Report on Random Forest Quarterly- Rebalanced Portfolio and Different Portfolio Weights Adjustments

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1 Introduction on Random Forest Forecasting and Quarterly-Rebalancing

The method of random forest is well-presented in literature, and we have used a random forest classification algorithm to forecast the quarterly return based on three previous months' data. For instance, let's denote the corporate fundamental data of a given stock i at time t by $F_{i,t}$, then the random forest algorithm works such that $\forall t$:

$$R_{i,t+3} = RF(F_{i,t}, F_{i,t+1}, F_{i,t+2}) \tag{1}$$

where RF is the trained model of Random Forest Classifier, and $R_{i,t+3}$ is the indicator variable that classifies positive returns as 1, and negative returns as 0.

1.1 Random Forest Specification

For our random forest model, we have used the default setting of 100 trees in the forest, along with 475 total number of fundamental factors as training variables, to predict the next quarterly return for a total of 1500 stocks.

1.2 Quarterly- Rebalancing

For the quarterly-rebalancing scheme, we have employed a dollar-neutral strategy, so that we will always be spending $\frac{x}{2}$ amount on taking long position in equities, while spending -$\frac{x}{2}$ amount on taking short position in equities. Therefore, we will be taking a zero dollar net position at any given time.

1.3 Portfolio Construction Methods

For the portfolio weights of different equities, we have three methods respectively. Firstly, we have the equal-weighted portfolio weights, where each equities takes an equal share in their respective long or short position. Secondly, we have the liquidity-weighted portfolio, where we takes a heavier weight in more liquid stocks. Lastly, we have the momentum-weighted portfolio where we takes a heavier weight in stocks with higher return in last quarter.

2 Random Forest Forecasting with Equal Weights

In this section, we have the benchmark portfolio construction scheme where we would use random forest model to forecast all the stocks to long equally weighted and to short equally weighted, respectively, while maintaining a dollar-neutral strategy with outstanding investment of 0.

2.1 Numerical Results

The portfolio returns of a starting value $x = 1$ is shown over time below :
And the portfolio yearly breakdown is shown below :

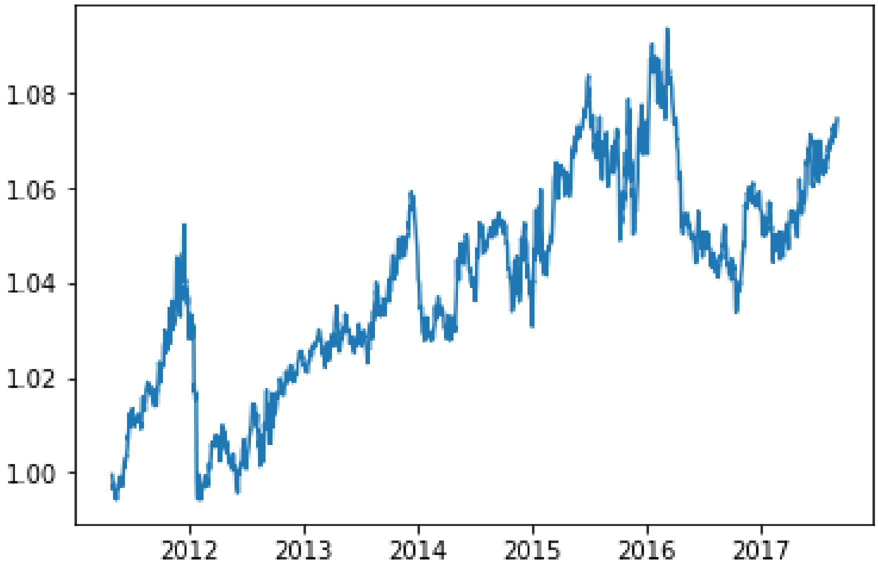

Figure 1. Random Forest Model with Equal-Weighted Dollar-Neutral Portfolio

Tableau 1. Yearly Breakdown of An Equal-Weighted Dollar-Neutral Portfolio

$T =$	Mean$_r eturn \mu$	Volatility σ	Sharpe Ratio	Sortino Ratio
T = 2011	5.3954	3.3569	1.6072	2.3523
T = 2012	-1.1774	3.3611	-0.3503	-0.3752
T = 2013	2.1913	2.1676	1.0109	1.4425
T = 2014	-0.9860	2.8868	-0.3416	-0.5090
T = 2015	3.3979	4.2940	0.7913	1.1879
T = 2016	-1.4295	3.0653	-0.4663	-0.8155

Overall, the portfolio gives a return of 0.0747127. Therefore, we would also like to experiment with other portfolio weight adjustment methods, to improve results.

3 Random Forest Forecasting with Liquidity- Adjusted Weights

In this section, we have the liquidity-weighted portfolio construction scheme where we would use random forest model to forecast all the stocks to long/short. Subsequently, we would take a higher weights in stocks that are more liquid, as measure by the product of their market price multiplied by trading volume.
The rationale behind this weight-adjustment method is that the liquid stocks are able to perform better than illiquid stocks. Therefore, we believe that taking heavier investment in liquid stocks would likely improve the results.

3.1 Distribution of Liquidity Metric and Data-Processing

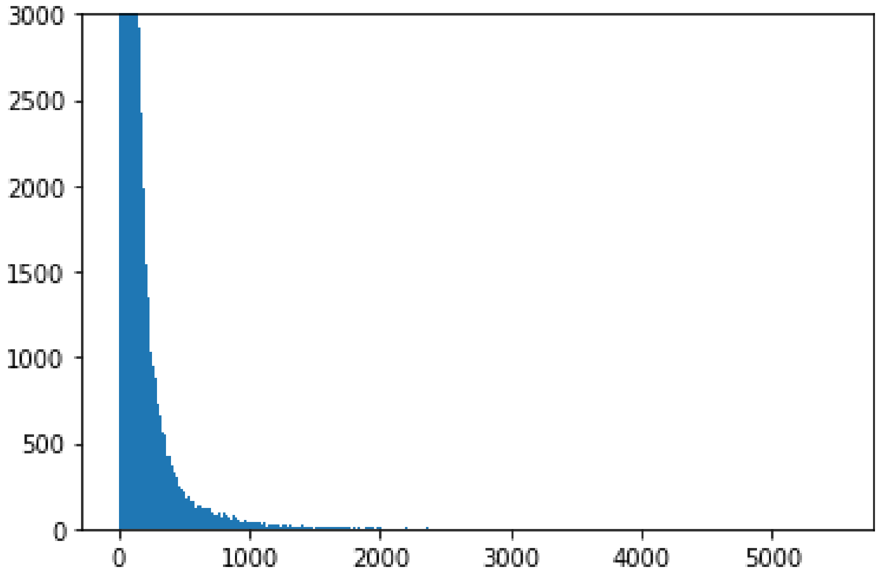

Figure 2. Distribution of Liquidity Metric

Specifically, we have observed that the most stocks have a relative liquidity metric between $[0, 500]$. And the number of stocks with higher liquidity metric tend to zero almost exponentially.

3.2 Treatment of Liquidity Metric

Therefore, due to a distribution similar to zero-inflated poisson, it would be hard to find a continuous transformation that maps directly from liquidity to weights directly. This is because weight for a given stock would be within the range of $\pm[0, \frac{x}{2}]$

Inspired by the financial concept of decile-based factor ranking, we would instead rank liquidity into four quartiles. For the long side dollar-neutral investing, we would classify the stocks into highly illiquid(1st quartile), illiquid (2nd quartile), liquid(3rd quartile), and highly iliquid (4nd quartile) stocks. The concept applies similarly for short side position.
Each quartile would be assigned with a scaling factor that assigns a higher weights to equities with higher liquidity, and less weights to the ones with lower liquidity.

3.3 Yearly Breakdown of A Dollar-Neutral Portfolio With Long Most Liquid Stocks

The portfolio value is shown over time.
And the portfolio yearly breakdown is also shown below :

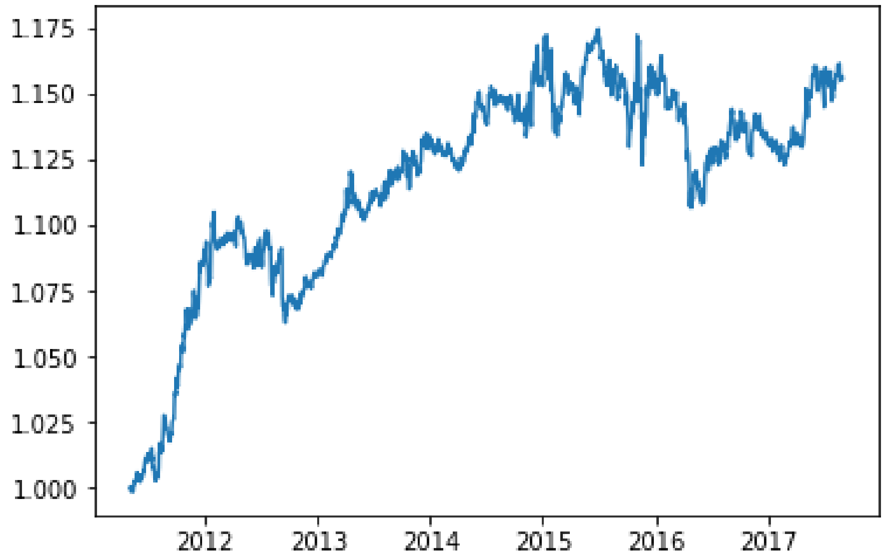

Figure 3. Random Forest Model with Dollar-Neutral Portfolio With Only Most Liquid Stocks

Tableau 2. Yearly Breakdown of Dollar-Neutral Portfolio With Only Most Liquid Stocks

$T =$	Mean return μ	Volatility σ	Sharpe Ratio	Sortino Ratio
T = 2011	12.1871	3.4702	3.5120	6.0151
T = 2012	-0.3674	3.5715	-0.1029	-0.1400
T = 2013	4.7482	2.8376	1.6733	2.1109
T = 2014	1.9404	3.2107	0.6044	0.9021
T = 2015	0.0801	5.1606	0.0155	0.0224
T = 2016	-2.0112	3.4513	-0.5827	-0.9582

Overall, the portfolio has a cumulative return of 0.1559305. This liquidity-weighted portfolio give us superior result, compared to equal-weighted portfolio. This is likely because of the liquidity premium given to good quality stocks.

4 Random Forest Forecasting with Momentum-Adjusted Weights

In this section, we have the momentum-weighted portfolio construction scheme where we use the same random forest model. Subsequently, we would adjust the weights so that equities with higher absolute return are invested more heavily, proportional to their return size in the previous quarter.
The motivation for this approach is so that firms that have greater returns in last quarter would likely retain their high level performance in the next quarter.

4.1 Yearly Breakdown of Quarterly-Momentum Weighted Portfolio

The portfolio value is shown over time.
And the portfolio yearly breakdown is also shown below :

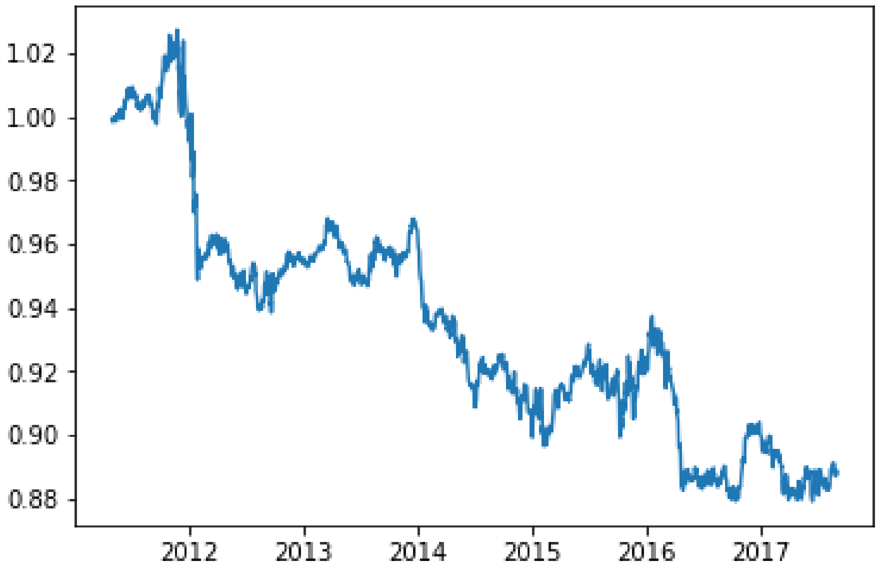

Figure 4. Random Forest Model with Dollar-Neutral Portfolio With Quarterly Momentum Weighted Stocks

Tableau 3. Yearly Breakdown of Dollar-Neutral Portfolio With Quarterly Momentum Weighted Stocks

$T =$	Mean return μ	Volatility σ	Sharpe Ratio	Sortino Ratio
T = 2011	-0.0752	4.0578	-0.0185	-0.0205
T = 2012	-4.3365	4.6098	-0.9407	-1.0066
T = 2013	0.9370	2.0718	0.4523	0.7058
T = 2014	-6.2305	2.8146	-2.2136	-3.1144
T = 2015	1.8675	4.1987	0.4448	0.6516
T = 2016	-2.4001	3.1090	-0.7720	-1.2340

Overall, the portfolio gives a return of -0.1115021. Therefore, the quarterly-momentum adjustment in portfolio weights don't give a significant improvement over equal-weighted construction.

In fact, the portfolio performance emphasizes the point that quarterly momentum doesn't seem to be strong enough to present in the data.