Maximizing Diversification

December 3, 2018

SUMMARY

- Diversification within a portfolio can be quantified using the diversification ratio, which measures how much the volatility is reduced relative to a scenario where all assets are perfectly correlated.
- By maximizing the diversification ratio, we can construct the most diversified portfolio for a given investment universe.
- We construct the most diversified portfolio using data from 1973 and look at the assumptions and conditions for optimality for this method.
- Over our backtest period, we find that this portfolio is generally conservative, yet exhibits significant tracking error relative to a standard stock/bond portfolio.
- While investors are right to desire diversification, pursuing the most diversification possible may be out of line with their objectives.

NEWFOUND RESEARCH

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1. Introduction

Diversification is a common topic in portfolio construction. Rather than serving as the sole, quantifiable objective, it is most often either pursued in tandem with another objective – such as return maximization – or pursued simply by including more asset classes or adding constraints based on intuition (e.g. position size limits).

But it does not have to be this way; diversification can be pursued explicitly as the sole objective in portfolio construction.

In the 2008 paper, Toward Maximum Diversification[1], the diversification ratio, D, of a portfolio, $\boldsymbol{w}$, is defined as:

$$D = \frac{\boldsymbol{w}'\boldsymbol{\sigma}}{\sqrt{\boldsymbol{w}'\boldsymbol{\Sigma}\boldsymbol{w}}}$$

where $\boldsymbol{\sigma}$ is the vector of volatilities and $\boldsymbol{\Sigma}$ is the covariance matrix. The term in the denominator is the volatility of the portfolio and the term in the numerator is the weighted average volatility of the assets. More diversification within a portfolio decreases the denominator and leads to a higher diversification ratio.

The authors propose maximizing this ratio as a portfolio construction technique.

Like all portfolio construction methods, there are a set of assumptions that have a bearing on the results and conditions under which this portfolio will be optimal, and it is beneficial to examine both of these before blindly seeking diversification for diversification's sake.

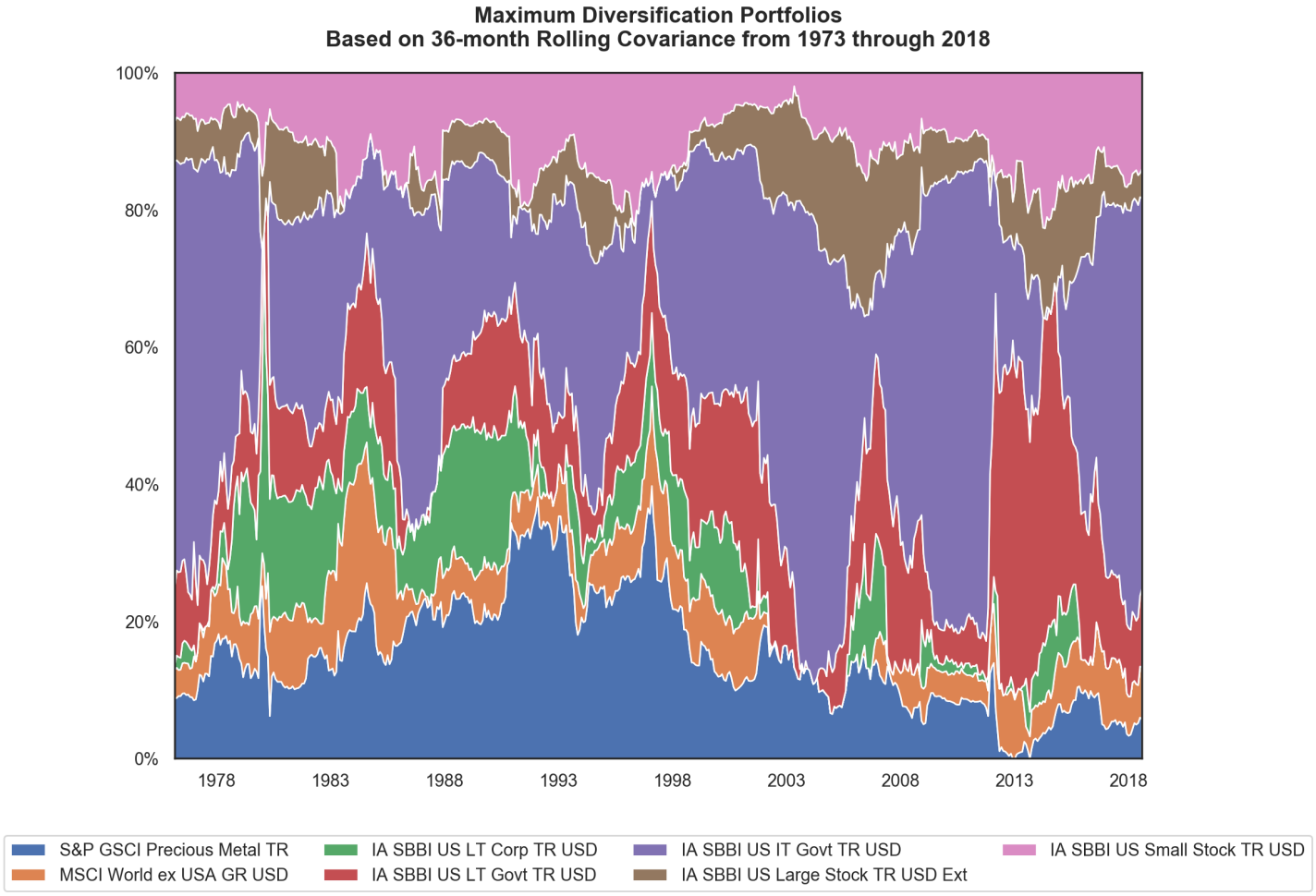
2. Assumptions Behind Maximizing Diversification

According to the portfolio construction flow chart in ReSolve Asset Management's article titled *Portfolio Optimization: A General Framework for Portfolio Choice*, constructing the maximum diversification portfolio means that we have active views on volatilities and correlations, confidence in our ability to estimate them, no active views on returns, the belief that markets are risk-efficient, and that markets reward total risk.

Whether we explicitly acknowledge these assumptions is irrelevant. They are made nonetheless.

Using a cross-section of asset classes going back to 1973, we can construct long-only portfolios that maximize the diversification ratio using a 3-year rolling covariance matrix.

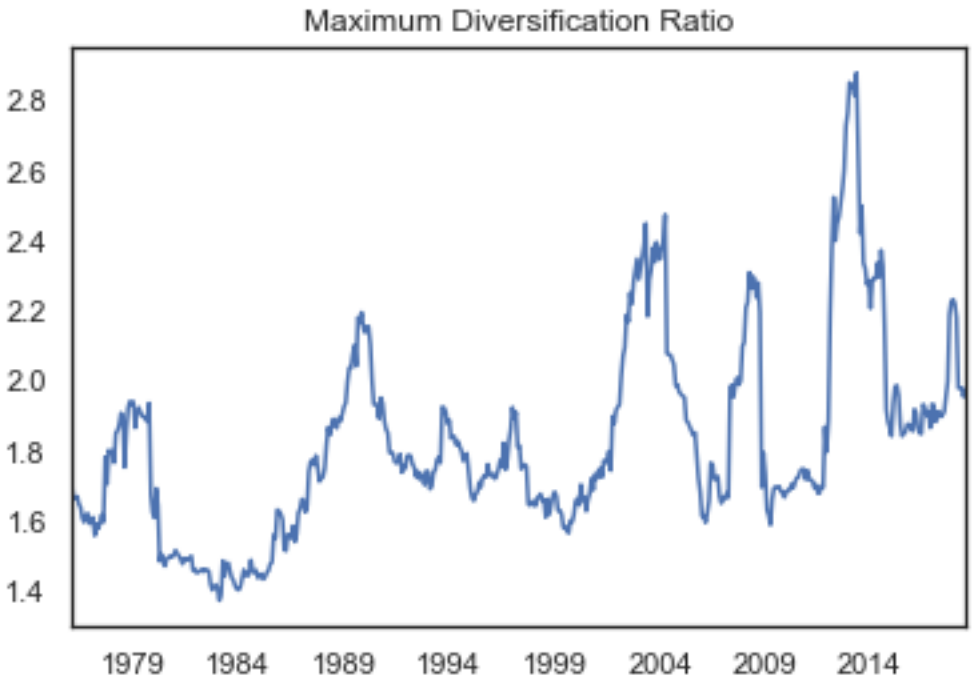
[1] Choueifaty, Yves, and Yves Coignard. 2008. "Toward Maximum Diversification." Journal of Portfolio Management 35 (1). http://www.tobam.fr/wp-content/uploads/2014/12/TOBAM-JoPM-Maximum-Div-2008.pdf: 40–51.



Over time we see some significant shifts in the allocation to precious metals, peaking around 40% and declining to 0%. The overall bond allocation ranges between 30% and 75% with an average of about 60%, and equities range from 15% to 40% with an average around 25%. The concentration seen in certain asset classes and the large swings in allocations demonstrate that the mathematical measure of diversification employed herein may not always align with a more intuitive expression of the concept.

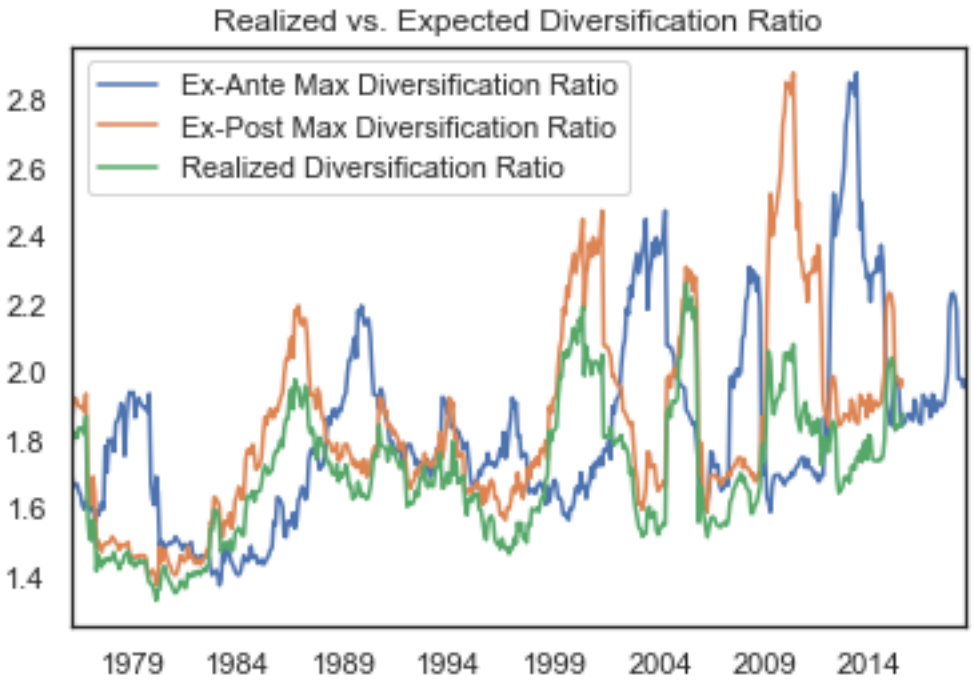
We can also see that the bond split across the term and credit spectrum and the equity split across size and geographies varies as diversification benefits ebb and flow within the asset classes.

The diversification ratio of these portfolios also varies considerably over time as correlations and volatilities fluctuate. Over some periods, it appears that the portfolio has a significant amount of internal diversification with a ratio approaching 3. At other times, the ratio is closer to 1.5, meaning that the expected volatility of the portfolio is only 33% less than if all the assets were perfectly correlated.



Static asset allocations can vary substantially in their diversification benefit as the markets evolve, and this graph highlights how much diversification changes even if we are flexible with the allocations we choose.

These diversification ratios are what we expected based on the trailing covariance data: but diversification can come and go from one period to another. The realized diversification ratio can be very different (green line in the following chart) and will be bounded by the maximum diversification ratio (orange line) over the out-of-sample period; that is, the diversification achievable if we had perfect foresight. This realized and potential diversification can be very different from the ex-ante diversification ratio (blue line) used in portfolio construction.

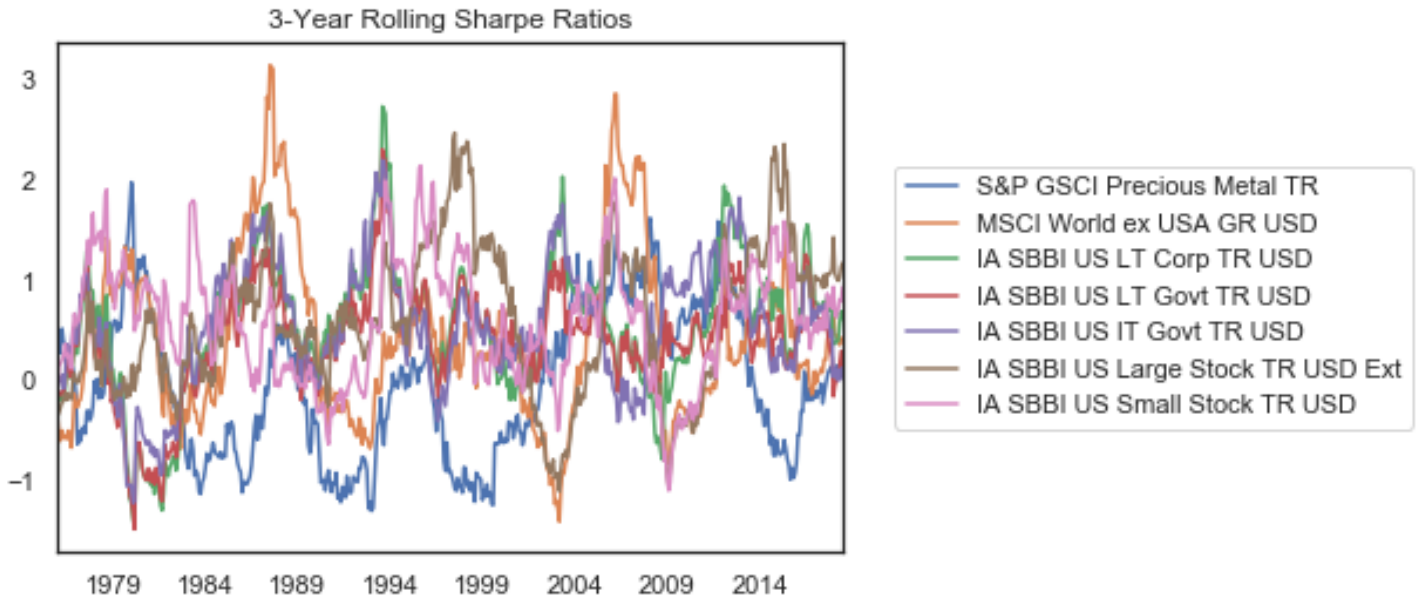


In the recent months, the maximum expected diversification ratio has been around 2. The confidence in the covariance matrix estimate will determine how close this is to reality going forward.

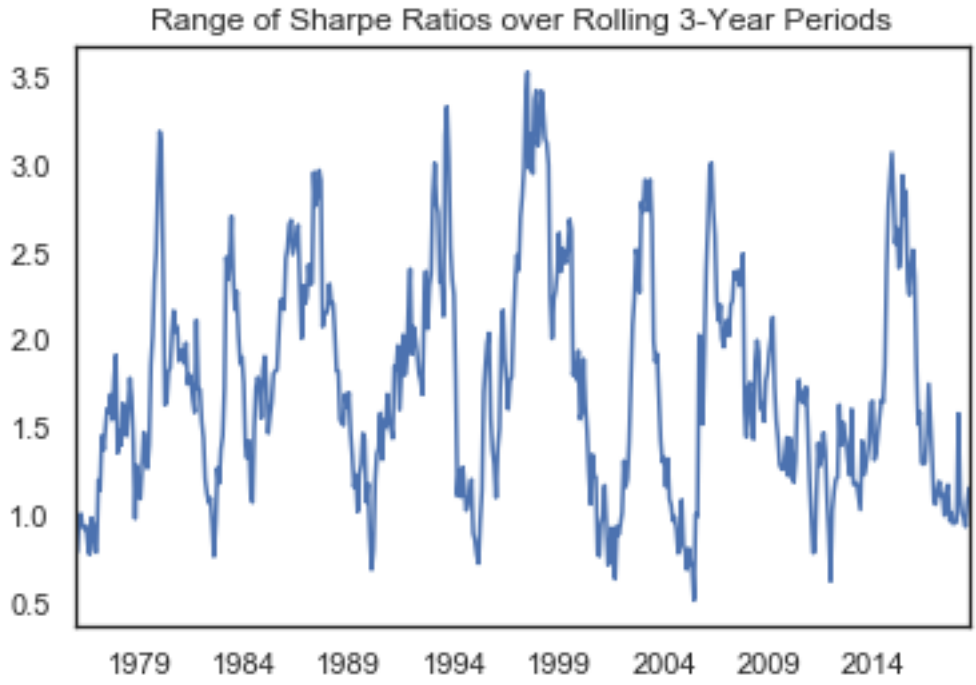
3. Optimal Diversification

From the perspective of Sharpe ratio maximization, the maximum diversification portfolio is only going to be optimal ex-post if the realized excess returns are proportional to the volatilities. This implies constant Sharpe ratios for all assets through time.

We know that this is not true, so from the start we should *not* expect to end up with the most diversified portfolio over the out-of-sample period. Actually achieving the most diversified portfolio is likely a case of luck, where Sharpe ratios across assets just so happen to align.



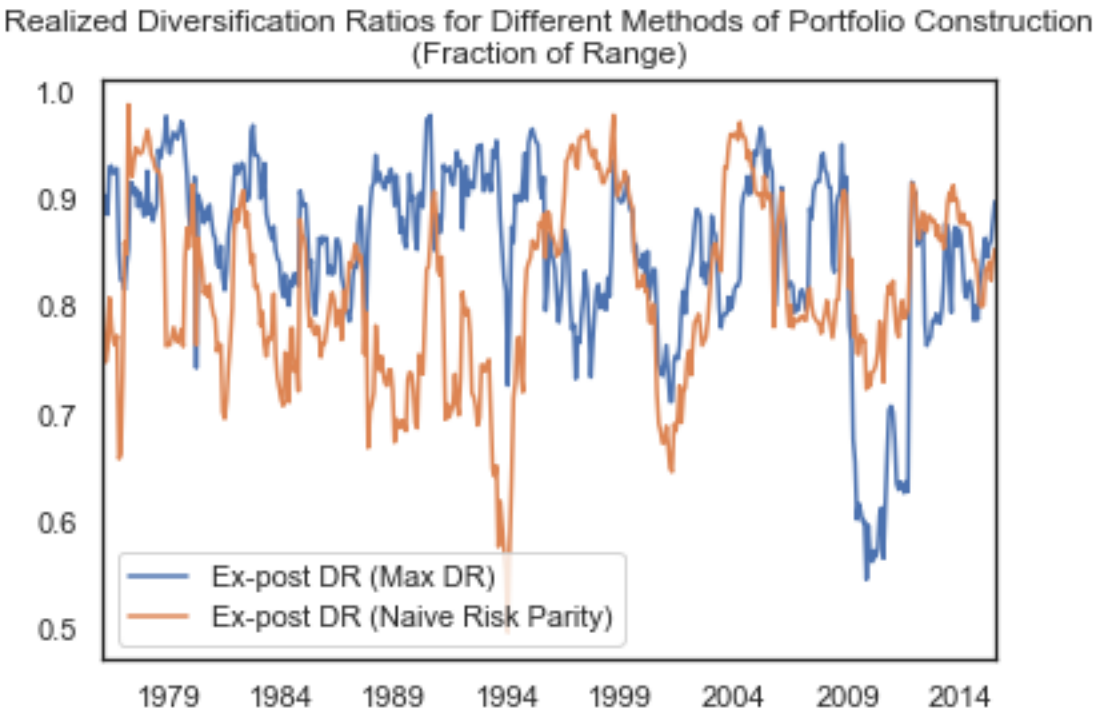
To see this spread more clearly, we can calculate the range of Sharpe ratios at each point. The difference in the proportionality of the return to the volatility goes as high as 3.5 and dips down below 1. However, it is never zero.



Optimal portfolios aside, getting close to the maximum diversification portfolio ex-post would still be a win for the method and a show of robustness.

For comparison, assume for a moment that we still held the same views about portfolio construction but removed the active views on correlation. This leads to inverse volatility weighting the portfolio (naïve risk parity).

The following chart compares these two portfolios as a fraction of realized range of potential diversification ratios. For example, if the maximum diversification ratio was 3 and the minimum was 1, a realized diversification ratio of 2.5 would correspond to a fraction of 75% of the possible range.



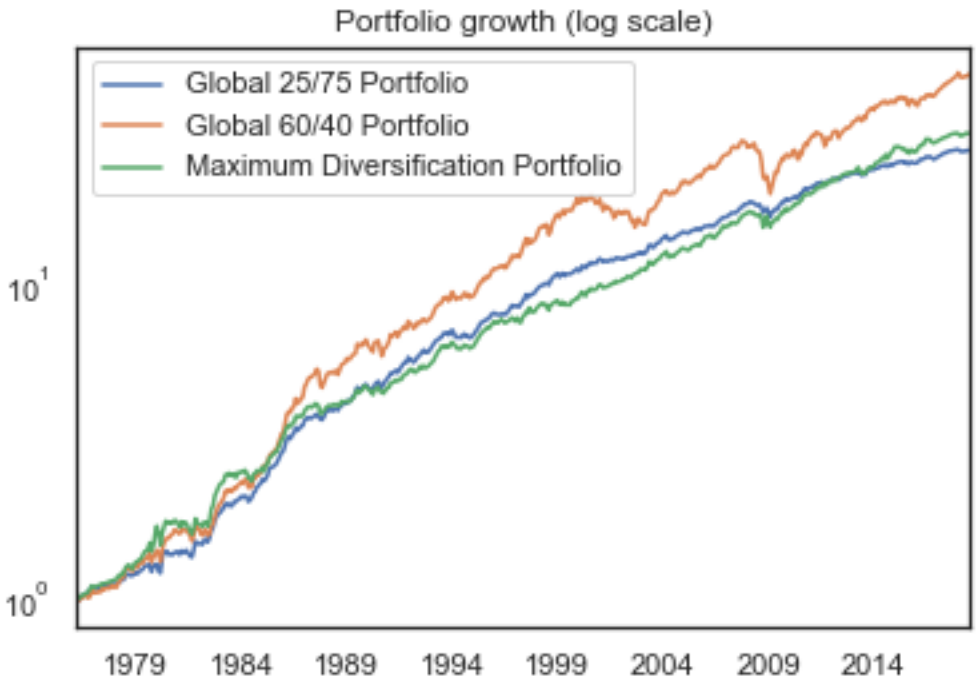
As a testament to its robustness, the median position of the diversification ratio for the maximum diversification portfolio within the potential range was 87%.

The maximum diversification portfolio led to a higher diversification ratio than that of the naïve risk parity portfolio in 65% of the rolling periods. During the Financial Crisis and Tech Bubble, when correlations climbed the most, both methods showed less diversification – an important reminder that correlations are not a law.

4. What About Returns?

While the maximum diversification portfolio requires no active views on returns, this may be the area that would make investors hesitate before adopting this method of portfolio construction, especially if they are not willing to employ leverage.

Over the test period, the maximum diversification portfolio has been similar to a conservative 25/75 stock/bond allocation.



Its maximum drawdown of 13% compared to 11% for the 25/75 demonstrates diversification-based risk management (the 60/40 had a maximum drawdown of 32%). It did experience periods in the 70s and 80s when it outperformed simple strategic allocations, but with an annualized tracking error of 6%, this performance difference can cut both ways.

Assuming that your beliefs about correlations, volatilities, and returns align with those needed for the maximum diversification portfolio, three uses of this technique are:

1. Combine it with leverage and other portfolio construction techniques (for mitigating estimation risk) to target a specific volatility.

2. Use it to construct a conservative portfolio that requires careful management of sequence risk.

3. Use it as a benchmark for assessing diversification within an existing portfolio and considering tactical tilts to improve the diversification ratio.

5. Conclusion

Like all portfolio construction techniques, the calculation of the most diversified portfolio requires a set of assumptions that are not often met by out-of-sample data. It does not entail as much estimation risk as mean-variance optimization, as it does not require estimates of asset returns.

It can generate a Sharpe optimal portfolio if Sharpe ratios are constant for all assets, but since this is rarely the case, it is probably best to treat it as simply another portfolio construction technique in the quantitative toolbox for managing uncertainty in estimation.

Beyond that, the most diversified portfolio is somewhat of an idealized target but is not generally in line with the objectives of most investors. It could be directly useful in some isolated cases, but its true value comes from the information it provides about what level of diversification is possible in a given investment universe.

Through the diversification ratio, we can see how diversified a portfolio is and the theoretical maximum value that could have been achieved.

With the pursuit of diversification already at odds with how investors evaluate portfolios in hindsight, finding the correct level of diversification is probably more important than maximizing it.

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