Problem Set 2

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Question 1

Abstract:
Use CRSP Bonds data to construct equal-weighted, value-weighted bond market return and lagged total bond market capitalization. Input data and output result date start from January 1926 to December 2017 which is available on WRDS > CRSP website.

-Inputs:

1. data.table **CRSP_Bonds**, with column:

Variable Name	Variable type
KYCRSPID	Character
MCALDT	Date
TMRETNUA	Numeric
TMTOTOUT	Integer

-Outputs:

Start from January 1926 to December 2017

1. data.table, with with each row corresponding to a unique year and month, with columns:

Variable Name	Variable type	Variable Description
Year	Integer	Year
Month	Integer	Month
Bond_lag_MV	Integer	Total market value the previous month (in millions)
Bond_Ew_Ret	Numeric	Equal-weighted returns
Bond_Vw_Ret	Numeric	Value-weighted returns

Data Processing:

1. **Missing Data**: Detecting the missing data code in the data, such as -66, -77, -88, -99, etc…… which represent different reasons of the missing data. Assign those data with NA. Remove every row that has NA missing data in return,

date or outstanding amount.

2. **Return**: Use TMRETNUA as the return of Bonds.
3. **Market Value**: Use TMTOTOUT as the Market Value of Bonds.
4. **Lag Market Value**: Calculate lag market value bond by bond. Each bond is a data group. For each group, the first row of lag Market Value is always NA. The last value of Market Value will always be discard because the bond will no longer exist in the next period.
5. **Portfolio Weight**: Value based weight is calculated by market value divided by total market value.
6. **Sample Period**: Use the whole data set in WRDS-CRSP which starts from January 1926 to December 2017.

Question 2

Abstract:
Aggregate Bonds, Stocks and risk-less data set. For each year-month, calculate the lagged Market Value and Excess Value-weighted returns for both bonds and stocks. Input and output data date start from January 1926 to December 2017.

-Inputs:

1. data.table **Monthly_CRSP_Stocks**, an extended version of the output of PS1_Q1.
2. data.table **Monthly_CRSP_Bonds**, the output of PS2_Q1.
3. data.table **Monthly_CRSP_Riskless**, with columns:

Variable Name	Variable type
caldt	Date
t90ret	Numeric
t30ret	Numeric

-Outputs:

Start from January 1926 to December 2017

1. data.table, with with each row corresponding to a unique year and month, with columns:

Variable Name	Variable type	Variable Description
Year	Integer	Year
Month	Integer	Month
Stock_lag_MV	Numeric	Total market value the previous month (in millions)
Stock_Vw_Ret	Numeric	Value-weighted returns
Bond_lag_MV	Integer	Total market value the previous month (in millions)
Bond_Vw_Ret	Numeric	Value-weighted returns

Data Processing:

1. **Risk-less rate**: Use t30ret as the risk-free rate for calculation of Excess Return.
2. **Merge Datasets**: Merge the input data sets and order by Year-Month.
3. **Excess Return**: Value-weighted return above the risk-free rate of return.

Question 3

Abstract:
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 $\hat{\sigma}$ over the longest matched holding period of both.

-Inputs:

1. data.table **Monthly_CRSP_Universe**, the output of PS2_Q2

-Outputs:

Start from January 1926 to December 2010 for comparison with the paper result.

1. data.table, with with each row corresponding to a unique year and month, with columns:

Variable Name	Variable type	Variable Description
Year	Integer	Year
Month	Integer	Month
Stock_Excess_Vw_Ret	Numeric	
Bond_Excess_Vw_Ret	Numeric	
Excess_Vw_Ret	Numeric	Value-weighted portfolio above riskless rate
Excess_60_40_Ret	Numeric	60-40 stock-bond portfolio return above riskless rate
Stock_inverse_sigma_hat	Numeric	As defined by Asness et at. (2012)
Bond_inverse_sigma_hat	Numeric	As defined by Asness et at. (2012)
Unlevered_k	Numeric	As defined by Asness et at. (2012)
Excess_Unlevered_RP_Ret	Numeric	Unlevered RP portfolio return above riskless rate
Levered_k	Numeric	To match $\hat{\sigma}$ of Excess_Vw_Ret
Excess_Levered_RP_Ret	Numeric	RP portfolio return above riskless rate

Data Processing:

1. **Date constrain**: Remove data with date later than December 2010.
2. **Excess Value-weighted Return**:

$$\frac{Lagged\ Stock\ Market\ Value}{Total\ Lagged\ Market\ Value} \times Stock\ ExRet + \frac{Lagged\ bond\ Market\ Value}{Total\ Lagged\ Market\ Value} \times Bond\ ExRet$$

3. **Excess 60/40 Return**: $0.6 \times Stock\ ExRet + 0.4 \times Bond\ ExRet$
4. **Stock inverse sigma hat**: $\widehat{\boldsymbol{\sigma}}_{\boldsymbol{t}}^{-\mathbf{1}}$**,** 3-year rolling volatility of stock monthly excess returns, using data up to $t-1$
5. **Bond inverse sigma hat**: $\widehat{\boldsymbol{\sigma}}_{\boldsymbol{t}}^{-\mathbf{1}}$**,** 3-year rolling volatility of bond monthly excess returns, using data up to $t-1$

6. **Unlevered k:** $k_t = \frac{1}{\sum_i \hat{\sigma}_{t,i}^{-1}}$, i = 1, 2, ……, n, for n types of asset. In our case, n=2

7. **Excess Unlevered RP Return:**

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

$$r_t^{RP} = \sum_i w_{t-1,i}(r_{t,i} - rf_t)$$

n, for n types of asset. In our case, n=2

8. **Levered k:** $k_t = k,\ k$ is constant across periods such that the annualized volatility of this portfolio matches the ex post realized volatility of the benchmark (Value-weighted portfolio). That is,

$$\sigma_{levered\ RP} = sigma\big(\ k\big(\hat{\sigma}_{t,stock}^{-1} \times ExRet_{stock} + \hat{\sigma}_{t,bond}^{-1} \times ExRet_{bond}\big)\ \big)$$
$$= sigma(Value - weighted\ portfolio\ ExRet)$$

9. **Excess levered RP Return:**

$$w_{t,i} = k\ \hat{\sigma}_{t,i}^{-1}$$

$$r_t^{RP} = \sum_i w_{t-1,i}(r_{t,i} - rf_t)$$

Question 4

Abstract:
Replicate and report Panel A of Table 2 in Asness, Frazzini, and Pedersen (2012), except for Alpha and t-stat of Alpha columns. Specically, 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 1929 to December 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?

-Inputs:

1. data.table **Port_Rets**, the output of PS2_Q3.

-Outputs:

6 x 6 numeric matrix, reproducing part of the Long Sample subtable. Match the formatting of the paper to the extent possible. Rows: CRSP stocks, CRSP bonds, Value-weighted portfolio, 60/40 portfolio, unlevered RP, and levered RP. Columns: Annualized Mean, t-stat of Annualized Mean, Annualized Standard Deviation, Annualized Sharpe Ratio, Skewness, and Excess Kurtosis.

	Annualized Mean	t-stat of Annualized Mean	Annualized Standard Deviation	Annualized Sharpe Ratio	Skewness	Excess Kurtosis
CRSP Stocks	0.06979989	3.308144	0.19106326	0.3653234	0.22126214	7.573472
CRSP Bonds	0.01560858	4.295469	0.03290482	0.4743552	-0.01950794	4.379452
Value-weighted portfolio	0.04018445	2.420978	0.15030525	0.2673523	0.47755656	13.928288
60/40 portfolio	0.04812336	3.721895	0.11708433	0.4110145	0.23594199	7.517031
unlevered RP	0.02246071	4.773740	0.04260609	0.5271714	0.05257090	4.533946
levered RP	0.08067447	4.871938	0.14994821	0.5380155	-0.34621063	1.920148

(Replicated Portfolio outcome)

Data Processing:

1. **Data Cleaning:** Remove NA data for the first three years in the data because we calculate sigma hat in a 3-year rolling basis so that the first three would not have any sigma as weight for the calculation.
2. **Annualized Mean**: Average of Monthly return, and times 12 as annualization.
3. **t-stat of Annualized Mean**: Mean(data) / (sd(data)/ sqrt(number of data))

Table 2. Historical Performance of the Risk Parity, Market, and 60/40 Portfolios

	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
RP minus value-weighted	4.15*	2.95	5.50*	4.30	12.69	0.33	–0.79	8.30
RP minus 60/40	3.34*	2.93	3.76*	3.33	10.31	0.32	–0.61	5.04

(Paper Result)

Discussion:

We can observe from the result of our replicated portfolio that we do obtain a precise outcome as the paper's result. Most of the errors are insignificant and is negligible because the periods of our data and the paper are slightly different. One is from January 1929 to December 2010, the other one January 1929 to June 2010. Besides, the data cleaning methodology which is not mentioned in the paper could be different. We simply remove all the data with NA or missing value while the paper did not reveal their method for cleaning NA data. Furthermore, in handling the lagged market capital, we calculated lagged market value bond by bond, which could generate more NA data in the first row of each group and could discard the last row of each group for that the bond will no longer exist in the next period. Both of the data processing methods can result in a smaller bond market capital that cause a relatively higher rate of return that the paper's result.