Regimes, Risk Factors, and Asset Allocation

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- We provide a full spectrum of proprietary investor behavior indicators, risk indices, inflation series, and advisory research services.

- Our research agenda is rooted in financial theory, yet recognizes that theory must bend to real-world complexities.

**Advisory Research**
Bespoke analysis on the macro issues of investment management to help our clients manage risk, formulate strategies, and optimize performance.

**Indicators**
Proprietary measures of investor behavior across equities and fixed income, daily country inflation series, and indices to monitor tail risk.

**Publications**
A range of daily and monthly reports to monitor trends in our indicators and provide market context.
Overview

• The increasing liquidity and integration of global financial markets in recent decades has made it more challenging than ever to construct diversified portfolios that deliver an acceptable level of return.

• The global financial crisis of 2008 and 2009 provided a stark and costly reminder that diversification often disappears when we need it most. It also stimulated many investors to take a fresh look at their asset allocation processes and their reliance on MPT in particular.

• The Risk Parity framework has emerged as perhaps the most prominent alternative to traditional MPT. While we commend its focus on risk and diversification, we argue that Risk Parity suffers from some significant drawbacks. Notably, it is unclear whether the factors that drove its past performance will persist going forward.

• Risk factor analysis has also gained visibility over the past several years. Risk factor analysis cannot change the fundamental opportunity set facing investors. However, it is a powerful tool that can improve our ability to understand and communicate the inherent risks of investing. It should be an integral component of the asset allocation process.

• We present several innovations in MPT and demonstrate how they can be applied. These innovations enable investors to incorporate multiple dimensions of risk, non-normal return distributions, asymmetric preferences, within-horizon loss considerations, and regime-specific assumptions into the asset allocation framework.
Factor analysis and risk parity
Risk Parity

- Risk Parity calls for investors to allocate their portfolios such that each asset class has an equal contribution to portfolio volatility. This calculation does not require estimates of expected returns – only volatilities and correlations.
- Risk Parity portfolios almost always allocate more dollars to bonds than to equities, and hence offer lower expected returns than most institutions require.
- However, proponents argue that Risk Parity portfolios are better diversified than equity-heavy portfolios and will therefore generate higher Sharpe ratios.
Risk Parity and the efficient frontier

*This stylized illustration assumes that for stocks and bonds, respectively, expected returns are 9% and 6%, standard deviations are 20% and 5%, and correlation is zero.*
Critiques of Risk Parity

• Inker (2011) questions whether the levered risk premia that have fueled the strong backtest performance of Risk Parity portfolios will persist in the future.

• Chaves, Hsu, Li, and Shakernia (2011) present evidence that the performance of Risk Parity strategies depends heavily on the time period and the asset classes that are included in the portfolio.

• Bhansali (2011) argues that investors would be better off diversifying their exposures across risk factors than asset classes. The author suggests that macroeconomic forecasts can be mapped easily to risk factors, whereas the mapping to asset classes (which are “complex baskets of risk factors”) is obscured.

• Numerous authors underscore that the inherent leverage in Risk Parity portfolios presents operational and liquidity challenges for many investors.
Risk factor analysis

• The objective of risk factor analysis is to identify the underlying investment risks that describe the return variation in a particular portfolio or asset.

• Extensive academic literature suggests that certain factors (such as size and value in the equity markets) are associated with long-term risk premia.

• Bhansali (2011) finds that four or five underlying risk factors can explain approximately 70% of the variation in most liquid assets.

• Ang (2010) provides an intuitive analogy to describe the relationship between risk factors and investments. He suggests that:

  Factor risk is reflected in different assets just as nutrients are obtained by eating different foods. Peas, wheat, and rice all have fiber. Similarly, certain sovereign bonds, corporate bonds, equities, and credit default swap derivatives all have exposure to credit risk. Assets are bundles of different types of factors just as foods contain different combinations of nutrients.
Innovations in Modern Portfolio Theory
Expanding MPT to incorporate:

1. **Multiple dimensions of risk.** The risk of loss is important, but other risks matter too. There are consequences of being “wrong and alone”.

2. **Non-normal return distributions.** Recent (and not-so-recent) evidence indicates that investors cannot ignore fat tails and skewed correlation profiles.

3. **Asymmetric investor preferences.** The Pension Protection Act of 2006 imposes meaningful consequences for plan sponsors whose funding ratios fall below a particular threshold.

4. **Within-horizon losses.** In the real world – where liquidity requirements and government regulations abound – interim risk matters.

5. **Regime-specific assumptions for return and risk.** Investors who rely on long-run historical averages to build their return and risk forecasts will be lulled into a false sense of security.
A digression on “sigma”

- A “1-sigma” event is a one standard deviation move, a “2-sigma” event is a two standard move, and so forth.

- When investors describe events using sigma, they are implicitly assuming that returns follow a normal, “bell curve” distribution.

- On average, we would expect:
  - a 1-sigma event to occur on 1 trading day out of 8,
  - a 2-sigma event to occur on 1 trading day out of 44, and
  - a 3-sigma event to occur on 1 trading day out of 741.

- In the summer of 2007, a high-profile hedge fund announced that it had experienced two 25-sigma events in a row.
How often would you expect a 7-sigma event to occur?

A. Approximately 1 trading day in 300 years
B. Approximately 1 trading day in 300,000 years
C. Approximately 1 trading day in 3,000,000 years
D. Approximately 1 trading day in 3,000,000,000 years

Putting N-sigma events in perspective

• “A 5-sigma event corresponds to an expected occurrence of less than just one day in the entire period since the end of the last Ice Age,” or approximately 1 day every 14,000 years.

• “A 7-sigma event corresponds to an expected occurrence of just once in a period approximately five times the length of time that has elapsed since multi-cellular life first evolved on this planet,” or approximately 1 day every 3 billion years.

• An 8-sigma event corresponds to an expected occurrence of once in “a period that is considerably longer than the entire period since the Big Bang.”

• “The probability of a 25-sigma event is comparable to the probability of winning the lottery 21 or 22 times in a row.”

Full-Scale Optimization

- Full-Scale Optimization (FSO) is a numerical portfolio construction technique that relies on genetic search algorithms to maximize utility based on an investor’s unique preferences.

- A kinked utility function controls for the probability that portfolio losses will exceed a particular threshold.

- FSO implicitly takes every feature of the distribution (fat tails, skewness, correlation asymmetries) into account.

- Like standard mean-variance optimization, FSO can generate concentrated and intractable allocations. A full-scale analog of Mean-Variance-Tracking Error optimization is more well behaved.
Full-Scale Optimization with multiple risks
Our approach in practice: a simple case study
# Asset classes*

<table>
<thead>
<tr>
<th>Asset class</th>
<th>Index</th>
<th>Start date</th>
</tr>
</thead>
<tbody>
<tr>
<td>US equities</td>
<td>S&amp;P 500 Composite</td>
<td>January 1970</td>
</tr>
<tr>
<td>International equities</td>
<td>MSCI World ex US Index</td>
<td>January 1970</td>
</tr>
<tr>
<td>Emerging equities</td>
<td>MSCI Emerging Markets</td>
<td>January 1988</td>
</tr>
<tr>
<td>US government bonds</td>
<td>Barclays Long Treasuries Index</td>
<td>January 1973</td>
</tr>
<tr>
<td>US corporate bonds</td>
<td>Barclays Long Credit Index</td>
<td>January 1973</td>
</tr>
<tr>
<td>High yield bonds</td>
<td>Barclays US HY Composite</td>
<td>July 1983</td>
</tr>
<tr>
<td>Inflation-linked bonds</td>
<td>Barclays US TIPS Index</td>
<td>March 1997</td>
</tr>
<tr>
<td>Commodities</td>
<td>S&amp;P GSCI Total Return Index</td>
<td>January 1970</td>
</tr>
<tr>
<td>Real estate</td>
<td>NCREIF Property Index</td>
<td>December 1977</td>
</tr>
<tr>
<td>Private equity</td>
<td>Cambridge Associates PE Index</td>
<td>March 1986</td>
</tr>
</tbody>
</table>

*All asset class data is monthly with the exception of real estate and private equity which are quarterly.*
# Risk factors

<table>
<thead>
<tr>
<th>Factor</th>
<th>Description</th>
<th>Details</th>
<th>Start date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equity premium</td>
<td>MSCI World minus Barcap Long Treasuries</td>
<td>Total return spread</td>
<td>February 1973</td>
</tr>
<tr>
<td>EM premium</td>
<td>MSCI Emerging Markets minus MSCI World</td>
<td>Total return spread</td>
<td>January 1988</td>
</tr>
<tr>
<td>Interest rates</td>
<td>10-year constant maturity treasury yield (FRED)</td>
<td>Average daily yield; first differences</td>
<td>February 1973</td>
</tr>
<tr>
<td>Term premium</td>
<td>10-year constant maturity yield minus 2-year (FRED)</td>
<td>Average daily yield; first differences</td>
<td>July 1976</td>
</tr>
<tr>
<td>Credit spread</td>
<td>Barcap Long Credit minus Barcap Long Treasuries</td>
<td>End of period spread; first differences</td>
<td>February 1973</td>
</tr>
<tr>
<td>Breakeven inflation</td>
<td>10-year constant maturity yield minus 10-year TIPS</td>
<td>End of period spread; first differences</td>
<td>February 1997</td>
</tr>
<tr>
<td>Currency</td>
<td>DXY dollar index (U.S. dollar versus a currency basket)</td>
<td>Price return</td>
<td>February 1973</td>
</tr>
<tr>
<td>Oil</td>
<td>West Texas Intermediate spot price</td>
<td>Price return</td>
<td>June 1983</td>
</tr>
<tr>
<td>Gold</td>
<td>Gold Bullion LBM $/Troy Ounce</td>
<td>Price return</td>
<td>February 1973</td>
</tr>
</tbody>
</table>
Five-asset portfolio

Asset Allocation (%)

- US equities: 40%
- International equities: 20%
- US government bonds: 20%
- US corporate bonds: 13%
- Commodities: 7%
Five-asset portfolio: risk factor exposures through time
April 1973 – December 2010
Five-asset portfolio: optimal allocations
April 1973 – March 2011

Expected returns: US Equity 8%, International Equity 9%, US Govt Bonds 4%, US Corp Bonds 5%, Commodities 5%
Five-asset portfolio: correlation profiles

US Equity and Commodities

Intl Equity and Commodities

Corp Bonds and Commodities
Five-asset portfolio: correlation asymmetries

Excess Downside Correlation Minus Excess Upside Correlation

- Commodities vs. US Equity: 82.7%
- Commodities vs. US Corp. Bonds: 63.0%
- US Corp. Bonds vs. International Equity: 58.9%
- Commodities vs. International Equity: 30.0%
- International Equity vs. US Equity: 17.2%
- US Corp. Bonds vs. US Equity: 2.1%
- US Govt. Bonds vs. US Equity: -2.3%
- US Corp. Bonds vs. US Govt. Bonds: -5.1%
- Commodities vs. US Govt. Bonds: -15.3%
- US Govt. Bonds vs. International Equity: -16.7%
Event-sensitive portfolio methodology

1. By selecting return observations (months) randomly without replacement from the historical data, construct a training sample and a testing sample of equal size.

2. Within the training sample, identify an inflationary subsample by comparing each period’s inflation rate with a threshold.

3. Using the full training sample, derive an unconditional optimal portfolio that is expected to be optimal in all market conditions, inflationary or otherwise.

4. Using the inflationary subsample combined with information from the full training sample, derive a conditioned optimal portfolio for withstanding inflation.

5. Evaluate the performance of the unconditioned and the conditioned optimal portfolios, using both the full testing sample and its inflationary subsample, which we identify using the same threshold as in step two.

6. Repeat the previous five steps 1,000 times and report the average performance of the conditioned and unconditioned portfolios in the out-of-sample testing data.

See: Kritzman and Li (2010), Cremers, Kritzman and Page (2005)
Event-sensitive portfolio methodology

randomly split historical data in half

portfolio construction sample

performance testing sample

construct optimal unconditioned portfolio

construct event-conditioned portfolio

high  low  high  low

…and repeat many times
Sample results: inflation

Optimal weights:
Conditioned minus unconditioned

Out of sample performance:
Return-to-risk ratio

*Results cover July 1983 through March 2011. Multi-risk Full-Scale Optimization imposes absolute and relative kinks at -2% and left slopes of 10. We use the 80th percentile next-month inflation rate to partition the samples. Results are averages for 1,000 runs. Expected returns: Domestic equities 8%, International equities 9%, Long government bonds 4%, Short government bonds 3%, Corporate bonds 5%, Inflation-linked bonds 4%, Commodities 5%.

Inflation-linked bonds: 8.9%
Commodities: 6.2%
Short government bonds: 4.3%
Long government bonds: -2.7%
International equity: -3.9%
Domestic corporate bonds: -3.9%
Domestic equity: -8.8%

Full sample
- Unconditioned portfolio: 9.6%
- Conditioned portfolio: 9.3%

Inflationary sample
- Unconditioned portfolio: 8.6%
- Conditioned portfolio: 10.8%
References


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