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Discussed with: Nanhao Wang

Q1.

- Shareholders' equity (SHE): variable reported in Compustat is "Stockholders' Equity - Total" (SEQ). If not available, use "Common/Ordinary Equity - Total" (CEQ) plus "Preferred/Preference Stock (Capital) - Total" (PSTK). If not avail- able, use "Assets - Total" (AT) minus "Liabilities - Total" (LT) minus "Minority Interest (Balance Sheet)" (MIB). If not available, use AT minus LT.
- Deferred taxes and investment tax credit (DT): variable reported in Compustat is "Deferred Taxes and Investment Tax Credit" TXDITC. If not available, use "Investment Tax Credit (Balance Sheet)" (ITCB) plus "Deferred Taxes (Balance Sheet)" (TXDB). If not available, sum what is not missing.
- Book value of preferred stock (PS): Use redemption value, which is variable "Preferred Stock Redemption Value" (PSTKRV). If not available, use liquidation value, which is "Preferred Stock Liquidating Value" (PSTKL). If not available, use par value, which is "Preferred/Preference Stock (Capital) - Total" (PSTK).
- Define book equity (BE) as: BE = SHE − PS + DT − PRBA (need value of SHE to compute BE, other variables included if not missing). The last variable is "Postretirement Benefit Asset" (PRBA), and you will have to get this variable from Compustat's Pension Annual data: merge to Compustat using Compustat's global variable key (GVKEY).
- (optional) For missing value of book equity, you can use historical book equity value available n French's website—Davis, Fama and French (2000)'s data.

- To calculate book-to-market, you will have to sum the market equity of subsidiaries. A company (permanent identifier variable: PERMCO) may have different securities (identified by PERMNO).

Reference: https://wrds-www.wharton.upenn.edu/pages/support/applications/risk-factors-and-industry-benchmarks/fama-french-factors-python/

Connect to WRDS using Python package wrds to download all the data sets: Compustat, CRSP, and linked table.

Create Shareholders' equity, deferred taxes and investment tax credit, preferred stock, and create book equity as the instructions above by using Compustat data set.

Create total market cap of all the firms by sum up all the me across different PERMNO according to the same PERMNO on a given date. And denote the market cap of each December as dec_me.

Create a column called 'ffyear', which is the fiscal year corresponding to the period from July last year to this June.

Link link table with compustat by gvkey. And then link with CRSP by ffyear and PERMNO. Calculate book-to-market using be/dec_me.

Extract July data as the benchmark to rebalance for the next fiscal year. And then extract NYSE data to create breakpoints for both size and book-to-market. And then create decile by using those breakpoints.

Merge back the deciles to get the final dataframe based on fiscal year, so that for each PERMNO, the decile does not change within the same fiscal year.

Calculate value-weighted return based on both size decile and book-to-market decile.

For SMB, it's similar to size decile except that the market cap is divided to 2 parts. And for HML, it's similar to book-to-market decile expect that the book-to-market is divided to 3 parts: the lower 30%, higher 30% and 40% in the middle. $SMB = \frac{1}{3}(Small\ value + Small\ neutral + Small\ growth) - \frac{1}{3}(Big\ value + Big\ neutral + Big\ growth)$ $HML = \frac{1}{2}(Small\ value + Big\ value) - \frac{1}{2}(Small\ growth + Big\ growth)$

Output of question 1

	Year	Month	port	Size_Ret	BtM_Ret	HML_Ret	SMB_Ret
0	1973	1	1.0	-0.036063	-0.010181	2.223979	-3.108647
1	1973	1	2.0	-0.041768	-0.049391	2.223979	-3.108647
2	1973	1	3.0	-0.050724	-0.050517	2.223979	-3.108647
3	1973	1	4.0	-0.066884	-0.047901	2.223979	-3.108647
4	1973	1	5.0	-0.054671	-0.018638	2.223979	-3.108647
5	1973	1	6.0	-0.046942	-0.004542	2.223979	-3.108647
6	1973	1	7.0	-0.057130	-0.017961	2.223979	-3.108647
7	1973	1	8.0	-0.047499	-0.011810	2.223979	-3.108647
8	1973	1	9.0	-0.066290	-0.029559	2.223979	-3.108647
9	1973	1	10.0	-0.005412	-0.048175	2.223979	-3.108647
10	1973	2	1.0	-0.077244	-0.024979	2.147442	-3.591549
11	1973	2	2.0	-0.086348	-0.046918	2.147442	-3.591549
12	1973	2	3.0	-0.076031	-0.049377	2.147442	-3.591549
13	1973	2	4.0	-0.064241	-0.042010	2.147442	-3.591549
14	1973	2	5.0	-0.075851	-0.053065	2.147442	-3.591549
15	1973	2	6.0	-0.065527	-0.050147	2.147442	-3.591549
16	1973	2	7.0	-0.064866	-0.046174	2.147442	-3.591549
17	1973	2	8.0	-0.049762	-0.057316	2.147442	-3.591549
18	1973	2	9.0	-0.036469	-0.025129	2.147442	-3.591549
19	1973	2	10.0	-0.032830	-0.039739	2.147442	-3.591549
20	1973	3	1.0	-0.025368	-0.015935	2.278014	-2.354737
21	1973	3	2.0	-0.029205	-0.008121	2.278014	-2.354737
22	1973	3	3.0	-0.017010	-0.021288	2.278014	-2.354737
23	1973	3	4.0	-0.027501	-0.014330	2.278014	-2.354737
24	1973	3	5.0	-0.021702	0.009721	2.278014	-2.354737
25	1973	3	6.0	-0.027830	0.007591	2.278014	-2.354737
26	1973	3	7.0	-0.015350	0.007414	2.278014	-2.354737
27	1973	3	8.0	-0.029137	0.004760	2.278014	-2.354737

```
28    1973       3   9.0 -0.010600 -0.008195  2.278014 -2.354737
29    1973       3  10.0  0.002189  0.019358  2.278014 -2.354737
...    ...     ...   ...       ...       ...       ...       ...
5490  2018      10   1.0 -0.106321 -0.115916  3.490169 -4.552330
5491  2018      10   2.0 -0.112489 -0.066827  3.490169 -4.552330
5492  2018      10   3.0 -0.117944 -0.050660  3.490169 -4.552330
5493  2018      10   4.0 -0.114711 -0.066817  3.490169 -4.552330
5494  2018      10   5.0 -0.112032 -0.091214  3.490169 -4.552330
5495  2018      10   6.0 -0.095991 -0.049168  3.490169 -4.552330
5496  2018      10   7.0 -0.104168 -0.044148  3.490169 -4.552330
5497  2018      10   8.0 -0.088892 -0.059503  3.490169 -4.552330
5498  2018      10   9.0 -0.078257 -0.060141  3.490169 -4.552330
5499  2018      10  10.0 -0.066754 -0.083860  3.490169 -4.552330
5500  2018      11   1.0 -0.020913  0.035290  0.375407 -0.890703
5501  2018      11   2.0 -0.006387 -0.024576  0.375407 -0.890703
5502  2018      11   3.0  0.012520  0.024782  0.375407 -0.890703
5503  2018      11   4.0  0.031010  0.040562  0.375407 -0.890703
5504  2018      11   5.0  0.015718  0.016926  0.375407 -0.890703
5505  2018      11   6.0  0.015628  0.025952  0.375407 -0.890703
5506  2018      11   7.0  0.039732  0.018410  0.375407 -0.890703
5507  2018      11   8.0  0.020782  0.020342  0.375407 -0.890703
5508  2018      11   9.0  0.017583  0.028547  0.375407 -0.890703
5509  2018      11  10.0  0.017759 -0.001027  0.375407 -0.890703
5510  2018      12   1.0 -0.125755 -0.081975 -1.121218 -2.589685
5511  2018      12   2.0 -0.122696 -0.095641 -1.121218 -2.589685
5512  2018      12   3.0 -0.116662 -0.080497 -1.121218 -2.589685
5513  2018      12   4.0 -0.124721 -0.083660 -1.121218 -2.589685
5514  2018      12   5.0 -0.121940 -0.109434 -1.121218 -2.589685
5515  2018      12   6.0 -0.116842 -0.108027 -1.121218 -2.589685
5516  2018      12   7.0 -0.112798 -0.113162 -1.121218 -2.589685
5517  2018      12   8.0 -0.105454 -0.110789 -1.121218 -2.589685
5518  2018      12   9.0 -0.093070 -0.099780 -1.121218 -2.589685
5519  2018      12  10.0 -0.087640 -0.121404 -1.121218 -2.589685
```

Q2.

	1	2	3	4	5	6
Annualized Mean	4.956	6.166	7.519	7.755	7.186	7.552
Annualized Volatility	18.290	16.487	16.095	16.462	15.850	15.625
Sharpe Ratio	0.271	0.374	0.467	0.471	0.453	0.483
Skewness	-0.236	-0.443	-0.547	-0.491	-0.472	-0.367
correlation	0.991	0.980	0.971	0.970	0.964	0.968

	6	7	8	9	10	Long-Short
Annualized Mean	7.552	7.571	7.987	8.289	9.297	4.341
Annualized Volatility	15.625	15.442	15.895	15.847	19.332	15.390
Sharpe Ratio	0.483	0.490	0.502	0.523	0.481	0.282

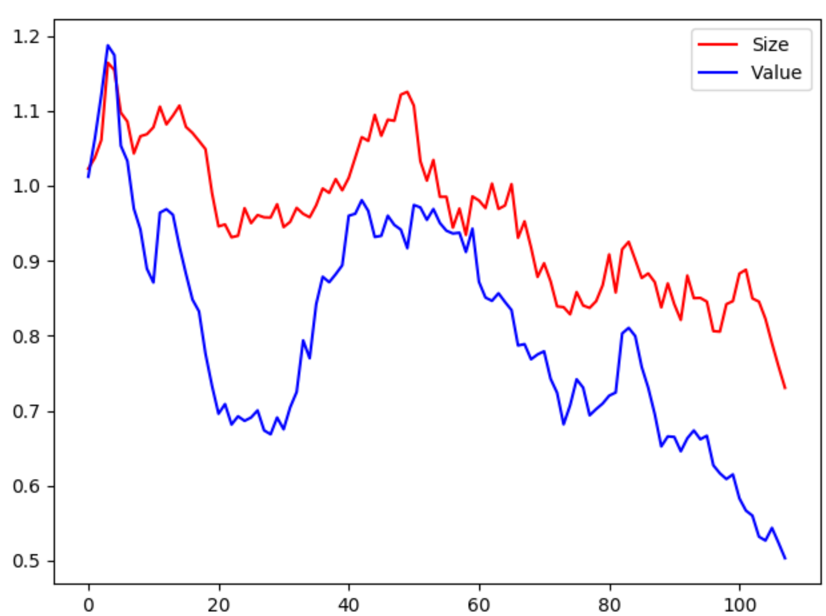
Skewness	-0.367	-0.273	-0.520	-0.284	-0.162	0.354
correlation	0.968	0.952	0.952	0.943	0.951	0.906

Q3.

	1	2	3	4	5	6
Annualized Mean	4.956	6.166	7.519	7.755	7.186	7.552
Annualized Volatility	18.290	16.487	16.095	16.462	15.850	15.625
Sharpe Ratio	0.271	0.374	0.467	0.471	0.453	0.483
Skewness	-0.236	-0.443	-0.547	-0.491	-0.472	-0.367
correlation	0.991	0.980	0.971	0.970	0.964	0.968

	6	7	8	9	10	Long-Short
Annualized Mean	7.551558	7.570848	7.987096	8.289102	9.296549	4.340931
Annualized Volatility	15.625131	15.442419	15.895425	15.847016	19.331899	15.389518
Sharpe Ratio	0.483296	0.490263	0.502478	0.52307	0.480892	0.282071
Skewness	-0.367341	-0.273134	-0.520222	-0.284202	-0.161642	0.353955
correlation	0.968325	0.952223	0.951935	0.943369	0.951071	0.905526

Q4.



According to the graph above, the value and size anomaly worked in the past few years.

Q5.

decile	SMB	HML
Annualized Mean	2.305072	3.844527
Annualized Volatility	10.661128	10.415698
Sharpe Ratio	0.216213	0.369109
Skewness	0.540577	0.036251
correlation	0.992527	0.971065

Q6.