Empirical Assignment

Asset Pricing – 2023

Instructions: Submit your answers as an Excel file via Canvas. If you prefer to solve the problems using some other statistical software you are free to do so, but your answers should nevertheless be submitted as an Excel file.
Deadline: Friday 17th of November at 17:00.

Problem 1. In this problem you are asked to analyse the five Fama-French asset pricing factors (Mkt-Rf, SMB, HML, RMW, and CMA) discussed in "A five-factor asset pricing model" by Fama and French (2015), as well as factors for momentum (MOM) and short-term reversal (STREV). The data for the problem can be found in the file "ap-2023-ff-data.xlsx," which contains monthly factor returns from Jan-1964 to Dec-2021.

Note that you can perform portfolio optimizations and regressions in Excel with the Solver and Analysis ToolPak add-ins. You can activate the add-ins from Options $\rightarrow$ Add-ins $\rightarrow$ Manage Excel Add-ins.

(a) Using the entire sample period, construct a portfolio from the Mkt-Rf, SMB, and HML factors in such a way that (1) the Sharpe ratio of the portfolio is maximized, (2) the portfolio weight of each factor is greater than or equal to zero, (3) the portfolio weights sum up to one, and (4) the portfolio weights do not change over time. What are the portfolio weights of the different factors? What is the monthly Sharpe ratio of the portfolio? When calculating and maximizing the Sharpe ratio, assume for simplicity that the risk-free rate is zero.

(b) Regress the RMW factor returns on the Mkt-Rf, SMB, and HML factors:

$$\text{RMW}_t = \alpha + \beta_1 \text{Mkt-Rf}_t + \beta_2 \text{SMB}_t + \beta_3 \text{HML}_t + \varepsilon_t.$$

Can the Fama-French three-factor model explain the returns of the RMW factor?

(c) Regress the CMA factor returns on the Mkt-Rf, SMB, and HML factors:

$$\text{CMA}_t = \alpha + \beta_1 \text{Mkt-Rf}_t + \beta_2 \text{SMB}_t + \beta_3 \text{HML}_t + \varepsilon_t.$$

Can the Fama-French three-factor model explain the returns of the CMA factor?

(d) Repeat the calculations in (a) using all five Fama-French factors. What are the portfolio weights of the different factors? What is the monthly Sharpe ratio of the portfolio? Briefly discuss the results in light of your results from (b) and (c).

(e) Regress the HML factor returns on the other Fama-French factors:

$$\text{HML}_t = \alpha + \beta_1 \text{Mkt-Rf}_t + \beta_2 \text{SMB}_t + \beta_3 \text{RMW}_t + \beta_4 \text{CMA}_t + \varepsilon_t.$$

Briefly discuss the results in light of your results from (d). What do the regression results tell us about the relation between the HML factor and the CMA factor?

(f) Regress the momentum (MOM) factor returns on the five Fama-French factors:

$$\text{MOM}_t = \alpha + \beta_1 \text{Mkt-Rf}_t + \beta_2 \text{SMB}_t + \beta_3 \text{HML}_t + \beta_4 \text{RMW}_t + \beta_5 \text{CMA}_t + \varepsilon_t.$$

What is the monthly alpha of the MOM factor?

(g) Regress the short-term reversal (STREV) factor returns on the five Fama-French factors:

$$\text{STREV}_t = \alpha + \beta_1 \text{Mkt-Rf}_t + \beta_2 \text{SMB}_t + \beta_3 \text{HML}_t + \beta_4 \text{RMW}_t + \beta_5 \text{CMA}_t + \varepsilon_t.$$

What is the monthly alpha of the STREV factor?

(h) Repeat the calculations in (a) using all seven factors. What are the portfolio weights of the different factors? What is the monthly Sharpe ratio of the portfolio?

(i) Suppose today is January 1, 2000. Repeat the calculations in (h) using the data from Jan-1964 to Dec-1999. What is the monthly Sharpe ratio of the portfolio? Using the same portfolio weights, what is the out-of-sample monthly Sharpe ratio of the portfolio from Jan-2000 to Dec-2021? Briefly discuss the results.

Problem 2. In this problem you are asked to construct and analyse your own asset pricing factor based on the illiquidity measure $ILLIQ$ from "Illiquidity and stock returns: cross-section and time-series effects" by Amihud (2002). The data for the problem can be found in the file "ap-2023-amihud-data.xlsx," which contains daily dollar volumes of trade, daily returns, and monthly returns for 40 stocks, as well as monthly Fama-French-Carhart factor returns from Jan-1996 to Dec-2015. Each of the stocks is identified by a five-digit code that is derived from the Center for Research in Security Prices (CRSP) database.

Factor Construction

(i) For each stock and each day, calculate the daily $ILLIQ$ measure

$$ILLIQ_{id} = 10^6 \times \frac{|r_{id}|}{dvol_{id}},$$

where r_{id} and $dvol_{id}$ are the return and dollar volume of trade of stock i on day d.

(ii) For each stock and each month, calculate the monthly $ILLIQ$ measure by taking the equally weighted average of the daily $ILLIQ$ values in a given month.

(iii) For each month, sort the stocks into quintiles based on the monthly $ILLIQ$ values, with the most illiquid stocks in quintile one and the most liquid stocks in quintile five.

(iv) For each month excluding Jan-1996, calculate the equally weighted average returns of the stocks in the most illiquid quintile and the stocks in the most liquid quintile. By taking the difference between these returns, calculate the returns of the IML (illiquid minus liquid) factor. To calculate the returns for month t, use the quintile sorts from month $t - 1$. For example, the most illiquid quintile returns for Feb-1996 are calculated using the returns from Feb-1996, but the $ILLIQ$ quintiles from Jan-1996.

Analysis

(a) Calculate the monthly average return, monthly volatility, and monthly Sharpe ratio of the IML factor. When calculating the Sharpe ratio, assume for simplicity that the risk-free rate is zero.

(b) Repeat the calculations in (a) for the subperiods Feb-1996 to Dec-2005 and Jan-2006 to Dec-2015. Briefly discuss the results.

(c) Suppose you invested \$1 into the IML factor at the beginning of Feb-1996. Plot the value of the investment over the sample period. What is the final value of the investment at the end of Dec-2015?

(d) Regress the IML factor returns on the Fama-French-Carhart factors:

$$\text{IML}_t = \alpha + \beta_1 \text{Mkt-Rf}_t + \beta_2 \text{SMB}_t + \beta_3 \text{HML}_t + \beta_4 \text{UMD}_t + \varepsilon_t.$$

Does the IML factor generate a statistically significant alpha that is not explained by the Fama-French-Carhart model?

(e) The IML factor in this problem is a simplified version of the IML factor in "The pricing of the illiquidity factor's conditional risk with time-varying premium" by Amihud and Noh (2021). An extract from their Table 1 is reproduced below. Briefly discuss the similarities and differences between your results from (d) and their results.

Table 1
Time-series estimation results for the illiquidity return premium factor *IML*

	(1)	(2)	(3)
	1947−2017	1947-6/1982	7/1982−2017
Panel B: Regression of *IML*			
alpha$_{IML}$	0.341 (5.47)	0.441 (4.94)	0.288 (3.33)
β_{RMrf}	−0.287 (−15.59)	−0.328 (−13.00)	−0.234 (−10.08)
β_{SMB}	0.606 (18.87)	0.595 (13.56)	0.574 (12.88)
β_{HML}	0.404 (12.34)	0.468 (8.02)	0.366 (10.00)
β_{UMD}	−0.078 (−3.77)	−0.206 (−5.37)	−0.006 (−0.26)
R^2	0.61	0.66	0.61