Mapleridge Capital Corporation

Fields-MITACs Industrial Problem Solving Workshop

Thomas Barford, PhD

About Mapleridge

- Mapleridge Capital is a CTA (Commodity Trading Advisor) operating out of Toronto
- Specialize in Short-Term Systematic Trading

Summary of Problem

Portfolio Construction

How do we take many different return streams and combine them at chosen weights to maximize the performance of the portfolio?

Who's Interested?

- At Mapleridge, we think about combining different trading strategies/systems.
- Pension funds think about distributing cash among Managers…
- … and those Managers think about allocating cash to different sectors/stocks.

Philosophy

- 1950s Harry Markowitz defined the problem of optimal portfolio construction using more mathematical language…
- ***Maximize the ratio of the expected portfolio return to the uncertainty in that return***
- …surely no 'rational' investor would accept the same expected return with higher uncertainty (or in the financial lingo - risk)
- In theory, all we need now is the joint probability distribution of future returns for all possible investments and we can solve this problem fairly easily (just crunching the numbers if necessary).

Sharpe Ratio

- In real life we deal with time-series data, not probability distributions and stochastic processes.
- Thus, even after the event, we can't measure the expected return and we especially can't measure the uncertainty in that return. But we need to measure something.
- How, then, do we determine the success of a portfolio?
- When we have realized a series of portfolio returns r_i, then we can calculate the Sharpe ratio

$$s = \frac{\mu - r_f}{\sigma} \qquad \mu = \frac{1}{N}\sum_i r_i \qquad \sigma^2 = \frac{1}{N}\sum_i r_i^2 - \mu^2$$

- Essentially, a measure of return and potential leverage. Commonly used throughout the financial services to measure of portfolio performance.
- The Sharpe ratio is not without its faults and many other ideas have been proposed to measure the success of a given portfolio, for example, the Sortino ratio.
- However, Sharpe is the most universally recognized and is how our peers and clients measure our success. This is the metric that should be used to gauge our success in this problem. So in essence we're hoping to maximize the Sharpe ratio of future realized returns.

The Challenge

- Mapleridge will provide a collection of return time-series data, generated by real strategies trading on futures markets.
- Given this dataset, the group is to explore methods of constructing portfolios in a causal fashion in such a way to maximize the Sharpe ratio of future returns.
- The dataset is comprised of the daily returns for 35 strategies for 2,608 days
- The strategies were developed on data that overlaps with the first half of the dataset.

How to improve the Sharpe Ratio

- Two possibilities:
  - Seek the best performing strategies – single strategies that themselves have better Sharpe ratios. This is essentially an exercise in time-series prediction
  - Seek the best team of strategies – find strategies whose return streams complement each other – Diversification. Often described in financial circles as the only free lunch.

Traditional Methodology

- Estimate μ_i, the expected returns, and σ_{ik}^2, the covariance matrix of the returns, and then find the weights, w_i, that maximize the expected portfolio Sharpe ratio

$$s = \frac{\mu}{\sigma} \qquad \mu = \sum_i w_i \mu_i \qquad \sigma^2 = \sum_i \sum_k w_i w_k \sigma_{ik}^{\ 2}$$

$$\sum_i w_i \le 1 \qquad w_i \ge 0$$

- Resulting in a fairly straightforward constrained quadratic optimization, which can be solved using well known methods.

- We can see the two sides of the optimization here, choose the strategies with the best μ_i to maximize μ, while choosing the pairs with the lowest (especially negative) σ_{ik}.

Traditional Methodology: Estimating Parameters

- Simple way to estimate parameters is to measure the realized mean and covariance of recent returns
- Choose a look-back and calculate with the usual formulas
- Re-estimate parameters and re-optimize every month or quarterly or whatever timescale suits you best
- Obviously…the performance going forward depends entirely on the quality of these estimations.

Maximum Entropy Method

- Suppose that we don't care much for performance prediction…
- …we know nothing about the future returns or distributions of any of our possible return streams
- What portfolio do we chose?
- Maximize the entropy of the weights – assumes the least information about the future
- => Equally weight all strategies!!

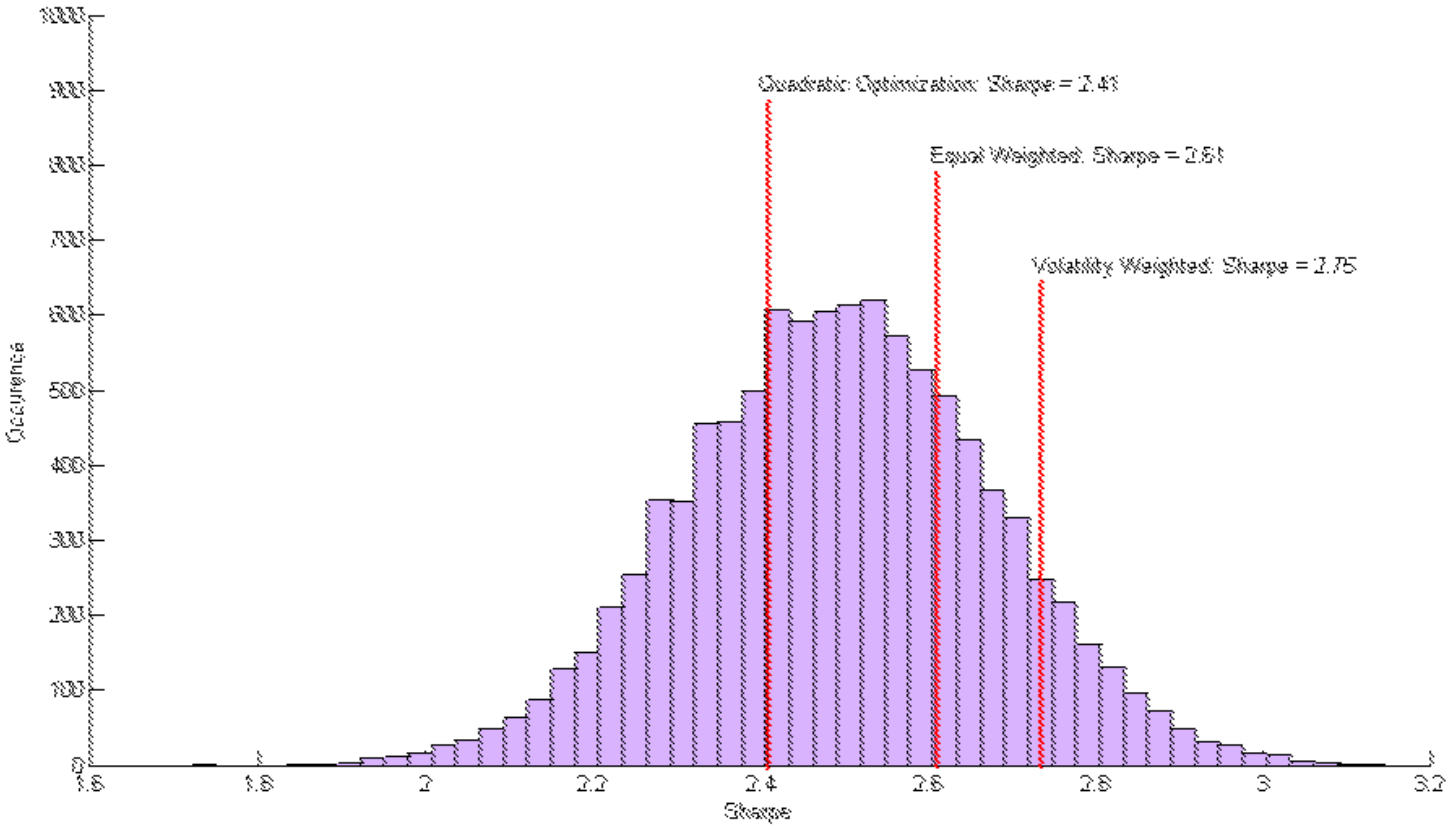
Volatility Weighted Method

- Now suppose we are confident in our measure of σ_{ii} for each strategy. Then we can presumably improve on the equally weighted method but weighted each strategy proportional to the inverse of σ_{ii}.
- Assumes nothing about returns or correlations but simply equalizes the risk in each strategy
- Since the quadratic optimization knows about these values, this method is a simplified version of that – one that admits some ignorance

Performance on the dataset

- Split the set into an optimization set, the first 1500 points and a test set, the final 1108 points.
- Optimize the weighting of the strategies on the using the three techniques described and then measure their performance in the test set.
- How do they compare against randomly chosen portfolios?

Performance on the dataset

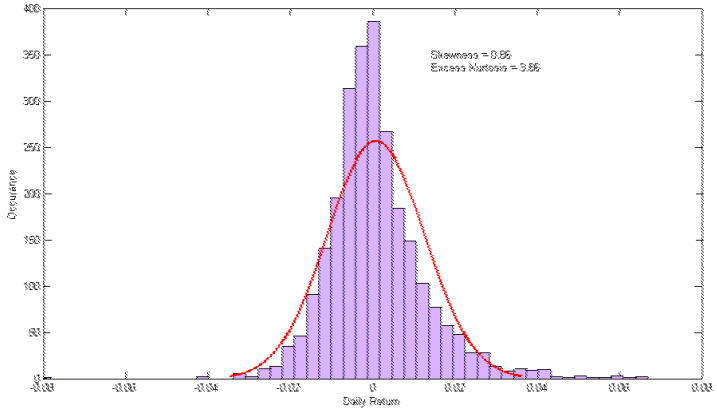


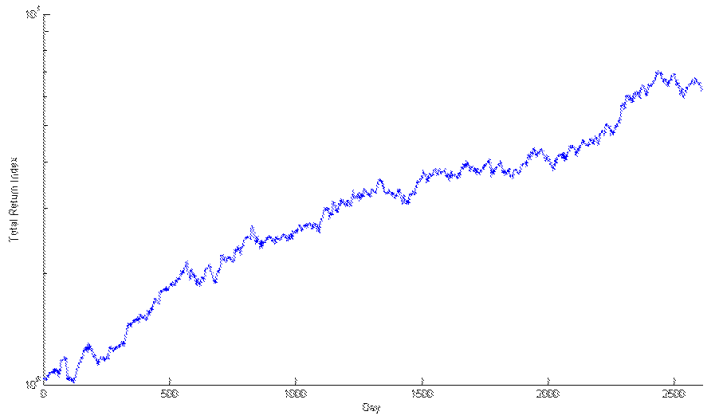
The Crux of the Matter

- Why does the specifically optimized portfolio, which has the most knowledge, do no better than random?
  - Bad estimates?
  - Bad methodology?
  - Failure to correctly estimate errors?
- Why does the equally weighted portfolio outperform random?
  - Remember an equally weighted portfolio is special – not typical
- How does the volatility weighted portfolio outperform the optimized portfolio so well when it has no knowledge of performance or correlations?
  - Are the estimates so much better for volatility?
  - When building a strategy, constant quantified risk is a goal, in the dataset the return distributions show a fairly constant width
- The suggestion from this result is that prediction of performance going forward is so bad as to be detrimental to portfolio performance and that the best approach is to maximize diversity!

The Nature of the Dataset

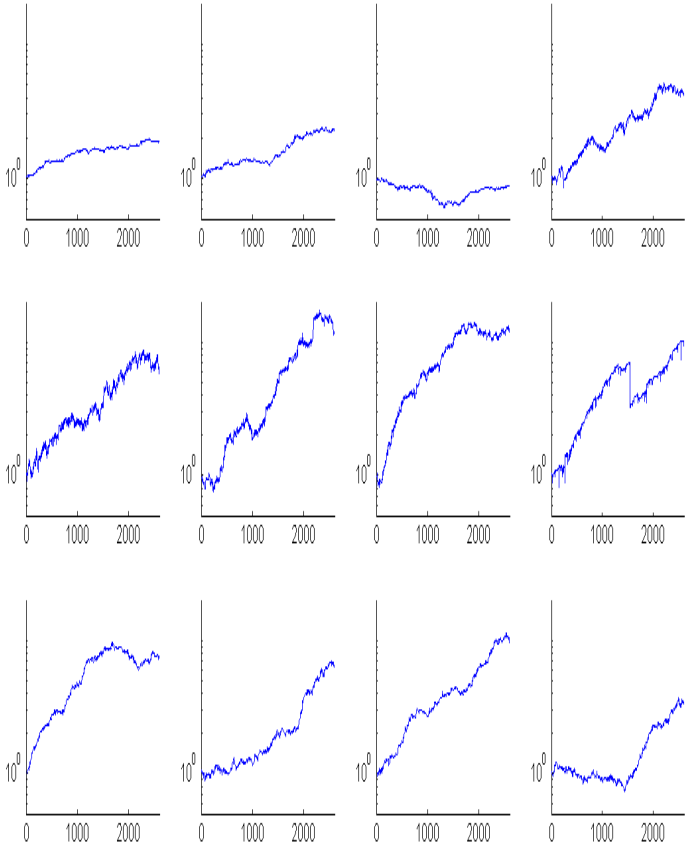
- The Strategy Returns are not Gaussian!
- They have positive excess kurtosis
- They may have negative or positive skewness, which may be quite severe





More on the Dataset

- It is also not clear if the returns are generated by a stationary process
- The market data process on which the strategies are tested is to a high degree of certainty, non-stationary. Exhibited time varying volatility, in the least.
- Some Strategies appear to show marked improvements or declines in performance…
- …is this an illusion or can it be detected?
- Others appear to be fairly consistent, how do we know which ones will continue to be consistent – which ones are liable to fail?



Some Questions

- How can we better understand this trade-off between uncertainty, which we protect ourselves by diversifying, and prediction, which when done well will surely lead to better results!
- Is this as simple as correcting the estimations for quadratic optimization to work with the skewness and higher kurtosis? Can we include the error in prediction into the quadratic optimization?
- Are the return streams stationary? Does this question even make sense when dealing with time-series data, a single realization of some process?
- …is prediction of performance even possible?
- Do we even need to explicitly calculate and expound such predictions or can we use algorithms that work directly with the data.

To re-optimize or not to re-optimize

- The results presented above held the weights constant throughout the out-sample – imagine the possibilities if the weights are updated on a monthly or even daily basis

- The width of possible solutions grows…is it best to focus on diversification and risk management…or to go for actually predicting the performance of individual strategies?

- There is always a cost to re-optimizing – we suggest a 4 basis point charge, doesn't sound a lot but it will add up over the course of a year if you re-optimize every day.

Good Luck

…and if you find something good, tell me first…