Problem Set 2 Risk Parity

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Names of whom I discussed this problem set with: N/A

Question 1

Before calculating the portfolio time series, I conduct a series of data cleaning as part of my PS2_Q1 function. Next, I describe my data cleaning process and their respective assumptions:

1. **Universe:**
   US Treasuries from 1926.01 to 2019.12

2. **Missingreturns:**
   Omit rows with no TMRETNUA or TMTOTOUT. Also, remove TMRETNUA if it is -99.

3. **Market Capitalization calculation**:
   Use one-month lag TMTOTOUT. We reserve rows with a NA lag Cap but a non-NA TMRETNUA, for equal-weighted portfolio calculations.

4. **Portfolio weights:**
   for value-weighted portfolio, return is weighted by lag market cap in that period; for equal-weighted portfolio, returns are weighted equally across all observations in that period.

5. **Sample output:**

Year	Month	Bond_lag_MV	Bond_Ew_Ret	Bond_Vw_Ret
1926	1	809	5.101107e-03	0.0133947648
1926	2	809	3.621403e-03	0.0061540892
1926	3	809	3.811553e-03	0.0038812188
1926	4	809	4.013734e-03	0.0074408444
1926	5	809	2.146412e-03	0.0014718107
1926	6	809	4.319121e-03	0.0037497713
1926	7	809	6.839763e-04	0.0007335050
1926	8	809	3.007598e-03	0.0004093055
1926	9	809	2.075086e-03	0.0037686188
1926	10	809	4.315595e-03	0.0096233616

Question 2

1. **Data Used:**
   Stock returns data from problem set 1, US treasuries data from question 1, and riskless interest rate data from CRSP.

2. **Return Calculations:**
   Merge all the data table by month and year. Then subtract the 30-day T-bill returns from the stock and bond value weighted returns.

3. **Sample output:**

Year	Month	Stock_lag_MV	Stock_Excess_Vw_Ret	Bond_lag_MV	Bond_Excess_Vw_Ret
2008	6	15673142	-0.0842954307	4269719	4.137922e-03
2008	7	14346824	-0.0075845816	4336789	2.230355e-03
2008	8	14225544	0.0152219619	4397943	5.223072e-03
2008	9	14407248	-0.0929196355	4426388	3.828086e-03
2008	10	13067700	-0.1717881251	4683573	5.309963e-05
2008	11	10766297	-0.0775098519	5174109	2.792215e-02
2008	12	9844526	0.0176414879	5214952	1.697709e-02
2009	1	9950089	-0.0811333209	5065036	-1.543135e-02
2009	2	9147980	-0.1009189248	5309632	-2.152852e-03
2009	3	8175821	0.0896597944	5434174	1.111225e-02
2009	4	8784206	0.1016609308	5685797	-9.867453e-03
2009	5	9661245	0.0520657344	5770134	-5.413373e-03
2009	6	10182012	0.0043013619	5847341	-1.408782e-03

Question 3

1. **Data Used:**

   Consolidated table from question 2.

2. **Calculations:**

   Excess_Vw_Ret: market cap of stocks / (market cap of stocks + market cap of bonds) *(Stock Excess_Vw_Ret) + market cap of bonds / (market cap of stocks + market cap of bonds) *(Bond Excess_Vw_Ret)

   ***Excess_60_40_ Ret*:** 0.6*(Stock Excess_Vw_Ret) + 0.4*(Bond Excess_Vw_Ret)

   Stock_inverse_sigma_hat: 1/ 3-year rolling volatility of stock monthly excess returns

   Bond_inverse_sigma_hat: 1/ 3-year rolling volatility of bond monthly excess returns

   Unlevered_k: (below are stock and bond inverse sigma hat)

   $$\frac{1}{\sigma_s{}^{-1}+\sigma_b{}^{-1}}$$

   Levered K: set to a value such that each month's portfolio standard deviation is equal to that of the value-weighted benchmark portfolio (sd of Excess_Vw_Ret). After derivation, we have:

   Levered K = sd(Excess_Vw_Ret) divided by $\mathbf{sd}(\sigma_{\mathbf{s}}{}^{-1}\mathbf{R_{st}} + \sigma_{\mathbf{b}}{}^{-1}\mathbf{R_{bt}})$

   With Unlevered K and Levered K, we can compute the weights and both **Excess_Unlevered_RP_Ret,** and **Excess_Levered_RP_Ret:**

   $$w_{t,i} = k_t\,\hat{\sigma}_{t,i}^{-1}, \qquad r_t^{RP} = \sum_i w_{t-1,i}\left(r_{t,i} - rf_t\right),$$

Question 4

1. **Data Used:**
   Previous data table with returns from 1930.01 to 2010.06

2. **Calculations:**
   Annualized Excess Returns = arithmetic mean * 12
   Annualized Volatility = monthly standard deviation * sqrt(12)
   Sharp Ratio = annualized excess returns/annualized volatility
   T-statistic, Skewness, Excess Kurtosis: use R functions

3. **Comparing Results:**

Replication

	Excess Return	t-stat of Excess Return	Volatility	Sharpe Ratio	Skewness	Excess Kurtosis
CRSP stocks	7.01	3.32	18.93	0.37	0.29	7.89
CRSP bonds	1.56	4.33	3.22	0.48	-0.05	4.84
Value-weighted portfolio	4.09	2.49	14.76	0.28	0.63	14.87
60/40 portfolio	4.83	3.72	11.63	0.42	0.28	7.82
unlevered RP	2.26	4.79	4.23	0.53	0.07	4.80
levered RP	8.05	4.88	14.79	0.54	-0.35	1.99

Paper

	Excess Return	*t*-Stat. of Excess Return	Alpha	*t*-Stat. of Alpha	Volatility	Sharpe Ratio	Skewness	Excess Kurtosis
A. Long sample (U.S. stocks and bonds, 1926–2010)								
CRSP stocks	6.71%*	3.18			19.05%	0.35	0.18	7.51
CRSP bonds	1.56*	4.28			3.28	0.47	–0.01	4.37
Value-weighted portfolio	3.84*	2.30			15.08	0.25	0.37	13.09
60/40 portfolio	4.65*	3.59			11.68	0.40	0.20	7.46
RP, unlevered	2.20*	4.67	1.39%*	4.44	4.25	0.52	0.05	4.58
RP	7.99*	4.78	5.50*	4.30	15.08	0.53	–0.36	1.92

The difference between my results and those of the paper is not zero, but I believe this is mainly due to the difference in sample period. The paper uses data from 1926 to 2010, while we use 1930 to 2010. Moreover, data manipulation such as approaches to deal with NA terms could also contribute mildly to our differences. However, these discrepancies are fairly small, and overall, my replication is very

consistent with the paper. Therefore, I believe the differences are negligible.