Problem Set 2: Risk Parity

Name: Jiaming Huang

Names of whom I discussed this problem set with: [Yanxiang Zhao],[Xichen Luo]

Question1

Construct the equal-weighted bond market return, value-weighted bond market return, andlagged total bond market capitalization using CRSP Bond data 1. Your output should be from January 1926 to December 2018, at a monthly frequency.

Answer :

Firstly, I will show the result of my replicating portfolio:

```
##       Year Month Bond_lag_MV  Bond_Ew_Ret  Bond_Vw_Ret
##    1: 1926     1       0.809  0.005101107  0.013394765
##    2: 1926     2       0.809  0.003621403  0.006154089
##    3: 1926     3       0.809  0.003811553  0.003881219
##    4: 1926     4       0.809  0.004013734  0.007440844
##    5: 1926     5       0.809  0.002146412  0.001471811
##   ---
## 1112: 2018     8   13941.011  0.005910083  0.005431343
## 1113: 2018     9   14248.302 -0.006616908 -0.006163339
## 1114: 2018    10   14123.373 -0.002260627 -0.002286712
## 1115: 2018    11   14173.523  0.007736914  0.007176645
## 1116: 2018    12   14410.397  0.015826425  0.014692552
```

Then I will explain detailedly about my process getting the result:

1. Data Cleaning

For the TMRETNUA column, there are some missing values which are represented of -99. To deal with those exceptions, I reassign those rows with return value NA.

For the MCALDT column, I use as.Date function to transform the date from character type to date type.

The Market Capitalization is simply replaced by shareoutstanding column, which is the column of TMTOTOUT.

2. Calculating the total lagged market capitalization

Firstly, I use shift function by KYCRSPID column to get lagged market capitalization for each bond. Than I sum up this attribute by date to get total lagged market capitalization.

3. Calculation of value-weighted return and equal-weighted return

It is exactly the same way I did in PS1 to get the value and equal weighted return of stock.

Question 2

Aggregate stock, bond, and riskless datatables. For each year-month, calculate the lagged market value and excess value-weighted returns for both stocks and bonds. Your output should be from January 1926 to December 2018, at a monthly frequency.

Answer:

The summary statistics are in Table below.

```
##        Year Month Stock_lag_MV Stock_Excess_Vw_Ret Bond_lag_MV
##    1: 1926     1      0.00000       -0.0029510000       0.809
##    2: 1926     2     27.03235       -0.0367630225       0.809
##    3: 1926     3     26.16208       -0.0677395168       0.809
##    4: 1926     4     24.50693        0.0338677203       0.809
##    5: 1926     5     25.27439        0.0119198887       0.809
##   ---
## 1112: 2018     8  28779.92660        0.0344351577   13941.011
## 1113: 2018     9  29710.25401        0.0006065615   14248.302
## 1114: 2018    10  29697.43816       -0.0765305722   14123.373
## 1115: 2018    11  27365.59752        0.0170333559   14173.523
## 1116: 2018    12  27679.27067       -0.0954249471   14410.397
##        Bond_Excess_Vw_Ret
##    1:        0.010443765
##    2:        0.003386089
##    3:        0.001103219
##    4:        0.004368844
##    5:        0.001129811
##   ---
## 1112:        0.003856343
## 1113:       -0.007653339
## 1114:       -0.004176712
## 1115:        0.005381645
## 1116:        0.012762552
```

For this question, I have things below to talk about:

1. Monthly_CRSP_Stocks data

I use the function of PS1_Q1 to get the monthly data for stocks with one extension. For PS1_Q1, we get the data started from Feb 1926. However, for this question, I get the data from Jan 1926 and fill the missing value with 0.

2. Calculate the excess return

I download 30 days Bill rate as monthly inflation rate from CRSP. and since we already got Monthly Stock return and Bond return from PS1_Q1 and PS2_Q1, to calculate the excess return, simply use those returns to subtract the inflation rate.

Question 3

3. Calculate the monthly unlevered and levered risk-parity portfolio returns as defined by Asness, Frazzini, and Pedersen (2012).3 For the levered risk-parity portfolio, match the value-weighted portfolio???s ???? over the longest matched holding period of both. Your output should be from January 1926 to December 2018, at a monthly frequency.

Answer :

In Table 3 below, I got the excess return for different strategies.

```
##       Year Month Stock_Excess_Vw_Ret Bond_Excess_Vw_Ret Excess_Vw_Ret
##    1: 1926     1       -0.0029510000        0.010443765   0.010443765
##    2: 1926     2       -0.0367630225        0.003386089  -0.035596390
##    3: 1926     3       -0.0677395168        0.001103219  -0.065674573
##    4: 1926     4        0.0338677203        0.004368844   0.032925049
##    5: 1926     5        0.0119198887        0.001129811   0.011585225
##   ---
## 1112: 2018     8        0.0344351577        0.003856343   0.024456454
## 1113: 2018     9        0.0006065615       -0.007653339  -0.002070723
## 1114: 2018    10       -0.0765305722       -0.004176712  -0.053211046
## 1115: 2018    11        0.0170333559        0.005381645   0.013057687
## 1116: 2018    12       -0.0954249471        0.012762552  -0.058384388
##       Excess_60_40_Ret Stock_inverse_sigma_hat Bond_inverse_sigma_hat
##    1:      0.002406906                      NA                     NA
##    2:     -0.020703378                      NA                     NA
##    3:     -0.040202423                41.82576               200.3795
##    4:      0.022068170                30.85982               205.3629
##    5:      0.007603857                22.85717               250.7831
##   ---
## 1112:      0.022203632                33.56677               150.1103
## 1113:     -0.002697399                33.28084               152.5096
## 1114:     -0.047589028                36.19883               149.7344
## 1115:      0.012372672                32.80101               152.2512
## 1116:     -0.052149948                35.23978               151.1140
##       Unlevered_k Excess_Unlevered_RP_Ret  Levered_k Excess_Levered_RP_Ret
##    1:          NA                      NA 0.02549731                    NA
##    2:          NA                      NA 0.02549731                    NA
##    3: 0.004128729            -0.010785044 0.02549731                    NA
##    4: 0.004233294             0.008222539 0.02549731             0.05899418
##    5: 0.003654434             0.002031106 0.02549731             0.01660341
##   ---
## 1112: 0.005444337             0.009444584 0.02549731             0.04417993
## 1113: 0.005382408            -0.006173734 0.02549731            -0.02924152
## 1114: 0.005378276            -0.018263089 0.02549731            -0.08088764
## 1115: 0.005403880             0.007446942 0.02549731             0.03661284
## 1116: 0.005366136            -0.007695863 0.02549731            -0.03063332
```

I will then explain how I got return for different strategy:

1. Value-Weighted Portfolio

Simply just assign weights of stock and bond market portfolio with the market capitalization of each asset.

2. 60/40 Portfolio

This strategy is to assign 60% weight to stock portfolio and 40% to bond.

3. Unlevered RP portfolio.

To get weights for stock portfolio and bond portfolio of unlevered RP strategy, I firstly calculate Stock_inverse_sigma_hat and Bond_inverse_sigma_hat, which equal to the inverse of the standard deviation of three year previous return according to the papaer.

Then the weights of stock and bond are related to this inverse sigma hat number.

4. Levered RP portfolio.

The only difference between levered and unlevered RP is that for levered RP, we have a constant number k multiplied to the whole portfolio in order to make the volatility of portfolio equals to the volatility of value-weighted portfolio. Therefore, we make up a portfolio with weight of each asset equals to inverse_sigma_hat, and the number of k equals to the std of value weighted portfolio divide by this make-up portfolio.

Question 4

Replicate and report Panel A of Table 2 in Asness, Frazzini, and Pedersen (2012), except for Alpha and t-stat of Alpha columns. Specifically, for all strategies considered, report the annualized average excess returns, t-statistic of the average excess returns, annualized volatility, annualized Sharpe Ratio, skewness, and excess kurtosis. Your sample should be from January 1930 to June 2010, at monthly frequency. Match the format of the table to the extent possible. Discuss the difference between your table and the table reported in the paper. It is zero? If not, justify whether the difference is economically negligible or not. What are the reasons a nonzero difference?

The summary statistics are in Table below. I report the following six statistics: annualized mean,t-stats of mean, annualized standard deviation, annualized sharpe ratio, skewness, and excess kurtosis.

```
##                       Asset Annualized_Mean t_stat_of_Annualized_Mean
## 1:              CRSP stocks        7.023567                   3.327532
## 2:               CRSP bonds        1.556383                   4.333759
## 3: Value-weighted portfolio        4.103179                   2.492857
## 4:          60/40 portfolio        4.836693                   3.729351
## 5:             unlevered RP        2.259584                   4.795520
## 6:               levered RP        7.865932                   4.779703
##    Annualized_Standard_Deviation Annualized_Sharpe_Ratio    Skewness
## 1:                     18.937973               0.3708722  0.28777923
## 2:                      3.222179               0.4830219 -0.05155025
## 3:                     14.767978               0.2778430  0.63326485
## 4:                     11.636255               0.4156572  0.28156987
## 5:                      4.227570               0.5344878  0.06208339
## 6:                     14.765468               0.5327249 -0.35285474
##    Excess_Kurtosis
## 1:        7.883708
## 2:        4.818185
## 3:       14.838511
## 4:        7.805974
## 5:        4.697965
## 6:        2.094031
```

Annualized Mean

I use formula below:

$$AnnualizedMean = 12 * MonthlyMean$$

t_stat_of_Annualized_Mean

I use the function t.test to get the t_stat value.

Annualized Standard Deviation

The formula to calculate annualized standard deviation is:

$$AnnualizedStandardDeviation = \sqrt{12} MonthlyStandardDeviation$$

Annualized SharpRatio

The formula to calculate annualized sharp ratio is:

$$AnnualizedSharpRatio = \frac{AnnualizedMean}{AnnualizedStandardDeviation}$$

Skewness and Kurtosis

Using skewness and kurtosis function from DistributionUtils to calculate two moments.

Reasons for difference:

1. The Stat attribute for stock excess return is maybe because I use weighted.mean value rather than calculate the weighted mean annually. Those two methods to calculate weighted mean will be slighted different, especially when na.rm = TRUE.
2. The difference of stock excess return could result in difference of other strategies' result.
3. For levered RP, the difference also comes from how we calculate the K value. Since in the paper, they did not directly tell us how they calculate k value.