U.S. MACROECONOMIC
Equity Risk Model

IDENTIFY

ANALYZE

QUANTIFY
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The Northfield Macroeconomic US Equity Risk Model is a tool to forecast one year volatility and understand and manage macroeconomic risks in diversified US equity portfolios. Additionally, the model can be paired with a portfolio optimizer, for example the Northfield Open Optimizer, to build risk/return optimized portfolios or to tilt portfolios to take advantage of one’s beliefs about changes in the model’s seven macroeconomic variables.

The model is based on Arbitrage Pricing Theory (APT), which is an extension of the Capital Asset Pricing Model (CAPM). CAPM relates a security’s return to the market return; APT relates a security’s return to a set of macroeconomic factors. In the Northfield macroeconomic model, a stock is first modeled using seven aspects of the general economy. To capture behavior unexplained by the macroeconomic factors, five statistical (statistically inferred) factors are added as a second step.

It is structured to achieve accuracy and clarity in analyzing diversified portfolios. Within the structure, accuracy at the individual security level is a priority, one reason being that portfolio optimization weights securities based on their forecasts.

The model covers roughly 5000 securities. Economic indicators are from Barron’s; returns, capitalizations, and other data are from Thomson Reuters. The model is updated monthly.

Securities are covered within one month. Bayesian estimation (described below) eliminates the need for history. Securities without return history are assumed to have the median exposure and 75th percentile stock-specific risk of similar securities. As information becomes available, the estimate balances the prior and the information based on the quantity and quality of information, just as it does for securities having a complete return history.

Each security’s return is explained by 12 factors. Exposures to the factors are inferred via three stepwise regressions:

1. The four macroeconomic factors described in Chen, Roll, and Ross¹ - unexpected inflation, industrial production, credit risk premium, slope of the term structure. The intention was to preserve the results of the original research.

2. Three macroeconomic factors added to the basic model by Northfield - oil prices, housing starts, exchange value of the USD.

3. Five statistical factors to pick up behavior not captured by the macroeconomic factors.

Statistical factors are not pre-specified and come directly from the returns unexplained by the other factors. They pick up pervasive risks that are often transient, hence falling outside of any fixed factor set, and automatically adapt the model to dynamic market phenomena. Since statistical factors are dynamic, they are not easily labeled. A statistical factor in one market or period doesn’t necessarily correspond to the same in another. In this model,

### The Factors

- **Unexpected Inflation**: The change in inflation net of the change in the risk free rate.
  
  \[
  \text{Inflation}_t = \left( \frac{\text{CPI}_t}{\text{CPI}_{t-1}} - 1 \right) \times 100 \times 12
  \]

  \[
  \text{UI Factor}_t = \left( \text{Inflation}_t - \text{Inflation}_{t-1} \right) - \left( \text{TBYield}_{t-1} - \text{TBYield}_{t-2} \right)
  \]

- **Industrial Production**: The percentage change in the industrial production index published by the Federal Reserve Board. The index is periodically re-indexed to a new base; Northfield is careful to use figures that are comparable.
  
  \[
  \text{IP Factor}_t = \left( \frac{\text{IPIndex}_t}{\text{IPIndex}_{t-1}} - 1 \right) \times 100
  \]

- **Credit Risk Premium**: The change in the spread between the yields on Moody’s BBB Corporate Bond Index and Moody’s AAA Corporate Bond Index.
  
  \[
  \text{CRP Factor}_t = (\text{BBB} - \text{AAA})_t - (\text{BBB} - \text{AAA})_{t-1}
  \]

- **Slope of the Term Structure**: The change in the spread between the yield-to-maturity of the 20-year U.S Treasury bond and the bond-equivalent yield of the one-year Treasury bill.
  
  If more than one issue of the 20-year bond are trading, the issue nearest par is used.
  
  \[
  \text{STS Factor}_t = (\text{20YrYld}_t - \text{1YrYld}_{t-1}) - (\text{20YrYld}_{t-1} - \text{1YrYld}_{t-1})
  \]

- **Oil Prices**: The percentage change in the settlement price of the (closest to expiration) futures contract for crude oil on the New York Mercantile Exchange.
  
  \[
  \text{OP Factor}_t = \left( \frac{\text{OilPrice}_t}{\text{OilPrice}_{t-1}} - 1 \right) \times 100
  \]

- **Housing Starts**: The percentage change in the number of new housing starts.
  
  \[
  \text{HS Factor}_t = \left( \frac{\text{HousingStarts}_t}{\text{HousingStarts}_{t-1}} - 1 \right) \times 100
  \]
<table>
<thead>
<tr>
<th><strong>US Macroeconomic Equity Risk Model</strong></th>
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<tbody>
<tr>
<td><strong>Exchange Value of the USD</strong></td>
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<tr>
<td>The percentage change in the strength of the USD as measured by the index underlying the New York Futures Exchange U.S. Dollar futures contract.</td>
</tr>
<tr>
<td>( \text{EVUSD Factor}_t = (\text{USDIndex}<em>t / \text{USDIndex}</em>{t-1} - 1) \times 100 )</td>
</tr>
<tr>
<td><strong>Statistical Factors</strong></td>
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<tr>
<td>Principal components inferred from all securities’ returns stripped of the other factors. Security returns are weighted by square root of cap after being normalized to unit variance; period weights are exponentially decayed. The first factor is labeled Residual Market and scaled so the average exposure is 1. The other factors are labeled Statistical Factor 2..5 and scaled so the cross-sectional spread of exposures is one, i.e. their exposures can be interpreted as Z-scores.</td>
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<tr>
<td><strong>Model Estimation</strong></td>
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<tr>
<td><strong>Exposures</strong></td>
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<tr>
<td>Security exposures to the factors are estimated via Bayesian regression(^2). Observation weights exponentially decay with age. The decay rate varies by country, with emerging markets decaying faster than developed. Faster decay rates emphasize recent behavior.</td>
</tr>
<tr>
<td><strong>Bayesian Inference</strong></td>
</tr>
<tr>
<td>Bayesian inference combines observations with prior beliefs(^3) – e.g. alike securities tend to behave similarly. It raises the accuracy of individual forecasts and, by softening extremes, improves the out-of-sample performance of optimized portfolios.</td>
</tr>
<tr>
<td><strong>Stepwise Regression</strong></td>
</tr>
<tr>
<td>Each regression step is run on the unexplained return remaining after the preceding step. Thus, earlier steps explain more variance than later steps.</td>
</tr>
<tr>
<td>The order guides how to interpret exposures. For example, exposure to oil is estimated in the second stepwise regression, so the factor explains return net of unexpected inflation, industrial production, credit risk premium, and slope of the term structure. If earlier step exposures change from the previous month, later step exposures will change and may reverse sign.</td>
</tr>
<tr>
<td><strong>Factor Covariance</strong></td>
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<tr>
<td>Forecast variance of a factor is estimated as the variance of the past 60 months of factor returns, with observations exponentially decay weighted. The decay rate is the slowest of the decay rates used to infer exposures, i.e. the decay rate of the most developed markets.</td>
</tr>
<tr>
<td><strong>Robust Correlation</strong></td>
</tr>
<tr>
<td>To stabilize against outliers, correlation between factors is estimated as the Spearman rank correlation between the factor returns, with observations exponentially decay weighted.</td>
</tr>
<tr>
<td><strong>Parkinson Volatility</strong></td>
</tr>
<tr>
<td>Parkinson(^4) estimates volatility from intra-period high and low prices. For securities with the data available, it provides a second estimate. (The first is</td>
</tr>
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\(^2\) Prior and regression errors are Gaussian. Bayesian median regression (double exponential prior and regression errors) was tried but performed worse in out of sample tests.  

\(^3\) A security’s prior comes from its industry membership  

Believing it wise to consider flags suggested by intra-period behavior, Northfield conservatively combines the two sources: if the Parkinson is higher, a security’s specific risk is increased to make up the difference.

As each expansion or improvement of the model has taken place, history dating back monthly to 1994 - has been rebuilt to embody the change.

The Northfield US Macroeconomic Model is a sophisticated quantitative tool to help investment professionals understand and manage macroeconomic risks in their US equity portfolios. The factors combine comprehensible insight and predictive power. As a final step to capture transient effects which cannot be articulated by any static model, statistical factors are included. Developed through rigorous research, it is a powerful tool in portfolio management. Northfield is committed to making certain that clients are fully satisfied with our products.

Separate versions of the model are available identifying securities by SEDOL, CUSIP, or ticker.

The model contains securities having unit exposure to each of the factors:

* IN Unexpected Inflation
* IP Industrial Production
* RP Credit Risk Premium
* SL Slope Term Structure
* OP Oil Price
* HS Housing Starts
* EX Exchange Value of the USD
* RM Residual Market
* BF2 Statistical Factor 2
* BF3 Statistical Factor 3
* BF4 Statistical Factor 4
* BF5 Statistical Factor 5

A cap-weighted portfolio of all securities in the model is identified by ‘*UNIV’

A cap-weighted portfolio of securities in each industry is identified by ‘*I’ followed by the industry number, e.g. *I10 for industry 10