Problem Set 2

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Question 1

Construct the equal-weighted bond market return, value-weighted bond market return, and lagged total bond market capitalization using CRSP Bond data 1. Your output should be from January 1926 to December 2017, at a monthly frequency.

Approach –

Data Source –WRDS: CRSP > Annual Update> Treasuries > CRSP TREASURIES - Issue Descriptions and Monthly Time Series. Variables downloaded in files are KYCRSPID MCALDT TMRETNUA TMTOTOUT.
File imported in R and date is formatted as YYYY-MM-DD (R date format). And passed it as input to PS2_Q1 function.

Data cleaning steps:

1. **Universe of bonds**: All the bonds in CRSP treasuries data base have been taken without any filter.

2. **Missing Monthly Unadjusted Return (TMRETNUA)**: Missing returns are marked as '-99'. So, all -99 has been replaced with 0.

3. **Missing Total Amount Outstanding (TMTOTOUT)**: Missing values in amount outstanding are marked as NA. All these NA's have been changed to 0.

4. **Total Amount Outstanding Scaling:** Values in Total Amount Outstanding is in millions so multiplied by 1000000 for actual numbers.

Calculation:

1. **Market Capitalization**: Total Amount Outstanding is considered as market cap for each bond.

2. **Portfolio weights**: Weights of each bond has been calculated by dividing outstanding amount of each bond with total amount outstanding for all the bonds for each month.

3. **Sample period**: Sample period taken is Jan 1926 to Dec 2017.

4. **Calculation of Value Weighted Return**:

$$\text{Value Weighted Return} = \frac{\text{Amount outstanding for bond last month}}{\text{Sum of Total Amount Outstanding of all the bond last month}} * return\ of\ bond\ this\ month$$

5. **Calculation of equal weighted return**:

$$\text{Equal Weighted Return} = \frac{1}{\text{Number of bonds in the market}} * return\ of\ bonds\ this\ month$$

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 2017, at a monthly frequency.

Approach –

Data Source –

Monthly CRSP Stocks - WRDS →CRSP > Annual Update > Stock / Security Files > CRSP Monthly Stock. This time sample period taken is Dec 1925 to Dec 2017 (additional one initial month to have return data for Jan 1926). Output is generate using function PS1_Q1.

Monthly CRSP Bonds – Output from PS2_Q1.

Monthly CRSP Riskless2 - WRDS: CRSP > Annual Update> Index / Treasury and Inflation > US Treasury and Inflation Indexes. Variables downloaded are caldt, t90ret, t30ret data. Caldt has been formatted as YYYY-MM date.

Calculation:

All three tables have been merged as one with date as common key. 30 days risk free return has been subtracted from stock and bond monthly returns to calculate excess value weighted returns. This aggregate table has been names as Monthly CRSP Universe.

Question 3

Calculate the monthly unlevered and levered risk-parity portfolio returns as defined by Asness, Frazzini, and Pedersen (2012). 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 2017, at a monthly frequency.

Calculations:

1. **Volatility of Excess Return for Bonds and Stocks:** As per the approach taken in the research paper, for each month volatility of return has been calculated using historical data of last 36 months. (e.g. return volatility of 37th month is standard deviation of month 1 to month 36). For initial 36 months where there are no sufficient historical records, a rolling window length has been used to calculated volatility i.e. standard deviation of all the record since beginning of data.

2. **Portfolio Excess_Vw_Return:**

$$\text{Stock\_weight} = \frac{\text{Stock lagged Market Value}}{\text{Stock lagged Market Value} + \text{Bond lagged Market Value}}$$

$$Bond\_\text{weight} = \frac{\text{Stock lagged Market Value}}{\text{Stock lagged Market Value} + \text{Bond lagged Market Value}}$$

$$Excess\_Vw\_return = \text{Stock\_weight} * \text{Stock\_Excess\_Vw\_Ret} + \text{Bond\_weight} * \text{Bond\_Excess\_Vw\_Ret}$$

3. **Portfolio Excess_60-40_Return:**

$$Excess\_60{:}\,40\_return = 0.6 * \text{Stock\_Excess\_Vw\_Ret} + 0.4 * \text{Bond\_Excess\_Vw\_Ret}$$

4. **Excess_Unlevered_Risk_Parity_Portfolio_Return:**

$$Unlevered\ K = 1/(\ \sigma_{\text{stock}}^{-1} + \ \sigma_{\text{Bond}}^{-1}\ )$$

$$\text{Stock\_weight} = \text{Unlevered\_K} * \ \sigma_{\text{stock}}^{-1}$$

$$\text{Bond\_weight} = \text{Unlevered\_K} * \ \sigma_{\text{Bond}}^{-1}$$

$$Excess\_Unlevered\_RP\_return = \text{Stock\_weight}_{\text{lagged}} * \text{Stock\_Excess\_Vw\_Ret} + \text{Bond\_weight}_{\text{lagged}} * \text{Bond\_Excess\_Vw\_Ret}$$

One month lagged weights have been uses to calculate returns.

5. **Excess Levered_Risk Parity_Portfolio_Return:**

$$\text{Levered\_K} = \frac{\text{standard deviation of Excess\_Vw\_Return}}{\sigma_{\text{stock}}^{-1} * \text{Stock\_Excess\_Vw\_Ret} + \sigma_{\text{Bond}}^{-1} * \text{Bond\_Excess\_Vw\_Ret}}$$

$$\text{Stock\_weight} = \text{Levered\_K} * \sigma_{\text{stock}}^{-1}$$

$$\text{Bond\_weight} = \text{Levered\_K} * \sigma_{\text{Bond}}^{-1}$$

$$Excess\_Levered\_RP\_return = \text{Stock\_weight}_{\text{lagged}} * \text{Stock\_Excess\_Vw\_Ret} + \text{Bond\_weight}_{\text{lagged}} * \text{Bond\_Excess\_Vw\_Ret}$$

One month lagged weights have been uses to calculate returns.

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?

	Annualized Mean	t-stat of Annualized Mean	Annualized Standard Deviation	Annualized Sharpe Ratio	Skewness	Excess Kurtosis
CRSP stocks	6.74%	3.192	19.08%	0.354	0.229	7.643
CRSP bonds	1.24%	3.578	3.12%	0.396	-0.096	4.672
Value-weighted portfolio	3.70%	2.245	14.88%	0.249	0.523	14.557
60/40 portfolio	4.54%	3.508	11.69%	0.389	0.245	7.599
unlevered RP	1.92%	4.197	4.12%	0.465	0.092	5.037
levered RP	6.79%	4.119	14.88%	0.456	-0.350	1.925

Table from research paper (Panel A Table 2)

	Annualized Mean	t-stat of Annualized Mean	Annualized Standard Deviation	Annualized 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%	0.4	0.2	7.46
unlevered RP	2.20%	4.67	4.25%	0.52	0.05	4.58
levered RP	7.99%	4.78	15.08%	0.53	–0.36	1.92

1. **Sample period**: Monthly from Jan 1929 to Jul 2010. Entire table has been truncated to align with this sample period.

2. **Skewness**: Skewness has been calculated using skewness function in R moment package on full monthly time series data. There is no annualization or log scaling in calculation of Excess Skewness. Same method for each return series.

3. **Excess Kurtosis:** Using Kurtosis function in moment package, Kurtosis has been calculated for entire monthly data (without any annualization or log scaling). To calculate excess kurtosis, I have subtracted 3 from the Kurtosis value. Same method for each return series.

4. **Annualized Mean:** Mean annual return has been calculated from monthly data using the following formula -

$$\hat{\mu}_A = 12 \times \hat{\mu}_M$$

   Where μ_m is sample mean of all monthly returns.

5. **Annualized Standard Deviation:** Annualized standard deviation has been calculated using the following formula on monthly return and standard deviation.

$$\hat{\sigma}_A = \sqrt{12} \times \hat{\sigma}_M$$

   σ_m standard deviation of monthly return series.

6. **Sharpe Ratio** $= \frac{\text{Annual Mean Excess Return}}{\text{Annual Standard Deviation}}$

7. **T-stat:** t.test function in R has been used on monthly return time series.

Reason for non-zero difference:

The number obtained from exercise and from the panel A, table 2 in the research paper are quite close. The difference, however, are not exactly zero.

The paper uses value weighed return (vwretd) directly from CRSP which has included all the stock market data. While in our calculation value weighted return has been calculated as in Fama French data using New York Stock Exchange, American Stock Exchange, or the Nasdaq Stock Exchange. The time period shown in the table 2 of research paper is 1926 to 2010 while in our case calculation has been done for the sample period Jan 1929 to Jun 2010.

Method of annual return and annual standard deviation calculation has not been discussed in the paper. There could be difference in the method of annualization of return and standard deviation calculation and hence sharp ratio.

References-

- Wharton Research Data Services (WRDS) CRSP data taken on Apr 15, 2018 (CRSP > Annual Update > Stock / Security Files > CRSP Monthly Stock).
- Wharton Research Data Services (WRDS) CRSP data taken on Apr 15, 2018: (CRSP > Annual Update> Index / Treasury and Inflation > US Treasury and Inflation Indexes)