Risk Parity: Theory and Practice

Edward Qian, PhD, CFA
PanAgora Asset Management

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A short history of Risk Parity

» The present: Google searching “Risk Parity” yields 11 million hits

» The past
  » 1990s: Risk budgeting
  » 2005: the term Risk Parity christened
  » 2008: GFC – general acceptance of Risk Parity

» The future is here
  » Risk Parity applied to every investments
  » A portfolio construction tool to achieve true diversification
Introduction

Outline

» Risk Disparity: traditional portfolios and indices

» Risk Non-parity: trouble with incorrect interpretation

» Risk Parity: “smart” beta
Eggs (or 95% of it) in one basket
Lack of diversification (asset allocation)

Traditional “balanced” asset allocation

- Equity or equity-like assets contribute 95% of risk
Risk Disparity

Risk contribution

» Assumptions: stock volatility 15%, bond volatility 5%, no correlation

» Total risk is

$$\sqrt{(0.6 \times 15\%)^2 + (0.4 \times 5\%)^2} = 9.2\%$$

» Risk contributions are

- Stock

$$\frac{(0.6 \times 15\%)^2}{(0.6 \times 15\%)^2 + (0.4 \times 5\%)^2} \approx 95\%$$

- Bond

$$\frac{(0.4 \times 5\%)^2}{(0.6 \times 15\%)^2 + (0.4 \times 5\%)^2} \approx 5\%$$
Definition of risk contribution

» Marginal contribution: \( \frac{\partial \sigma}{\partial w_i}, i = 1, \ldots, N \)

» Risk contribution: \( w_i \frac{\partial \sigma}{\partial w_i}, i = 1, \ldots, N \)

» Then

\[
\sum_{i=1}^{N} w_i \frac{\partial \sigma}{\partial w_i} = \sigma, \quad \text{or} \quad \sum_{i=1}^{N} \frac{w_i \frac{\partial \sigma}{\partial w_i}}{\sigma} = 100\%
\]

» It works both ways

» It also applies to other linear risk measures such as VaR

» Financial interpretation as loss contribution
Lack of diversification (equity)

Capitalization weighted index: MSCI world Index

- Country bias in risk contribution

US has the highest risk contribution
Lack of diversification (bond)

» Capitalization weighted index: WGBI (World Government Bond)

• Country bias in risk contribution

US has the highest risk contribution

Japan is the second
Lack of diversification (commodity)

» Production weighted index: GSCI (Goldman Sachs Commodity)

• Sector bias in risk contribution

Energy sector combined has 95% of risk
Lack of diversification (stock indices)

» Capitalization weighted index: S&P 500

• Stock bias risk in contribution

Top 50 stocks contribute close to 50% of risk

Bottom 250 stocks contribute only 14% of risk
Risk Disparity

Lack of diversification (sector)

» Another view in terms of sector risk allocation
Why invest with such risk concentration?

» Asset allocation: required return from equity investments

» Capitalization-weighted indices: an investing paradigm
Risk Disparity

The painful consequences

» Unintended risk concentrations in asset/country/sector/stock

» Volatile returns, sensitivity to macro environment, low Sharpe ratios

» The reason why hedge funds look attractive!
Not all Risk Parity are created equal.

Injury risk, parity could prevent Chip Kelly's schemes from succeeding in NFL
Equal risk contribution

» Assumptions: stock volatility 15%, bond volatility 5%

» Then equal risk contribution portfolio is 25%/75% in stock/bond

» Risk contributions are

- Stock
  \[
  \frac{(0.25 \times 15\%)^2}{(0.25 \times 15\%)^2 + (0.75 \times 5\%)^2} = 50\%
  \]

- Bond
  \[
  \frac{(0.75 \times 5\%)^2}{(0.25 \times 15\%)^2 + (0.75 \times 5\%)^2} = 50\%
  \]
Equal risk allocation is not necessarily Risk Parity

- Asset class $1/n$ leads to Risk Non-parity

- Asset category $1/n$ leads to Risk Non-parity
  - 4 equity asset classes plus High Yield, EM Debt, Corporate Bonds, Government Bonds

- The fallacy of $1/n$
Are Risk Parity managers Risk Parity*?

» Research study based on 7 Risk Parity managers: A, B, C, D, E, F, G
  » Style analysis based on 36 month returns from Evestment database
  » Derive risk allocation from the style weights
  » Classify risk allocation to 1) equity risk 2) interest rate risk 3) inflation risk

*To be published in the *Journal of Portfolio Management*
Why three risk premia?

» The short answer: only these three are “independent”

» The long answer

  » Asset allocation portfolios are exposed to growth risk and inflation risk
  » To hedge growth risk, balance risk allocation to equity and interest rate
  » To hedge inflation risk, balance risk allocation to nominal assets (equity & interest rate) and real assets (inflation linked bonds & commodities)

» Hybrid asset classes (HY, EMD, Credit, TIPS) are mostly combinations of the three primary risk premia
Risk Non-parity

The three risk premia
## Risk Non-parity

### Style weights from style analysis

<table>
<thead>
<tr>
<th>Commodity</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
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</thead>
<tbody>
<tr>
<td>DJUBS</td>
<td>18%</td>
<td>7%</td>
<td>15%</td>
<td>25%</td>
<td>21%</td>
<td>13%</td>
<td>17%</td>
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<tr>
<td>BarCap US Treasury</td>
<td>0%</td>
<td>43%</td>
<td>66%</td>
<td>38%</td>
<td>65%</td>
<td>17%</td>
<td>0%</td>
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<tr>
<td>WGBI x US</td>
<td>87%</td>
<td>93%</td>
<td>57%</td>
<td>93%</td>
<td>52%</td>
<td>9%</td>
<td>74%</td>
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<tr>
<td>BarCap MBS</td>
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<td>0%</td>
<td>0%</td>
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<td>0%</td>
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<td>7%</td>
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<tr>
<td>Citi US TIP</td>
<td>57%</td>
<td>79%</td>
<td>46%</td>
<td>29%</td>
<td>55%</td>
<td>50%</td>
<td>37%</td>
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<tr>
<td>BarCap Credit</td>
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<td>18%</td>
<td>7%</td>
<td>0%</td>
<td>0%</td>
<td>15%</td>
<td>0%</td>
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<tr>
<td>Citi EM Debt</td>
<td>0%</td>
<td>7%</td>
<td>0%</td>
<td>1%</td>
<td>0%</td>
<td>0%</td>
<td>14%</td>
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<tr>
<td>BarCap US High Yield</td>
<td>1%</td>
<td>0%</td>
<td>4%</td>
<td>0%</td>
<td>0%</td>
<td>8%</td>
<td>32%</td>
</tr>
<tr>
<td>S&amp;P 500</td>
<td>0%</td>
<td>0%</td>
<td>8%</td>
<td>15%</td>
<td>4%</td>
<td>37%</td>
<td>2%</td>
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<tr>
<td>MSCI x US</td>
<td>22%</td>
<td>11%</td>
<td>3%</td>
<td>0%</td>
<td>28%</td>
<td>19%</td>
<td>19%</td>
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<tr>
<td>Russell 2000</td>
<td>13%</td>
<td>9%</td>
<td>15%</td>
<td>5%</td>
<td>8%</td>
<td>0%</td>
<td>15%</td>
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<tr>
<td>MSCI EM</td>
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<td>2%</td>
<td>5%</td>
<td>0%</td>
<td>0%</td>
<td>1%</td>
<td>9%</td>
</tr>
<tr>
<td>Leverage</td>
<td>228%</td>
<td>269%</td>
<td>226%</td>
<td>205%</td>
<td>232%</td>
<td>188%</td>
<td>225%</td>
</tr>
<tr>
<td>R-squared</td>
<td>92%</td>
<td>94%</td>
<td>95%</td>
<td>82%</td>
<td>89%</td>
<td>96%</td>
<td>96%</td>
</tr>
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</table>
## All look Risk Parity?

<table>
<thead>
<tr>
<th></th>
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<th>F</th>
<th>G</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Commodities</strong></td>
<td>18%</td>
<td>7%</td>
<td>15%</td>
<td>25%</td>
<td>21%</td>
<td>13%</td>
<td>17%</td>
</tr>
<tr>
<td><strong>Bonds</strong></td>
<td>174%</td>
<td>239%</td>
<td>180%</td>
<td>161%</td>
<td>172%</td>
<td>118%</td>
<td>163%</td>
</tr>
<tr>
<td><strong>Equities</strong></td>
<td>35%</td>
<td>22%</td>
<td>31%</td>
<td>20%</td>
<td>39%</td>
<td>58%</td>
<td>45%</td>
</tr>
<tr>
<td><strong>Leverage</strong></td>
<td>228%</td>
<td>269%</td>
<td>226%</td>
<td>205%</td>
<td>232%</td>
<td>188%</td>
<td>225%</td>
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<td>95%</td>
<td>82%</td>
<td>89%</td>
<td>96%</td>
<td>96%</td>
</tr>
</tbody>
</table>
Risk Non-parity

Risk allocation from style analysis - surprise!
## Risk Non-parity

### Risk allocation to risk on risk off

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<thead>
<tr>
<th></th>
<th>A</th>
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<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Risk on (E &amp; C)</strong></td>
<td>67%</td>
<td>33%</td>
<td>60%</td>
<td>64%</td>
<td>66%</td>
<td><strong>86%</strong></td>
<td><strong>93%</strong></td>
</tr>
<tr>
<td><strong>Risk off (Rate)</strong></td>
<td>33%</td>
<td><strong>67%</strong></td>
<td>40%</td>
<td>36%</td>
<td>34%</td>
<td>14%</td>
<td>7%</td>
</tr>
</tbody>
</table>
Why some managers are not risk parity?

» High notional allocation to bonds and portfolio leverage do not equate to Risk Parity

» Equal risk allocation is not Risk Parity

» Oversized strategic bets to either equity or interest rate are not Risk Parity
It is very hard to know who is “smart” in investing.
Risk Parity as “Smart” Beta

“Smart” or not?

» “Smart” beta
  » Minimum variance
  » Maximum diversification
  » Equal weight
  » Risk Parity

» Not so “smart” beta
  » Capitalization weighted indices
Risk Parity as “Smart” Beta

Why are cap-weighted indices not “smart”?

» Indices are from research of very smart people

» Implied returns of S&P 500 index seem to be “smart”

<table>
<thead>
<tr>
<th></th>
<th>Weight</th>
<th>Exp. Return</th>
<th>Volatility</th>
<th>Sharpe Ratio</th>
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</thead>
<tbody>
<tr>
<td>CSD</td>
<td>10.7%</td>
<td>7.7%</td>
<td>26.5%</td>
<td>0.29</td>
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<tr>
<td>CSS</td>
<td>11.3%</td>
<td>4.7%</td>
<td>17.1%</td>
<td>0.27</td>
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<tr>
<td>ENG</td>
<td>12.4%</td>
<td>7.5%</td>
<td>28.0%</td>
<td>0.27</td>
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<tr>
<td>FIN</td>
<td>14.2%</td>
<td>9.5%</td>
<td>33.0%</td>
<td>0.29</td>
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<tr>
<td>HEA</td>
<td>11.8%</td>
<td>4.9%</td>
<td>18.2%</td>
<td>0.27</td>
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<tr>
<td>IND</td>
<td>10.5%</td>
<td>8.2%</td>
<td>27.6%</td>
<td>0.30</td>
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<tr>
<td>MAT</td>
<td>3.6%</td>
<td>8.9%</td>
<td>31.0%</td>
<td>0.29</td>
</tr>
<tr>
<td>TEC</td>
<td>18.6%</td>
<td>7.0%</td>
<td>24.4%</td>
<td>0.29</td>
</tr>
<tr>
<td>TEL</td>
<td>3.1%</td>
<td>5.1%</td>
<td>20.9%</td>
<td>0.24</td>
</tr>
<tr>
<td>UTL</td>
<td>3.7%</td>
<td>4.2%</td>
<td>18.3%</td>
<td>0.23</td>
</tr>
</tbody>
</table>
All “smart” betas seem somewhat “naïve”
Risk Parity as “Smart” Beta

The value of not knowing

<table>
<thead>
<tr>
<th></th>
<th>RP</th>
<th>CW</th>
<th>EW</th>
<th>MV</th>
<th>MD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excess Return</td>
<td>7.4%</td>
<td>3.7%</td>
<td>4.6%</td>
<td>3.6%</td>
<td>4.7%</td>
</tr>
<tr>
<td>Risk</td>
<td>14.5%</td>
<td>15.8%</td>
<td>17.3%</td>
<td>10.6%</td>
<td>11.7%</td>
</tr>
<tr>
<td>Sharpe Ratio</td>
<td>0.51</td>
<td>0.23</td>
<td>0.27</td>
<td>0.34</td>
<td>0.40</td>
</tr>
</tbody>
</table>
Risk Parity as “Smart” Beta

Risk Parity everywhere

» Multi Asset portfolio allocation

» Equity investments
  » Global/US/International/EM/Sector

» Fixed income investments
  » Government/Credit/Inflation-linked/High Yield

» Commodities

» Factor premia
Conclusion

» Risk Parity provides a tool to build diversified portfolios with fundamental intuition

» Diversification works but conventional investment approach lacks diversification (Risk Disparity)

» Risk Parity is subject to wrong interpretation (Risk Non-parity)

» Risk Parity beta as “smart” beta from top-down to bottom-up