
   - A. *Semi-annually*
   - B. *End of June and December*

3) Relevant Individual Stock Variables Calculation Procedure
   - A. *Using PCA to calculate a variance covariance matrix from the past five-year monthly returns.*

4) Selection Procedure
   - A. *Use optimization to get the portfolio with the minimum variance subject to following constraints:*
     - i. Maximum weight of individual stock can be lower of 1.5% or 20 times the weight in starting universe. Minimum weight can be 0.05%.
     - ii. Country and sector weights cannot differ from the starting universe by more than 5%.
     - iii. One-way turnover at each rebalance cannot exceed 10%.
     - iv. Above constraints are relaxed if the optimization procedure doesn't converge to a solution.

5) Weighting Scheme
   - A. *Stocks are weighted using the result from the optimization.*

LOW VOLATILITY – ALL REGIONS

The Low Volatility simulation selects the 100 lowest-volatility stocks from the top 500 by market cap, where volatility is defined as the standard deviation of daily returns over the prior year. Stocks are weighted by 1/volatility and rebalanced quarterly.

1) Starting Universe
   - A. *Depth*
     - i. US: Top 500 stocks by market cap
     - ii. Developed and EM: Large + Mid Cap
   - B. *Notable exclusions*
     - i. None

2) Rebalancing Frequency
   - A. *Quarterly*
   - B. *End of June, September, December, and March*

3) Relevant Individual Stock Variables Calculation Procedure
   - A. *One-year Volatility*
     - i. Standard deviation of daily price changes over the preceding one year (i.e., 12 months)

4) Selection Procedure
   - A. *Count/Coverage*
     - i. US: 100 stocks
     - ii. Developed and EM: 200 stocks
   - B. *Selection Order*
     - i. Rank stocks in ascending order of volatility.
     - ii. US: Select the 100 stocks with the lowest volatility.
     - iii. Developed and EM
       01. If currently in the portfolio and volatility rank ≤ 240, select.
       02. Then, select names not currently in the portfolio with the lowest volatility until 200 total names are selected.

5) Weighting Scheme
   - A. *Weight stocks by 1/Volatility.*

DEFENSIVE – ALL REGIONS

The Defensive simulation reweights stocks by market cap according to a stability score, which captures low five-year and one-year volatility, low earnings variability and leverage, and high return on assets. The portfolio is reconstituted annually and reweighted quarterly.

1) Starting Universe

   A. *Depth*

      i. US: Top 1,000 stocks by market cap

      ii. Developed and EM: Large + Mid Cap

   B. *Notable exclusions*

      i. None

2) Rebalancing Frequency

   A. *Annually*

   B. *End of June*

3) Relevant Individual Stock Variables Calculation Procedure

   A. *Calculate Volatility Score as average of percentile rank within nation for one-year volatility and five-year volatility. Note companies with lowest volatility have highest score. Missing values get 25% as percentile rank.*

   B. *Calculate Quality Score as average of percentile rank within nation for Debt/Equity Ratio, Pre-Tax ROA, and Earnings Variability. Note that companies with lowest Debt/Equity, highest ROA, and lowest Earnings Variability have highest score. Missing values get 25% as percentile rank.*

   C. *Calculate Composite Score (X) as average of Volatility Score and Quality Score.*

   D. *Calculate cumulative market-cap weight ordered by Composite Score (X). Get break points for 25th, 50th, and 75th percentiles (XL, XM, XU, respectively).*

   E. *Calculate probability of being a defensive company as*

$$P(X) = \begin{cases} 1 & if\ X_U < X \\ \dfrac{1}{1+\exp\left(\dfrac{5X_M - X}{X_U - X_M}\right)} & if\ X_M < X < X_U \\ \dfrac{1}{1+\exp\left(\dfrac{5X_M - X}{X_M - X_L}\right)} & if\ X_L < X < X_M \\ 0 & if\ X < X_L \end{cases}$$

   F. *Apply 5% rule that makes P = 1 if P ≥ 0.95 and P = 0 if P ≤ 0.05.*

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4) Selection Procedure

A. *Count/Coverage*

i. Targets a number of securities that cover 50% of the starting universe by market cap for each nation.

5) Weighting Scheme

A. *Weight stocks by P(X) * market cap * free float.*

RAFI LOW VOLATILITY – ALL REGIONS

The RAFI Low Volatility™ simulation selects companies from the starting universe with low valuations and low global, country, and industry betas. Stocks are weighted by fundamental weights. Four tranches are each rebalanced annually for a quarterly staggered rebalance.

1) Starting Universe

   A. *Depth*

      i. Top 86% by fundamental weight from each of the following six regions: US, UK, Europe ex UK, Japan, Other Developed, and EM.

      ii. For US, the starting universe is top 1,000 by fundamental weight.

   B. *Notable exclusions*

      i. None

2) Rebalancing Frequency

   A. *Annual construction at the end of June implemented using QSR method in June, September, December, and March.*

3) Relevant Individual Stock Variables Calculation Procedure

   A. *Calculate Systematic Risk defined as the company's stock return variance that can be explained by a three-factor linear model.*

   B. *Calculate fundamental weight by the method explained in Fundamental Index with the following fundamentals: book, sales, cash flow, and dividends. If dividends are zero, then the composite weight is the average of the other three fundamentals.*

4) Selection Procedure

   A. *For each nation and sector, select 20% of the companies with lowest systematic risk.*

      i. Apply banding such that if a company was in the portfolio last year and now ranks among lowest 25% by risk, that company stays in.

      ii. Exclude companies with a ratio of cap weight to fundamental weight greater than 150%.

5) Weighting Scheme

   A. *Weight stocks by fundamental weight * free float.*

   B. *Apply liquidity contraint to the weights such that the weights cannot exceed four times their volume weight in portfolio of same constituents.*

RAFI LV FACTOR – ALL REGIONS

The RAFI LV Factor simulation selects the bottom quarter of large companies by systematic risk (defined by global, country, and industry betas) and weights by fundamental measures of company size. Four tranches are each rebalanced annually for a quarterly staggered rebalance.

1) Starting Universe

   A. *Depth*

      i. Top 86% by fundamental weight from each of the following six regions: US, UK, Europe ex UK, Japan, Other Developed, and EM.

   B. *Notable exclusions*

      i. None

2) Rebalancing Frequency

   A. *Annual construction at the end of June implemented using QSR method in June, September, December, and March.*

3) Relevant Individual Stock Variables Calculation Procedure

   A. *Calculate systematic risk defined as the company's stock return variance that can be explained by a three-factor linear model.*

   B. *Calculate fundamental weight as explained in Fundamental Index.*

   C. *Calculate momentum as total return of stock over the prior 12 months excluding the most recent month.*

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4) Selection Procedure

A. *For each region (US, UK, Europe ex UK, Japan, Other Developed, and EM) select 25% by cumulative fundamental weights of the companies with lowest systematic risk fundamental-to-cap ratio.*

   i. Apply banding such that companies in the top 90% weights of the portfolio stay in the portfolio after rebalancing.

   ii. Rank the trades from current to target portfolios by momentum. Companies in the top 25% of fundamental weights ranked by momentum get higher of current and target weights (do not sell high momentum companies); companies in the bottom 25% of fundamental weights ranked by momentum get lower of current and target weights (do not buy low momentum companies).

5) Weighting Scheme

A. *Weight stocks by fundamental weight * free float.*

B. *Apply liquidity constraint on the weights such that the weights cannot exceed four times their volume weight in portfolio of same constituents.*

Quality

QUALITY – ALL REGIONS

The Quality simulation selects companies from the starting universe based on a quality score. Quality score combines high return on equity with low debt to equity and low earnings variability. Stocks are weighted by market cap times quality score and are rebalanced semi-annually.

1) Starting Universe
   - A. *Depth*
     - i. Large + Mid Cap
   - B. *Notable exclusions*
     - i. None

2) Rebalancing Frequency
   - A. *Semi-annually*
   - B. *End of June and December*

3) Relevant Individual Stock Variables Calculation Procedure
   - A. *Return on Equity (ROE)*
     - i. Earnings/Book Value
   - B. *Debt to Equity (D/E)*
     - i. −1 * (Total Debt/Book Value)
       - 01. This variable is multiplied by −1 so that low D/E companies have the highest value.
   - C. *Earnings Variability (EarnV)*
     - i. −1 *(Standard deviation of year-over-year earnings per share growth over previous five years)
       - 01. This variable is multiplied by −1 so that low D/E companies have the highest value.
   - D. *Winsorize these variables at the 5% and 95% levels.*
   - E. *Calculate Z-scores from the winsorized variables.*
   - F. *Final Quality_Z = average (ROE_Z, D/E_Z, EarnV_Z)*
     - i. If any variables are missing, take the average of the nonmissing variables.
     - ii. However, if any of the following is true, then the stock is excluded
       - 01. If missing ROE
       - 02. If missing D/E and EarnV
   - G. *Calculate the quality score for each stock as*

$$Quality\ Score = \begin{matrix} 1 + Quality\_Z, & x > 0 \\ (1 - Quality\_Z)^{-1}, & x < 0 \end{matrix}$$

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4) Selection Procedure

A. *Count/Coverage*

i. Targets a fixed number of securities that cover 25–30% of the starting universe by market cap, rounded to the nearest appropriate number ending in 0 or 5.

5) Selection Order

A. *Stocks are ranked and selected in descending order by the quality score, but stocks currently in the portfolio are given precedence to avoid excess turnover. This is done by using a fixed security buffer algorithm of 20%.*

i. For example, if the targeted count is 200, the first 160 companies ((100% – 20%) * 200 = 160) ranked by the quality score are added. The existing constituents ranked between 161 and 240 ((100% + 20%) * 200 = 240) are added until 200 constituents have been selected. If 200 are not yet selected, constituents are added until 200 are selected.

6) Weighting Scheme

A. *The weight is then calculated as*

i. Quality Weight = Quality Score * Market Cap * Free Float

ii. Weights are capped at 5%.

SECTOR NEUTRAL QUALITY – ALL REGIONS

The Sector Neutral Quality simulation selects companies from the starting universe based on a quality score. Quality score combines high return on equity with low debt to equity and low earnings variability. Stocks are weighted by market cap times quality score times parent index sector weight (to achieve sector neutrality) and are rebalanced semi-annually.

1) Starting Universe
   - A. *Depth*
     - i. Large + Mid Cap
   - B. *Notable exclusions*
     - i. None

2) Rebalancing Frequency
   - A. *Semi-annually*
   - B. *End of June and December*

3) Relevant Individual Stock Variables Calculation Procedure
   - A. *Return on Equity (ROE)*
     - i. Earnings/Book Value
   - B. *Debt to Equity (D/E)*
     - i. −1 * (Total Debt/Book Value)
       - 01. This variable is multiplied by −1 so that low D/E companies have the highest value.
   - C. *Earnings Variability (EarnV)*
     - i. −1 *(Standard deviation of year-over-year earnings per share growth over previous five years)
       - 01. This variable is multiplied by −1 so that low D/E companies have the highest value.
   - D. *Winsorize these variables at the 5% and 95% levels.*
   - E. *Calculate Z-scores from the winsorized variables.*
   - F. *Final Quality_Z = average (ROE_Z, D/E_Z, EarnV_Z)*
     - i. If any variables are missing, take the average of the nonmissing variables.
     - ii. However, if any of the following is true, then the stock is excluded
       - 01. If missing ROE
       - 02. If missing D/E and EarnV
   - G. *Calculate the quality score for each stock as*

$$Quality\ Score = \begin{matrix} 1 + Quality\_Z, & x > 0 \\ (1 - Quality\_Z)^{-1}, & x < 0 \end{matrix}$$

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4) Selection Procedure

A. *Count/Coverage*

i. Targets a fixed number of securities that cover 25–30% of the starting universe by market cap, rounded to the nearest appropriate number ending in 0 or 5.

B. *Selection Order*

i. Stocks are ranked and selected in descending order by the quality score, but stocks currently in the portfolio are given precedence to avoid excess turnover. This is done by using a fixed security buffer algorithm of 20%.

01. For example, if the targeted count is 200, the first 160 companies ((100% – 20%) * 200 = 160) ranked by the quality score are added. The existing constituents ranked between 161 and 240 ((100% + 20%) * 200 = 240) are added until 200 constituents have been selected. If 200 are not yet selected, constituents are added until 200 are selected.

5) Weighting Scheme

A. *The weight is then calculated as*

i. Quality Weight = Quality Score * Market Cap*Sector Weight * Free Float

ii. Cap weights at 5%.

GROWTH AND STABILITY – ALL REGIONS

The Growth and Stability simulation selects stocks by quality score from the starting universe. Quality score combines high return on equity with low accruals and low debt to equity. Stocks are weighted by market cap times quality score, and are rebalanced semi-annually.

1) Starting Universe

   A. *Depth*

      i. US: Top 500 by market cap

      ii. Developed and EM: Large + Mid Cap

   B. *Notable exclusions*

      i. None

2) Rebalancing Frequency

   A. *Semi-annually*

   B. *End of June and December*

3) Relevant Individual Stock Variables Calculation Procedure

   A. *Return on Equity (ROE)*

      i. Earnings/Book Value

   B. *Debt to Equity (D/E)*

      i. Total Debt/Book Value

   C. *Accruals*

$$Accruals = \frac{NOA_t - NOA_{t-1}}{0.5 \times (NOA_t + NOA_{t-1})}$$

   D. *Winsorize these variables at the 2.5% and 97.5% levels.*

   E. *Calculate Z-scores from the winsorized variables.*

   F. *Final Quality_Z = average (ROE_Z, D/E_Z, Accruals_Z)*

      i. If any variables are missing, use the average of the available variables.

   G. *Calculate the Z-score of the Quality_Z, winsorize at +/−4.*

   H. *Calculate a quality score for each stock as*

$$Quality\ Score = \begin{matrix} 1 + Quality\_Z, & x > 0 \\ (1 - Quality_Z)^{-1}, & x < 0 \end{matrix}$$

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4) Selection Procedure

A. *Count/Coverage*

i. Top 20% of starting universe

B. *Selection Order*

i. Stocks are ranked and selected in descending order by the quality score, but stocks currently in the portfolio are given precedence to avoid excess turnover. This is done by using a fixed security buffer algorithm of 20%.

01. For example, if the targeted count is 200, the first 160 companies ((100% – 20%) * 200 = 160) ranked by the quality score are added. The existing constituents ranked between 161 and 240 ((100% + 20%) * 200 = 240) are added until 200 constituents have been selected. If 200 are not yet selected, constituents are added until 200 are selected.

5) Weighting Scheme

A. *The weight is then calculated as*

i. Quality Weight = Quality Score * Market Cap * Free Float

ii. Cap sector and nation weights at 40%.

iii. Cap individual weights at the minimum of 5% or 20 times the stock's starting universe weight.

iv. Round up to 5bps those stocks with less than 5bps of weight.

RAFI QUALITY FACTOR – ALL REGIONS

The RAFI Quality Factor simulation selects the top quarter of large companies with high profitability (operating profitability, ROE, and ROA) and with low investment (asset growth and book growth), and weights by fundamental measures of company size. Four tranches are each rebalanced annually for a quarterly staggered rebalance.

1) Starting Universe

   A. *Depth*

      i. Top 86% by fundamental weight from each of the following six regions: US, UK, Europe ex UK, Japan, Other Developed, and EM.

   B. *Notable exclusions*

      i. None

2) Rebalancing Frequency

   A. *Annual construction at the end of June implemented using QSR method in June, September, December, and March.*

3) Relevant Individual Stock Variables Calculation Procedure

   A. *Calculate quality score defined as average of profitability score and investment score. Profitability score is the average of standardized scores of return on equity (ROE), return on assets (ROA), and operating profitability. Investment score is (-1) times the average of standard scores of asset growth defined as change in assets/prior-year assets, and of book growth defined as change in book value/prior-year book value. Variables and standard scores are winsorized to cap extreme outliers.*

   B. *Calculate fundamental weight as explained in Fundamental Index.*

   C. *Calculate momentum as total return of stock over the prior 12 months, excluding the most recent month.*

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4) Selection Procedure

A. *For each region (US, UK, Europe ex UK, Japan, Other Developed, and EM) select 25% by cumulative fundamental weights of the companies with highest quality score.*

   i. Apply banding such that companies in the top 90% weights of the portfolio stay in the portfolio after rebalancing.

   ii. Rank the trades from current to target portfolios by momentum. Companies in the top 25% of fundamental weights ranked by momentum get higher of current and target weights (do not sell high momentum companies); companies in the bottom 25% of fundamental weights ranked by momentum get lower of current and target weights (do not buy low momentum companies).

5) Weighting Scheme

A. *Weight stocks by fundamental weight * free float.*

B. *Apply liquidity constraint to the weights such that the weights cannot exceed four times their volume weight in portfolio of same constituents.*

Momentum

SHARPE MOMENTUM – ALL REGIONS

The Sharpe Momentum simulation selects companies from the starting universe based on momentum score. Momentum score combines prior 6-month and 12-month Sharpe ratios. Stocks are weighted by market cap times momentum score, and are rebalanced semi-annually, with additional rebalances triggered by volatility spikes.

1) Starting Universe

A. Depth

i. Large + Mid Cap

B. Notable exclusions

i. None

2) Rebalancing Frequency

A. Semi-annually with rebalances, as needed.

i. If the month-over-month change in three-month market volatility is in the top 95th percentile of all historical observations, perform a rebalance.

B. Normal rebalances are at the end of June and December.

3) Relevant Individual Stock Variables Calculation Procedure

A. Volatility = standard deviation of weekly price returns over previous three years.

B. Risk-adjusted 6-month momentum = (6-month local price return starting 7 months ago minus local risk-free rate)/Volatility.

C. Risk-adjusted 12-month momentum = (12-month local price return starting 13 months ago minus local risk-free rate)/Volatility.

D. Calculate Z-scores of risk-adjusted 6- and 12-month momentum variables (Mom6_Z, Mom12_Z).

E. Final Mom_Z = average (Mom6_Z, Mom12_Z).

F. Winsorize Mom_Z at +/−3.

G. Calculate a momentum score for each stock as

$$Momentum\ Score = \begin{matrix} 1 + Mom\_Z, & x > 0 \\ (1 - Mom\_Z)^{-1}, & x < 0 \end{matrix}$$

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4) Selection Procedure

A. *Count/Coverage*

i. Targets a fixed number of securities that cover 25–30% of the starting universe by market cap, rounded to the nearest appropriate number ending in 0 or 5.

B. *Selection Order*

i. Stocks are ranked and selected in descending order by the momentum score, but stocks currently in the portfolio are given precedence to avoid excess turnover. This is done by using a fixed security buffer algorithm of 50%.

01. For example, if the targeted count is 200, the first 100 companies ((100% – 50%) * 200 = 100) ranked by the score are added. The existing constituents ranked between 101 and 300 ((100% + 50%) * 200 = 300) are added until 200 constituents have been selected. If 200 are not yet selected, constituents are added until 200 are selected.

ii. Exception: when performing an unscheduled rebalance, use only Mom6_Z to rank, select, and score the stocks.

5) Weighting Scheme

A. *The weight is then calculated as*

i. Momentum Weight
= Momentum Score * Market Cap * Free Float.

ii. Cap weights at 5%.

STANDARD MOMENTUM – ALL REGIONS

The Standard Momentum simulation selects the top third of companies by momentum from the starting universe, where momentum is defined as prior-year return, skipping the most recent month. Stocks are weighted by market cap and are rebalanced quarterly.

1) Starting Universe
   - A. *Depth*
     - i. US: Top 1,000
     - ii. Dev and EM: Large + Mid Cap
   - B. *Notable exclusions*
     - i. None

2) Rebalancing Frequency
   - A. *Quarterly*
   - B. *End of June, September, December, and March*

3) Relevant Individual Stock Variables Calculation Procedure
   - A. *Momentum*
     - i. Total return of the stock over the prior 12 months, excluding the most recent month

4) Selection Procedure
   - A. *Count/Coverage*
     - i. One-third of the starting universe by count
   - B. *Selection Order*
     - i. Rank stocks in descending order by momentum, and select the stocks with the highest momentum.

5) Weighting Scheme
   - A. *Weight stocks by market cap * free float.*

RA MOMENTUM FACTOR – ALL REGIONS

The RA Momentum Factor simulation selects the top half of the large company universe having the highest momentum score. Momentum score combines standard momentum (prior-year return, skipping most recent month), beta-adjusted momentum, and fresh momentum that adjusts for the previous-year return. Stocks are weighted by market cap and rebalanced quarterly.

1) Starting Universe

   A. *Depth*

      i. Top 86% by market capitalization weight from each of the following six regions: US, UK, Europe ex UK, Japan, Other Developed, and EM.

   B. *Notable exclusions*

      i. None

2) Rebalancing Frequency

   A. *Quarterly construction at the end of June, September, December, and March.*

3) Relevant Individual Stock Variables Calculation Procedure

   A. *Calculate momentum score defined as average of standardized scores of*

      i. momentum defined as total return of stock over the prior 12 months, excluding the most recent month,

      ii. idiosyncratic momentum defined as beta-adjusted return of stock over the prior 12 months, excluding the most recent month, and

      iii. fresh momentum defined as momentum minus total return of stock over a 12-month period from the 24th month to the 12th month prior to rebalancing.

   Variables and standard scores are winsorized to cap extreme outliers.

4) Selection Procedure

   A. *For each region (US, UK, Europe ex UK, Japan, Other Developed, and EM) select 50% by cumulative market-capitalization weights of the companies with highest momentum score.*

      i. Apply banding such that companies in the top 80% by portfolio weight stay in the portfolio after rebalancing.

5) Weighting Scheme

   A. *Weight stocks by market capitalization weight * free float.*

   B. *Apply liquidity constraint to the weights such that the weights cannot exceed four times their volume weight in portfolio of same constituents.*

Multi-Factor

MATHEMATICAL BETA 4 – ALL REGIONS

The Mathematical Beta 4 simulation equally weights four factor indices: value (top half by Book/Price), momentum (top half by prior-year return, skipping most recent month), mid-cap (bottom half by market cap), and low volatility (bottom half by prior two-year standard deviation of weekly returns). Stocks within each factor are diversified via five diversification methods. The portfolio is rebalanced quarterly.

1) Starting Universe

   A. *Depth*

      i. US: Top 500 stocks by market cap

      ii. Developed: 1,100 stocks by market cap with the following criteria:

         01. 60 from Canada
         02. 300 from Eurozone
         03. 100 from UK
         04. 100 from Developed Europe ex Eurozone and UK
         05. 40 from Israel
         06. 200 from Developed Asia Pacific ex Japan
         07. 300 from Japan

      iii. EM : 700 stocks by market cap with the following criteria:

         01. 140 from Emerging Americas
         02. 160 from Emerging Europe
         03. 400 from Emerging Asia Pacific

2) Rebalancing Frequency

   A. *Quarterly at the end of June, September, December, and March*

3) Relevant Individual Stock Variables Calculation Procedure

   A. *Value Score: Book/Market Ratio*

   B. *Size: Free-float market cap*

   C. *Momentum: Returns over past 52 weeks minus the last 4 weeks*

   D. *Volatility: Standard deviation of weekly returns for past 104 weeks*

4) Selection Procedure

   A. *Count/Coverage*

      i. For every geographic block, form four portfolios: one for each of the four factors (High Value, Small Size, High Momentum, and Low Volatility) by selecting 50% of the names in each block.

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5) Weighting Scheme

A. For each geographic block and for each of the four factor portfolios, calculate the weights for the following five weighting schemes:

i. $w^* = \frac{1}{N}\mathbb{1}$

ii. $w^* = \frac{diag(\sigma^{-1})}{\mathbb{1}' diag(\sigma^{-1})}$

iii. $w^* = \frac{\Omega^{-1}\mathbb{1}}{\mathbb{1}'\Omega\mathbb{1}}$

iv. $w^* = \frac{\Sigma^{-1}\mathbb{1}}{\mathbb{1}'\Sigma^{-1}\mathbb{1}}$

v. $w^* = \frac{\Sigma^{-1}\mu}{\mathbb{1}'\Sigma^{-1}\mu}$

B. Equal weight the five weighting schemes for every factor portfolio.

C. Equal weight the four factor portfolios to get 11 geographic regional portfolios.

D. Aggregate the blocks by their market-cap weight in the starting universe to get the final portfolio.

MATHEMATICAL BETA 6 – ALL REGIONS

The Mathematical Beta 6 simulation equally weights six factor indices: value (top half by Book/Price), momentum (top half by prior-year return, skipping most recent month), mid-cap (bottom half by market cap), low volatility (bottom half by prior two-year standard deviation of weekly returns), profitability (top half by Gross Profits/Assets), and investment (bottom half by asset growth). Stocks within each factor are diversified via five diversification methods. The portfolio is rebalanced quarterly.

1) Starting Universe

   A. *Depth*

      i. US: Top 500 stocks by market cap

      ii. Developed: 1,100 stocks by market cap with the following criteria:

         01. 60 from Canada
         02. 300 from Eurozone
         03. 100 from UK
         04. 100 from Developed Europe ex Eurozone and UK
         05. 40 from Israel
         06. 200 from Developed Asia Pacific ex Japan
         07. 300 from Japan

      iii. EM : 700 stocks by market cap with the following criteria:

         01. 140 from Emerging Americas
         02. 160 from Emerging Europe
         03. 400 from Emerging Asia Pacific

2) Rebalancing Frequency

   A. *Quarterly at the end of June, September, December, and March*

3) Relevant Individual Stock Variables Calculation Procedure

   A. *Value Score: Book/Market Ratio*
   B. *Size: Free-float market cap*
   C. *Momentum: Returns over past 52 weeks minus the last 4 weeks*
   D. *Volatility: Standard deviation of weekly returns for past 104 weeks*
   E. *Low Investment: Total asset growth over last two fiscal years*
   F. *High Profitability: Gross profitability (i.e., Gross Profit/Assets)*

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4) Selection Procedure

A. Count/Coverage

i. For every geographic block, form six portfolios: one for each of the six factors (High Value, Small Size, High Momentum, Low Volatility, Low Investment, and High Profitability) by selecting 50% of the names in each block.

5) Weighting Scheme

A. For each geographic block and for each of the six factor portfolios, calculate the weights for the following five weighting schemes:

i. $w^* = \frac{1}{N}\mathbb{1}$

ii. $w^* = \frac{diag(\sigma^{-1})}{\mathbb{1}' diag(\sigma^{-1})}$

iii. $w^* = \frac{\Omega^{-1}\mathbb{1}}{\mathbb{1}'\Omega\mathbb{1}}$

iv. $w^* = \frac{\Sigma^{-1}\mathbb{1}}{\mathbb{1}'\Sigma^{-1}\mathbb{1}}$

v. $w^* = \frac{\Sigma^{-1}\mu}{\mathbb{1}'\Sigma^{-1}\mu}$

B. Equal weight the five weighting schemes for every factor portfolio.

C. Equal weight the six factor portfolios to get 11 geographic regional portfolios.

D. Aggregate the blocks by their market-cap weight in the starting universe to get the final portfolio.

QUALITY/VALUE/LOW VOL – ALL REGIONS

The Quality/Value/Low Vol simulation equally weights the Quality Index, the Fundamentally Reweighted Index, and the Minimum Volatility Index. Please see the construction methodology for these indices for more information.

RAFI DYNAMIC MULTI-FACTOR – ALL REGIONS

The RAFI Dynamic Multi-Factor simulation dynamically weights the RAFI Value Factor, RAFI LV Factor, RAFI Quality Factor, RA Momentum Factor, and RAFI Size Factor indices based on long-term reversal and short-term momentum. Dynamic allocations are adjusted quarterly.

1) Underlying Sub-Indices

A. *RAFI Value Factor, RAFI LV Factor, RAFI Quality Factor, RA Momentum Factor, RAFI Size Factor*

B. *Notable exclusions: RAFI Size Factor is excluded from EM.*

2) Reallocation Frequency

A. *Quarterly reallocation at the end of June, September, December, and March*

3) Relevant Factor Return Characteristics Calculation Procedure

A. *Standardized Factor Momentum defined as the standardization across the five factors of total return of factor indices over the prior 12 months excluding the most recent month.*

B. *Standardized Factor Reversal defined as (-1) times the standardization across the five factors of total return of factor indices over the four-year period from five years prior to one year prior to the reallocation date.*

4) Weighting Scheme

A. *Weight factors with a static component (equally weight), plus a dynamic component calculated as average Standardized Factor Momentum and Standardized Factor Reversal scaled by 1/8.*

B. *Dynamic components are limited to plus or minus 15%.*

Size

SMALL CAP – ALL REGIONS

The Small Cap simulation selects stocks from the small cap starting universe, weights by market cap, and rebalances semi-annually.

1) Starting Universe
   - A. *Depth*
     - i. US: The 1,001–3,000 companies ranked by market cap
     - ii. Developed and EM: Small Cap
   - B. *Notable exclusions*
     - i. None

2) Rebalancing Frequency
   - A. *US: Annually, end of June*
   - B. *Developed and EM: Semi-annually, end of June and December*

3) Relevant Individual Stock Variables Calculation Procedure
   - A. *None, only requires market cap and free float.*

4) Selection Procedure
   - A. *Select all stocks in the starting universe.*

5) Weighting Scheme
   - A. *Weight by market cap * free float.*

EQUAL WEIGHT – ALL REGIONS

The Equal Weight simulation equally weights all stocks in the starting universe and rebalances quarterly.

1) Starting Universe
    - A. *Depth*
        - i. US: Top 500 companies by market cap
        - ii. Developed and EM: Large + Mid Cap
    - B. *Notable exclusions*
        - i. None

2) Rebalancing Frequency
    - A. *Quarterly*
    - B. *End of June, September, December, and March*

3) Relevant Individual Stock Variables Calculation Procedure
    - A. *None*

4) Selection Procedure
    - A. *Select all stocks in the starting universe.*

5) Weighting Scheme
    - A. *Weight by 1/number of constituents in the starting universe.*

EQUAL SECTOR EQUAL WEIGHT – ALL REGIONS

The Equal Sector Equal Weight simulation equally weights each sector within the starting universe, then equally weights each stock within the sector. The portfolio is reconstituted annually and rebalanced quarterly.

1) Starting Universe
    - A. *Depth*
        - i. US: Top 1000 companies by market cap
        - ii. Developed and EM: Large + Mid Cap
    - B. *Notable exclusions*
        - i. None

2) Rebalancing Frequency
    - A. *Quarterly*
    - B. *End of June, September, December, and March*

3) Relevant Individual Stock Variables Calculation Procedure
    - A. *None.*

4) Selection Procedure
    - A. *Select all stocks in the starting universe.*

5) Weighting Scheme
    - A. *Weight each stock by 1/number of constituents within its sector.*

RAFI SIZE FACTOR – US AND DEVELOPED

The RAFI Size Factor simulation equally weights RAFI Value Factor, RAFI LV Factor, RAFI Quality Factor, and RA Momentum Factor indices within the small cap universe, defined as the 86th to 98th percentile by cumulative weight.

RAFI FUNDAMENTAL INDEX SMALL – US AND DEVELOPED

The RAFI™ Fundamental Index™ Small simulation selects and weights companies according to four fundamental measures of company size: book value, cash flow, dividends + buybacks, and adjusted sales. Four tranches are each rebalanced annually for a quarterly staggered rebalance. The methodology is described in Fundamental Index, except that the starting universe consists of companies from the 86th percentile to the 98th percentile by cumulative fundamental weight from each major region.

Factors

FACTORS

A factor is a simulation of a long/short portfolio that is long stocks high in the desired attribute and short stocks low in the desired attribute. Factors are constructed within large caps and small caps.

1) Starting Universe

   A. *Depth*

      i. Liquid stock universe

2) Rebalancing Frequency

   A. *Value, Value Composite, Return on Equity, Operating Profitability, Investment, and Gross Profitability*

      i. Annually, end of June

   B. *Momentum, Low Beta, and Illiquidity*

      i. Monthly, end of each month

3) Relevant Individual Stock Variables Calculation Procedure

   A. *Value*

      i. Book/Price: Book Value/Market Value

      ii. Relevant paper: Fama and French (1993). "Common Risk Factors in the Returns of Stocks and Bonds."

   B. *Value Composite*

      i. Winsorize the following variables at 1% and 99% levels, then calculate their *Z*-scores.

         01. Book/Price (BP): Book Value/Market Value

         02. Earnings/Price (EP): Five-year average Earnings/Market Value

         03. Sales/Price (SP): Five-year average Sales/Market Value

         04. Dividend/Price: Five-year average Dividends/Market Value

      ii. Take the average of all four *Z*-scores. If DP is 0, take the average of the *Z*-scores for BP, EP, and SP. Call this average VC_*Z*.

   C. *Investment*

      i. Change in Assets: $\frac{Assets_t}{Assets_{t-1}} - 1$

      ii. Fama and French (2014)

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D. Gross Profitability

i. Gross Profitability: (Sales minus Cost of Goods Sold)/Assets

ii. Relevant paper: Fama and French (2014)

E. Momentum

i. Momentum: Total return of the stock over the prior 12 months, excluding the most recent month

ii. Relevant paper: Carhart (1997). "On Persistence in Mutual Fund Performance."

F. Low Beta

i. Beta: $\frac{\rho_{s,m} \times \sigma_s}{\sigma_m}$

01. $\rho_{s,m}$ = correlation between the stock and the market using previous five years of daily returns.

02. σ_s = standard deviation of the stock using previous one year of daily returns.

03. σ_m = standard deviation of the market using previous one year of daily returns.

ii. Relevant Paper: Frazzini and Pedersen (2013). "Betting Against Beta."

G. Illiquidity

i. Amihud Illiquidity: One-year average of abs(daily return)/Volume USD

ii. Relevant paper: Amihud (2002). "Illiquidity and Stock Returns: Cross-Section and Time-Series Effects."

4) Selection Procedure

A. Big and Small determination

i. US: Big stocks are those above the median NYSE market cap as of the end of June (for annually rebalanced factors) or the end of the month (for monthly rebalanced factors). Small stocks are those below the respective medians.

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ii. Developed and EM: Big stocks are those in the top 90% of cumulative market cap as of the end of June (for annually rebalanced factors) or the end of the month (for monthly rebalanced factors). Small stocks are those in the respective remaining 10%.

B. Long and Short determination

i. US: Long stocks are those whose variable is in the top 30% of NYSE stocks. Short stocks are those whose variable is in the bottom 70% of NYSE stocks.

ii. Developed and EM: Long stocks are those whose variable is in the top 30% of big stocks within the stock's sub-region. Short stocks are those whose variable is in the bottom 70% of big stocks within the stock's sub-region.

iii. Exception: Illiquidity, where selection is determined independently within Big and Small.

C. Stocks are placed into four portfolios: Big Long, Big Short, Small Long, Small Short

5) Weighting Scheme

*A. Each portfolio is weighted by market cap * free float.*

6) Factor Return calculation

A. Big Factor = Big Long return minus Big Short return.

B. Small Factor = Small Long return minus Small Short return.

Disclaimer

All data presented on the Smart Beta Interactive website is based on simulated portfolios computed by Research Affiliates LLC ("RA") using data from CRSP, Compustat, Worldscope, Datastream, and Bloomberg. The portfolios shown do not represent the results of live, investable portfolios, and this content is not investment or tax advice or an offer, sale or any solicitation of any offer to buy any security, derivative or any other financial instrument. All expected return forecasts are forward-looking statements based upon quantitative models developed by Research Affiliates LLC and is not a guarantee of future performance. All past returns of the strategies and factors are not a guarantee of future performance. All transaction cost estimates are based upon quantitative models developed by RA and could differ from actual experienced transaction costs in the future. All volatility, beta, and tracking error expectations are based upon an exponential decay-weighted estimation of recent volatility, beta, and tracking error and are not a guarantee of future volatility, beta, or tracking error.

Expected return forecasts come with multiple sources of uncertainty. The expected returns model used on this site estimates higher expected returns when the strategy or factor is valued below its historical norm and vice versa. However, cheap strategies can always get cheaper, resulting in poor returns when this site projects high returns. Expensive strategies can always get more expensive, resulting in high returns when this site projects poor returns. The choice of expected returns model itself is also a source of uncertainty. Model parameters were estimated using a finite amount of data and are therefore subject to estimation error. Model specification choices such as when and how to shrink parameter estimates could result in different expected return outputs than are generated by the model used here.

The data sources (CRSP, Compustat, Worldscope, Datastream, and Bloomberg) used to construct and evaluate portfolios may contain multiple errors. These errors may bias up or down performance of certain strategies or factors compared to what an actual investor would have been able to achieve in the real market. Further, the simulation results ignore management fees, costs of shorting and other potentially very important elements which may make the live portfolio outcome different from the theoretically simulated portfolio. Smart beta or factor tilt investing strategies are subject to all the risks common to equity investing such as loss of capital. They are also subject to risks that are unique to smart beta investing. The choice of which factor or factors to tilt toward or away from can result in strategies that either beat or lag the market. The factors chosen for study by academics and the strategies chosen for investment allocation by practitioners are typically noticed after periods of good performance. This has at least two consequences: 1) investors are likely to overestimate the performance that a given strategy can provide over the long term and 2) good recent performers are likely to be expensive and to mean-revert to cheaper valuations, causing poor future performance. Past 5-year historical data is included on this site not as an indication of what to expect going forward, but to provide contrast with expected returns which are based on valuations and will often be inversely related to prior 5-year performance.

Equity factors themselves, constructed on this site as long/short portfolios are often not implementable and not offered as investable equity products. Nevertheless, there are risks associated with individual equity factors that are also borne by investments that tilt their holdings toward these factors. Investing in factors can subject investors to unique risks that include, but are not limited to, the following: Momentum strategies invest in recent winners that tend to continue outperforming, however when the market changes direction momentum investors are subject to a quick burst of severe underperformance known as a momentum crash. Low beta or low volatility strategies have lower absolute risk than the market, but typically come at the cost of higher relative risk and low vol strategies tend to have higher tracking error, which represents the risk that the strategy deviates from the market for extended periods of time. Value strategies often have prolonged periods of underperformance sometimes followed by quick bursts of outperformance. Value investors who reduce their value exposure following periods of value underperformance run the risk of mistiming their exposure and missing out on the periods when the value factor recovers. The profitability factor often invests in more expensive companies and high corporate profits can mean revert to lower profits in the future due to increase in competition or decrease in barriers to entry. Investing in profitable companies at any cost runs the risk of overpaying for expected future profits. The illiquidity factor earns a premium by providing liquidity but leaves illiquidity-tilted investors prone to liquidity shocks that could lead to high costs of exiting the position. The investment factor tilts toward companies with lower asset growth which could run the risk of missing out on potential growth opportunities. Tilting toward the size factor by investing in small cap stocks can provide diversification away from large caps, but often comes with higher portfolio volatility, potentially lower liquidity, and higher transaction costs.

The methodologies displayed are based upon our interpretation of the publicly available information regarding several cited indices and because all details about the construction of these mentioned indices are not publicly available, there are differences between those mentioned indices and our interpretation and application of these indices. In addition to factors – theoretical, generally hard to replicate long-short portfolios – we estimate expected risk/return characteristics for a collection of the more popular smart beta strategies. In order to produce forecasts we replicated the strategies using the published methodologies of the underlying indices. Any replication exercise is subject to deviation from the original due, in part, to differences in databases, rebalancing dates, interpretations of the written methodologies, and omitted details in the methodology description – our replication is no exception. The results of the replicated exercise albeit imprecise should be informative of the underlying strategies.

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