Risk Based Asset Allocation
June 18, 2013

Wai Lee
Chief Investment Officer and Director of Research
Quantitative Investment Group
Growing Interest and Questions on Risk-Based Approaches

Today’s topics of discussion

“Risk-Based Asset Allocation: A New Answer to an Old Question?” (2011):
- “Magic formula” (Minimum Variance) defies all the rules – Financial Times, September 15, 2008
- Diversify – even to maximize diversification?
- Risk parity outperformed; outperformed what?

Recent advances in better understanding, and more questions, on risk-based portfolios and diversification:
- Risk and weight concentration of some risk-based portfolios
- Bayesian perspectives of risk-based portfolios: Forecast errors management
- Risk anomaly: Low beta/volatility premium
- Risk classes (factors) vs. Asset classes (factors); is diversification dead, or not?
The Market Portfolio and Benchmark Remain Meaningful

We believe investing in the Market Portfolio manages relative risk, but NOT absolute risk

Perold (2007): All portfolios that differ from the market cap-weighted portfolio are ACTIVE

The capitalization-weighted equity market portfolio holds a special place in modern-day investing – and for good reason. The capitalization-weighted portfolio offers broad diversification and low transaction costs. Capitalization weighting is also the only strategy that all investors can follow. Because the collective holdings of investors (by definition) aggregate to the market portfolio, for every investor who is underweight a stock, another is overweight that stock and between them, it is at best a zero-sum game. After fees and transaction costs, the average investor who deviates from capitalization weights must underperform the market portfolio.

Our thoughts…

• Not every investor has to follow the market portfolio; but the sum of all portfolios = market portfolio
• Today’s market portfolio is a database that reflects cumulative historical returns and risks of all assets
• If history does not repeat exactly, today’s market clearing equilibrium returns will not be the best predictors of future returns
• Some portfolios did, and will, outperform / underperform the Market Portfolio during certain periods
• Just saying “the Market is inefficient” does not make any one other portfolio smarter; the challenge is to find those which will outperform, a.k.a. ACTIVE MANAGEMENT

Market Portfolio = “Smart” Beta + “?”
Outperforming the Market Portfolio **WITHOUT** Forecasting Returns … **REALLY??**

- Portfolios evaluated based on risk-adjusted *returns, Sharpe Ratios*
  - “No return forecasts” in constructing the portfolios; but we all care about portfolio returns
  - Have you seen a bad simulation?
  - Who underperforms if everyone outperforms?

The Old Question: How Can Portfolio Efficiency be Improved?
## The Challengers to Market-Cap Weighted Portfolios

Some alternative “passive” portfolios outperformed market cap-weighted portfolios

<table>
<thead>
<tr>
<th>Alternative Passive Portfolios</th>
<th>Weights Determined by</th>
<th>Considerations</th>
<th>Characteristics</th>
<th>Optimal when all assets have the same</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equally Weighted (EW)</td>
<td>• Equal weights</td>
<td>• Ignores characteristics of assets</td>
<td>Same Wt</td>
<td>• Return</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Can be concentrated in risks: e.g. commodities</td>
<td></td>
<td>• Volatility</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Insensitive to covariance matrix (ignored)</td>
<td></td>
<td>• Correlation</td>
</tr>
<tr>
<td>Global Minimum Variance (GMV)</td>
<td>• Achieving minimum variance</td>
<td>• Fund Separation Theorem: Why not (cash + market)</td>
<td>Same MCTR</td>
<td>• Return</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Highly sensitive to covariance matrix</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Highly concentrated positions and risks are likely</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• High turnover</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Constraints necessary</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Most-Diversified Portfolio (MDP)</td>
<td>• Maximizing the ratio of portfolio of volatility to volatility of portfolio</td>
<td>• Based on one interpretation of “diversification”, not meaningful without an objective function</td>
<td>Same MCTR <em>\frac{MCTR}{\sigma}</em></td>
<td>• Sharpe Ratio, i.e., higher risk ⟷ higher return</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Highly sensitive to covariance matrix</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Highly concentrated positions and risks are likely</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• High turnover</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Constraints necessary</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Risk Parity</td>
<td>• Achieving equal risk contribution</td>
<td>• What assets are included?</td>
<td>Same Wt x MCTR</td>
<td>• Wt x Vol x Sharpe Ratio</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Long only by construction with positions on all assets</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Moderately sensitive to covariance matrix</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Moderate turnover</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note:**

Wt: Weight  
MCTR: Marginal Contribution To Risk  
Vol: Volatility
Example: A Portfolio of 10 US Sectors

Which risk profile do you like better? What do you want from “diversification?”

**The ONLY constraint: No short position allowed**

PORTFOLIO WEIGHTS ACROSS GICS SECTORS

PORTFOLIO CUMULATIVE PERCENTAGE CONTRIBUTION TO RISK

“RP” denotes the risk parity portfolio in which all assets are expected to contribute equal risk; to be discussed later

---

Source: Neuberger Berman Quantitative Investment Group.
Identify ACTIVE Investment Views Behind these Portfolios

Do not jump to join the empirical fancy; be critical but objective

Lee (2011):

• “… we are not aware of any theory that predicts ex ante how any of the risk-based portfolios discussed in this article should perform – outperform or underperform – relative to the market.”
• “… we believe that these risk-based portfolios come with various potential challenges, and most importantly, there is no theory to predict their performance relative to the market.”
• “… we view risk-based approaches as a subset of the modern portfolio theory paradigm rather than as a new paradigm itself.”

Scherer (2011):

• “… the minimization of risk is – on its own – a meaningless objective. The same applies to related concepts that try to maximize “diversity” as in Fernholz et al. (1998) or Choueifaty and Coignard (2006) or to minimize concentration as in King (2007)”

Clarke, de Silva, Thorley (2011):

• “… the emergence of new objective functions specifically designed to exploit the risk anomaly may constitute a subtle form of data mining.”
Many more studies run horse races of these portfolios applied to different universes of assets, sample periods, covariance matrices, and sets of constraints including positions and turnovers; a few, however, focus on the theoretical underpinnings and analytical perspectives.
Select Analytical Perspectives on Weight and Risk Concentration

Weight and risk concentration characteristics of risk-based portfolios are dictated by their construction methodologies

Clarke, de Silva, Thorley (2011)

• Critical variables in determining asset weights and subsequent risk profile:
  − “Threshold Beta” for Minimum Variance
  − “Threshold Correlation” for Maximum Diversification

• Weights and risk concentration:
  − “… weights in the Minimum Variance portfolio tend to be more concentrated than weights in the Maximum Diversification portfolio, …”
  − Both Minimum Variance and Maximum Diversification are far more concentrated on asset weights than Risk Parity
  − “… all assets have some positive weights so that the Risk Parity portfolio is long-only by definition.”
  − Together with results from Lee (2011) that relates asset weights to the the risk contribution profile, we understand why Minimum Variance and Maximum Diversification are more concentrated both in asset weights and risk contributions than others, and why they often require constraints on weights and turnovers, among others
Bayesian and Utility Perspectives

Kaya and Lee (2012), and Kaya (2012) analyze risk parity from a Bayesian investor’s perspective and introduce utility function maximization

- Kaya and Lee (2012) establishes that a sufficient but not necessary condition for a risk parity portfolio to be mean-variance optimal:
  - Risk-adjusted returns (Sharpe ratios) of, and correlations among, all assets are identical

Management of Forecast Errors

Minimum Variance
- Bayesian shrinkage
  - Expected returns to constant

Risk Parity
- Bayesian shrinkage
  - Risk-adjusted expected returns to constant
  - Correlations to constant

Deviating from Market-cap Weights
- High conviction

Other Optimal Portfolios
Kaya and Lee (2012) Risk Parity May be More Robust to Noise

We believe Risk Parity can mitigate estimation noise

Source: Neuberger Berman's Quantitative Investment Group, Kaya and Lee (2012). For illustrative purposes only.
Risk Anomaly: Low Beta/Volatility Premium

Low risk/beta premium, if it exists, benefits risk-based portfolios but does not make them “optimal”

HYPOTHETICAL SECURITY MARKET LINE

- Clarke, de Silva, Thorley (2011), Kaya and Lee (2012), and Jurczenko, Michel, and Teiletche (2013): risk-based portfolios load on assets with low beta and low idiosyncratic risks to different degrees
- Scherer (2011): “My conjecture is that the portfolio construction process behind minimum variance investing implicitly picks up risk based pricing anomalies. If that is true, minimum variance investing will be a clumsy and indirect process to benefit from. Investor would be better advised to directly decide if, when and to what degree they want to invest into long / short anomaly portfolios on top of a market weighted benchmark.”
- Is low risk premium really there??? Recent studies cast doubt on it:
  - Longstaff (1989): Temporal aggregation of returns can distort the Security Market Line and bring in more factors
  - Trainor (2012): Variance drag in compounding
  - Xu and Zhao (2013): beta instability and reversal of stocks with high betas and idiosyncratic risks confound the results; CAPM is alive
  - Amenc, Goltz, Martellini, Lodh (2013): anomaly disappears with longer investment horizons
Risk Premia Investing for Better Diversification?¹

The New School (Risk Premia) is an unconstrained, linear rotation of the Old School (Assets) with new ingredients: Shorts, Leverage, and Dynamic Trading

**THE OLD SCHOOL: ASSET CLASS DIVERSIFICATION**

<table>
<thead>
<tr>
<th>Asset Portfolio</th>
<th>US Stocks</th>
<th>Non-US Stocks</th>
<th>Global Gov’t</th>
<th>Global Non-Gov’t</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asset Portfolio</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>US Stocks</td>
<td>0.87</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-US Stocks</td>
<td>0.86</td>
<td>0.63</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Global Gov’t</td>
<td>0.32</td>
<td>0.16</td>
<td>0.11</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Global Non-Gov’t</td>
<td>0.48</td>
<td>0.34</td>
<td>0.22</td>
<td>0.87</td>
<td>1.00</td>
</tr>
<tr>
<td>Other</td>
<td>0.83</td>
<td>0.66</td>
<td>0.69</td>
<td>-0.03</td>
<td>0.13</td>
</tr>
</tbody>
</table>

**THE NEW SCHOOL: RISK PREMIA DIVERSIFICATION**

<table>
<thead>
<tr>
<th>Factor Portfolio</th>
<th>Equity</th>
<th>Value</th>
<th>Momentum</th>
<th>Carry</th>
<th>Trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factor Portfolio</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equity</td>
<td>0.65</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Value</td>
<td>0.07</td>
<td>-0.04</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Momentum</td>
<td>0.25</td>
<td>-0.11</td>
<td>-0.53</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Carry</td>
<td>0.53</td>
<td>0.35</td>
<td>0.15</td>
<td>-0.10</td>
<td>1.00</td>
</tr>
<tr>
<td>Trend</td>
<td>0.57</td>
<td>0.00</td>
<td>-0.13</td>
<td>0.28</td>
<td>-0.09</td>
</tr>
</tbody>
</table>

• Long only
• Market-cap weighted portfolios of investable constituents
• Buy-and-Hold

• Mostly dollar neutral long / short portfolios
• Use the identical set of investable constituents in asset classes, with flexibility on weights including gross leverage and shorts
• Dynamic trading

• Any randomly constructed long / short portfolio should have low correlations with long only asset classes
• The key considerations should be:
  – Economic underpinnings behind these “risk premia”
  – How much can you take them, a risk budgeting exercise

¹ The examples on this page are taken from Ilmanen, Antti, and Jared Kizer, “The Death of Diversification Has Been Greatly Exaggerated,” Journal of Portfolio Management, Spring 2012, pp. 15–27.
References


• Jurczenko, Emmanuel, Thierry Michel, and Jerome Teiletche, “Generalized Risk-Based Investing,” working paper, 2013


• Lee, Wai, “Risk-Based Asset Allocation: A New Answer to an Old Question?,” The Journal of Portfolio Management, Summer 2011


• Xu, Yexiao, and Yihua Zhao, “Beta Is Still Useful!” working paper, February 2013
This material is intended as a broad overview of the current style, philosophy and process of Neuberger Berman's Quantitative Investment Group. This material is presented solely for informational purposes and nothing herein constitutes investment, legal, accounting or tax advice, or a recommendation to buy, sell or hold a security. No recommendation or advice is being given as to whether any investment or strategy is suitable for a particular investor. It should not be assumed that any investments in securities, companies, sectors or markets identified and described were or will be profitable. Information is obtained from sources deemed reliable, but there is no representation or warranty as to its accuracy, completeness or reliability. All information is as of the date of this material, unless otherwise noted, and is subject to change without notice. Any views or opinions expressed may not reflect those of the firm as a whole.

Third-party economic or market estimates discussed herein may or may not be realized and no opinion or representation is being given regarding such estimates. Indexes are unmanaged and are not available for direct investment. Investing entails risks, including possible loss of principal. Past performance is no guarantee of future results.

The Neuberger Berman Group is comprised of various wholly owned subsidiaries including but not limited to Neuberger Berman LLC, Neuberger Berman Management LLC, Neuberger Berman Fixed Income LLC, NB Alternative Fund Management LLC, NB Alternative Investment Management LLC, NB Alternatives GP Holdings LLC and NB Alternatives Advisers LLC. “Neuberger Berman” and “NB Alternatives” are marketing names used by Neuberger Berman Group and its subsidiaries. The specific investment adviser for a particular product or service is identified in the product offering materials and or applicable investment advisory agreement.

©2013 NB Alternative Fund Management LLC. All rights reserved