Problem Set 2: Risk Parity

Professor Bernard Herskovic
bernardherskovic@anderson.ucla.edu

Due on **Sunday April 27.** This is an **individual assignment**, but you can discuss it with your classmates. If you discuss with other classmates, indicate their names in your write-up. Please submit Python code (.py file only) as well as a separate write-up. Explain the procedure and your answers clearly in the write-up (such that someone unfamiliar with the problem could solve it). Code must be formatted as instructed in order to receive a grade. Use Bruin Learn to submit your answers.

You should submit two files:

- .py **PS2_YourStudentID** (for example, PS2_012345678.py), with **all** code used in answering the questions written below
- .pdf **PS2_YourStudentID** (for example, PS2_012345678.pdf), with discussion on how you answered the questions written below, as well as responses to any particular questions asked

This problem set is based on the paper "Leverage Aversion and Risk Parity" by Clifford S. Asness, Andrea Frazzini, and Lasse H. Pedersen (2012, Financial Analysts Journal, Volumne 68, Number 1).

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 2024, at a monthly frequency.

Hint: read Appendix A in Asness, Frazzini, and Pedersen (2012), detail on the data construction.

- Suggested function: **PS2_Q1**
  - Inputs
    - dataframe **CRSP_Bonds**, with columns:

Variable Name	Variable type
KYCRSPID	string
MCALDT	datetime
TMRETNUA	float
TMTOTOUT	float

      - This should be the data as pulled from WRDS, with one exception. Format the MCALDT column as a datetime. This should be the full dataset available on WRDS; do not pre-filter by MCALDT.

[1] Available at WRDS: `https://wrds-www.wharton.upenn.edu/`. Bond data are available from WRDS: CRSP > Annual Update> Treasuries > CRSP TREASURIES - Issue Descriptions and Monthly Time Series.

  - Output
    - dataframe, 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	float	Total market value the previous month (in millions)
Bond_Ew_Ret	float	Equal-weighted returns
Bond_Vw_Ret	float	Value-weighted returns

      - Note: Returns should be formatted in decimal proportion (not percent).

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 2024, at a monthly frequency.

- Suggested function: **PS2_Q2**
  - Inputs
    - dataframe **Monthly_CRSP_Stocks**, an extended version of the output of **PS1_Q1**
    - dataframe **Monthly_CRSP_Bonds**, the output of **PS2_Q1**
    - dataframe **Monthly_CRSP_Riskless**[2], with columns:

Variable Name	Variable type
caldt	datetime
t90ret	float
t30ret	float

      - This should be the data as pulled from WRDS, with one exception. Format the caldt column as a datetime. This should be the full dataset available on WRDS; do not pre-filter by caldt.
  - Output
    - dataframe, 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	float	Total market value the previous month (in millions)
Stock_Excess_Vw_Ret	float	Value-weighted return above riskless rate
Bond_lag_MV	float	Total market value the previous month (in millions)
Bond_Excess_Vw_Ret	float	Value-weighted return above riskless rate

      - Note: Returns should be formatted in decimal proportion (not percent).

[2] Available at WRDS: `https://wrds-www.wharton.upenn.edu/`. Treasury data is available from WRDS: CRSP > Annual Update> Index / Treasury and Inflation > US Treasury and Inflation Indexes.

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 $\hat{\sigma}$ over the longest matched holding period of both. Your output should be from January 1926 to December 2024, at a monthly frequency.

- Suggested function: **PS2_Q3**
  - Inputs
    - dataframe **Monthly_CRSP_Universe**, the output of **PS2_Q2**
  - Output
    - dataframe, 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	float	
Bond_Excess_Vw_Ret	float	
Excess_Vw_Ret	float	Value-weighted portfolio return above riskless rate
Excess_60_40_Ret	float	60-40 portfolio return above riskless rate
Stock_inverse_sigma_hat	float	As defined by Asness et al. (2012)
Bond_inverse_sigma_hat	float	As defined by Asness et al. (2012)
Unlevered_k	float	As defined by Asness et al. (2012)
Excess_Unlevered_RP_Ret	float	Unlevered RP portfolio return above riskless rate
Levered_k	float	To match $\hat{\sigma}$ of Excess_Vw_Ret
Excess_Levered_RP_Ret	float	RP portfolio return above riskless rate

  - Note: Returns should be formatted in decimal proportion (not percent).

[3] "Leverage Aversion and Risk Parity" by Clifford S. Asness, Andrea Frazzini, and Lasse H. Pedersen (2012, Financial Analysts Journal, Volumne 68, Number 1).

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 1929 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 for a nonzero difference?

- Suggested function: **PS2_Q4**
  - Input
    - dataframe **Port_Rets**, the output of **PS2_Q3**
  - Output
    - 6×6 numeric matrix/dataframe, 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.

Additional Material

As a reference to guide your replication exercise, here is the replication table obtained by the professor:

(Question 4) Summary statistics:

	Excess Return	t-stat	Volatility	Sharpe Ratio	Skewness	Excess Kurtosis
CRSP stocks	6.71	3.16	19.15	0.35	0.22	7.84
CRSP bonds	1.36	4.31	2.84	0.48	0.24	4.36
Value-weighted portfolio	3.47	2.59	12.06	0.29	-0.58	4.63
60/40 portfolio	4.57	3.53	11.68	0.39	0.23	7.58
RP, unlevered	2.04	5.05	3.64	0.56	0.10	2.75
RP	6.68	5.00	12.06	0.55	-0.38	2.11
RP minus value-weighted	3.21	3.11	9.32	0.35	0.11	3.72
RP minus 60/40	2.11	2.14	8.89	0.24	-0.68	6.53

Sample from 01/31/1929 to 06/30/2010