Problem Set 2

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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 Treasury from 1926.1 to 2018.12.

2. **TMRETNUA:**
   If TMRETNUA = -99, we delete such rows.

3. **Market Capitalization:**
   By bonds, we also acquire the one-month lag CAP (CAP of the bond of the previous month), if the lagged CAP is NA, we drop the record.

4. **Portfolio weights:**
   For Equally-valued return, we assign each bond with the same weight, that is 1/ the number of bonds in that month. For Value-valued return, we weight the bond by their lagged CAP, that is lag_CAP_i/ sum(lag_CAP)

The first 24 records are displayed as follows:

Table 1: Record Sample

	Year	Month	Bond_lag_MV	Bond_Ew_Ret	Bond_Vw_Ret
1	1926	1	809	0.0108	0.0134
2	1926	2	809	0.0050	0.0062
3	1926	3	809	0.0021	0.0039
4	1926	4	809	0.0064	0.0074
5	1926	5	809	0.0019	0.0015
6	1926	6	809	0.0033	0.0037
7	1926	7	809	0.0028	0.0007
8	1926	8	809	0.0033	0.0004
9	1926	9	809	0.0038	0.0038
10	1926	10	809	0.0057	0.0096
11	1926	11	809	0.0093	0.0152
12	1926	12	809	0.0052	0.0075
13	1927	1	809	0.0057	0.0073
14	1927	2	809	0.0088	0.0088
15	1927	3	809	0.0159	0.0242
16	1927	4	809	0.0023	-0.0001
17	1927	5	809	0.0074	0.0104
18	1927	6	809	-0.0028	-0.0064
19	1927	7	809	0.0057	0.0051
20	1927	8	809	0.0051	0.0073
21	1927	9	809	0.0053	0.0022
22	1927	10	809	0.0119	0.0101
23	1927	11	809	0.0055	0.0092
24	1927	12	809	0.0061	0.0070

Question 2

1. **Stock_Excess_Vw_Ret:**
   Stock_Vw_Ret from PS1 – corresponding 30-day Treasury yields.

2. **Bond_Excess_Vw_Ret:**
   Bond_Vw_Ret from Q1 – corresponding 30-day Treasury yields.

The first 24 records are displayed as follows:

Table 2: Record Sample

	Year	Month	Stock_lag_MV	Stock_Excess_Vw_Ret	Bond_lag_MV	Bond_Excess_Vw_Ret
1	1926	1	26829.38	-0.002751	809	0.010449
2	1926	2	27017.23	-0.036768	809	0.003432
3	1926	3	26127.23	-0.067778	809	0.001122
4	1926	4	24323.52	0.033928	809	0.004328
5	1926	5	25269.52	0.011958	809	0.001158
6	1926	6	25499.71	0.051141	809	0.000241
7	1926	7	26449.01	0.029557	809	-0.001543
8	1926	8	27317.89	0.026364	809	-0.002136
9	1926	9	28348.24	0.003627	809	0.001527
10	1926	10	28154.44	-0.032395	809	0.006405
11	1926	11	27254.17	0.025307	809	0.012107
12	1926	12	28272.67	0.026222	809	0.004722
13	1927	1	29608.79	-0.000563	809	0.004837
14	1927	2	29747.28	0.041730	809	0.006230
15	1927	3	31084.31	0.001341	809	0.021241
16	1927	4	31125.37	0.004554	809	-0.002646
17	1927	5	31348.12	0.054492	809	0.007392
18	1927	6	33433.19	-0.023383	809	-0.008983
19	1927	7	32613.92	0.072609	809	0.002109
20	1927	8	34753.48	0.019643	809	0.004543
21	1927	9	35716.98	0.047604	809	0.000104
22	1927	10	38809.14	-0.043120	809	0.007580
23	1927	11	37222.67	0.065214	809	0.007114
24	1927	12	39337.43	0.020870	809	0.004770

Question 3

1. **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)

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

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

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

5. **Unlevered_k, Excess_Unlevered_RP_Ret, Levered_k, Excess_Levered_RP_Ret** are as defined in Asness et al. (2012)

Constructing Risk Parity Portfolios

We construct simple Risk Parity portfolios (hereafter RP) that are rebalanced monthly such as to target an equal risk allocation across the available asset classes. To construct a RP portfolio, at the end of each calendar month, we estimate volatilities $\hat{\sigma}_i$ of all the available asset classes (using data up to month t-1) and set the portfolio weight in asset class *i* to:

$$w_{t,i} = k_t \hat{\sigma}_{t,i}^{-1} \qquad i = 1,..,n$$

We estimate $\hat{\sigma}_{t,i}$ as the 3-year rolling volatility of monthly excess returns, but we get similar results for other volatility estimates. The number k_t is the same for all assets and controls the amount of leverage (or the target volatility) of the RP portfolio. We consider two very simple RP portfolios (i.e., two choices of k_t): The first portfolio is an unlevered RP, obtained by setting

$$k_t = 1/(\sum_i \hat{\sigma}_{t,i}^{-1})$$

This corresponds to a simple value-weighted portfolio that over-weights less volatile assets and under-weights more volatile assets.

The second portfolio is a levered RP obtained by keeping k_t constant over time:

$$k_t = k$$

The first 22 records are displayed as follows:

Table 3: Record Sample

Year	Month	Stock_Excess_Vw Ret	Bond_Excess_Vw Ret	Excess_60_40_Ret	Excess_Vw_Ret	Stock_inverse_sigma_hat	Bond_inverse_sigma_hat	Unlevered_k	Excess_Unlevered RP_Ret	Levered_k	Excess_Levered_RP_Ret
1926	1	-0.0028	0.01045	0.00253	-0.0024	NA	NA	NA	NA	0.02575	NA
1926	2	-0.0368	0.00343	-0.0207	-0.0356	NA	NA	NA	NA	0.02575	NA
1926	3	-0.0678	0.00112	-0.0402	-0.0657	NA	NA	NA	NA	0.02575	NA
1926	4	0.03393	0.00433	0.02209	0.03298	NA	NA	NA	NA	0.02575	NA
1926	5	0.01196	0.00116	0.00764	0.01162	NA	NA	NA	NA	0.02575	NA
1926	6	0.05114	0.00024	0.03078	0.04958	NA	NA	NA	NA	0.02575	NA
1926	7	0.02956	-0.0015	0.01712	0.02863	NA	NA	NA	NA	0.02575	NA
1926	8	0.02636	-0.0021	0.01496	0.02554	NA	NA	NA	NA	0.02575	NA
1926	9	0.00363	0.00153	0.00279	0.00357	NA	NA	NA	NA	0.02575	NA
1926	10	-0.0324	0.00641	-0.0169	-0.0313	NA	NA	NA	NA	0.02575	NA
1926	11	0.02531	0.01211	0.02003	0.02493	NA	NA	NA	NA	0.02575	NA
1926	12	0.02622	0.00472	0.01762	0.02562	NA	NA	NA	NA	0.02575	NA
1927	1	-0.0006	0.00484	0.0016	-0.0004	NA	NA	NA	NA	0.02575	NA
1927	2	0.04173	0.00623	0.02753	0.04079	NA	NA	NA	NA	0.02575	NA
1927	3	0.00134	0.02124	0.0093	0.00185	NA	NA	NA	NA	0.02575	NA
1927	4	0.00455	-0.0026	0.00167	0.00437	NA	NA	NA	NA	0.02575	NA
1927	5	0.05449	0.00739	0.03565	0.05331	NA	NA	NA	NA	0.02575	NA
1927	6	-0.0234	-0.009	-0.0176	-0.023	NA	NA	NA	NA	0.02575	NA
1927	7	0.07261	0.00211	0.04441	0.0709	NA	NA	NA	NA	0.02575	NA
1927	8	0.01964	0.00454	0.0136	0.0193	NA	NA	NA	NA	0.02575	NA
1927	9	0.0476	0.0001	0.0286	0.04655	NA	NA	NA	NA	0.02575	NA
1927	10	-0.0431	0.00758	-0.0228	-0.0421	NA	NA	NA	NA	0.02575	NA
1927	11	0.06521	0.00711	0.04197	0.06398	NA	NA	NA	NA	0.02575	NA
1927	12	0.02087	0.00477	0.01443	0.02055	NA	NA	NA	NA	0.02575	NA

Question 4

1. **Universe:**
   US Treasury from 1930.1 to 2010.6.

Panel A of Table 2 in Asness, Frazzini, and Pedersen (2012)

Panel A: Long Sample Stocks and Bonds, 1926 - 2010	Excess Return	t-stat Excess Return	Alpha	t-stat Alpha	Volatility	Sharpe Ratio	Skewness	Excess Kurtosis
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
Risk Parity, Unlevered	**2.20**	4.67	**1.39**	4.44	4.25	0.52	0.05	4.58
Risk Parity	**7.99**	4.78	**5.50**	4.30	15.08	0.53	-0.36	1.92
Risk Parity minus Value Weighted	**4.15**	2.95	**5.50**	4.30	12.69	0.33	-0.79	8.30
Risk Parity minus 60-40	**3.34**	2.93	**3.76**	3.33	10.31	0.32	-0.61	5.04

My replication:

	Annualized Mean	t-stat of Annualized Mean	Annualized Standard Deviation	Annualized Sharpe Ratio	Skewness	Excess Kurtosis
CRSP stocks	0.07025268	3.326497	0.18938640	0.3709489	0.28771908	7.882339
CRSP bonds	0.01606883	4.432638	0.03250836	0.4942984	-0.04962615	4.660644
Value-weighted portfolio	0.04111067	2.492001	0.14793787	0.2778915	0.62463636	14.726156
60/40 portfolio	0.04857914	3.744476	0.11634075	0.4175591	0.28151528	7.812484
unlevered RP	0.02297939	4.850759	0.04248170	0.5409245	0.05889961	4.685511
levered RP	0.08204181	4.951699	0.14857783	0.5521807	-0.34957742	1.986367

My replication result is not exactly with the table reported in the paper, but I believe that the difference is economically negligible as for each number, the discrepancy is quite small, so it seems that there is a consistency between my result and the paper. The discrepancy may come from the different methods that we used to treat NA values and the data source we used