Problem Set 8

Instructions: Work in a group of 1-3 people. Each group hands in one electronic copy of their answers. Try to make your answers readable. Be brief and to the point, but be sure to explain your logic. Do not print data, entire spreadsheets, or programs – instead, copy the relevant statistics to a table. All tables and charts should have legends and explanations. Answer text (excluding tables and figures) should be typed and a maximum seven pages long. Exceeding these limits will result in penalty points.

This problem set explores the role of various factors, such as value and momentum, across asset classes and how a combination of factors performs. It also examines other measures of risk such as higher moments of the distribution and drawdowns.

In order to proceed you need the Microsoft Excel file "Problem_Set8.xls". This file contains six spreadsheets:

1) The monthly returns to value and momentum factors (long-short portfolios) for stock selection strategies in the U.S., U.K., Europe, and Japan, country equity index futures, government bonds, currencies (relative to the $US), and commodities.

2) The monthly returns to the TSMOM factor of Moskowitz, Ooi, and Pedersen (2012), representing time-series momentum.

3) The monthly returns to the Fama-French factors consisting of *RMRF*, *SMB*, *HML*, and *UMD*, as well as STR (short-term reversals) and LTREV (long-term reversals).

4) The monthly returns to the BAB factor of Frazzini and Pedersen (2013), a globally diversified defensive/quality factor related to the work of Novy-Marx (2012) and Asness, Frazzini, and Pedersen (2015), and a global carry factor related to the work of Koijen, Moskowitz, Pedersen, and Vrugt (2015) and Asness, Ilmanen, Israel, and Moskowitz (2014).

5) The monthly returns to a set of hedge fund strategy indices from Dow Jones/Credit Suisse and HFRI.

*All portfolios except for 5) are long-short portfolios, so there is no need to subtract off the risk-free rate for these. The portfolios in 5) are long-only.

**Also, be careful of the dates for each of these series as they start at different times. You need to make sure you align things up properly.

Part 1: Value and Momentum portfolios

a) Compute the mean return, *t*-stat of mean, Sharpe ratio, skewness, and kurtosis of each value and momentum strategy in each market. Report the confidence interval around the Sharpe ratio (for both the normal distribution and the more general ergodic distribution). Report the percentage of observations exceeding + or – 3 standard deviations.

b) Can you statistically reject whether the value premia are equal across all markets and asset classes? For just the equity markets? Can you do the same for the momentum premia?

c) Compute the maximum drawdown of each strategy, which is the most negative return achieved on the strategy over its life, defined for each strategy as

MDD(T) = [trough value – peak value (prior to the trough)]/peak value

Or, equivalently

MDD(T) = (L-P)/P

P = peak value before largest drop; L = lowest value before new high established.

Also, report the length of the period of the maximum drawdown for each strategy (i.e., "how long the pain lasts").

d) Calculate a global value factor and separately a global momentum factor across all markets and asset classes by weighting each market's factor by the inverse of its in-sample volatility (standard deviation) estimate. We will call these $VAL^{everywhere}$ and $MOM^{everywhere}$, respectively. Compute the mean return, *t*-stat of mean, Sharpe ratio, skewness, kurtosis, and maximum drawdowns of these two global factors. Also, report the confidence interval around the Sharpe ratio (for both the normal distribution and the more general ergodic distribution). Report the percentage of observations exceeding + or – 3 standard deviations.

e) Calculate a 50-50 combination of value+momentum for each market/asset class, which is a 50-50 weighting of the value and momentum factors within each market and asset class. Compute the mean return, *t*-stat of mean, Sharpe ratio, skewness, kurtosis, and maximum drawdown of each val-mom combo factor. Also, report the confidence interval around the Sharpe ratio (for both the normal distribution and the more general ergodic distribution). Report the percentage of observations exceeding + or – 3 standard deviations.

f) Now, calculate a value+momentum factor across all markets and asset classes by weighting each market's val-mom combo factor by the inverse of its in-sample volatility (standard deviation) estimate. Compute the mean return, *t*-stat of mean,

Sharpe ratio, skewness, kurtosis, and maximum drawdown of this factor. Also, report the confidence interval around the Sharpe ratio (for both the normal distribution and the more general ergodic distribution). Report the percentage of observations exceeding + or – 3 standard deviations.

g) Can you comment on the benefits of diversification from combining across asset classes? What about from combining two factors (value and momentum)? Where are the biggest diversification benefits, from asset class diversification or from factor diversification in this case?

h) What do the weights of the in-sample tangency portfolio of all the value and momentum factors look like across markets and asset classes? Plot the efficient frontier of all value and momentum factors and include on the graph the individual value and momentum factors as well as the 50-50 combination of them.

i) Now, repeat the tangency portfolio exercise above using even months to compute tangency portfolio weights and then applied to odd-month returns and vice versa to generate an out-of-sample tangency portfolio of all the value and momentum portfolios. Plot this on the efficient frontier you created in h). How different are the results? How close do you get to the ex post optimal efficient frontier?

j) Examine the commonality among the value and momentum portfolios across markets and asset classes more formally. Compute the correlation matrix among the value and momentum factors across the U.S., U.K., Europe, and Japan stock markets, country equity indexes, commodities, government bonds, and currencies. Do the correlations surprise you? Does this correlation structure help point you to a risk-based explanation for value and momentum or a behavioral one? What else might account for this correlation structure?

k) Now, run a time-series regression test of each factor's returns in each market on a volatility-weighted average of all other markets (e.g., US equity value factor on the average of value factors in all other markets plus the momentum factor's returns across all other markets; then repeat in turn for each market). What do the alphas, and *R*-squares look like across markets? Plot in a graph the actual average return of each strategy against the predicted expected return of each strategy from the other markets/asset classes. Can you perform the GRS F-test here on the joint significance of the alphas? Why or why not?

l) Using all the value and momentum portfolios run time series regressions for each portfolio and compute the GRS *F-test* for the joint significance of the alphas using the following factor models:

Model 1) CAPM using *RMRF* as single factor
Model 2) Fama-French 4-factor model: *RMRF, SMB, HML, UMD*

Model 3) Asness-Moskowitz-Pedersen 3-factor model: *RMRF, $VAL^{everywhere}$, $MOM^{everywhere}$*
Model 4) Asness-Moskowitz-Pedersen 3-factor model + *TSMOM*
Model 5) Asness-Moskowitz-Pedersen 3-factor model + *TSMOM +LTREV+STR*

Report the individual alphas and *R*-squares from each regression as well. Which model performs the best at pricing the value and momentum portfolios and why? (Take into account both the alphas and the *R*-squares when making this assessment). Why are you able to run the GRS *F*-test here for these models?

Part 2: MOM vs. TSMOM

Now compare the MOM factor returns in equity index futures, currencies, fixed income, and commodities vs. TSMOM in each of these markets.

m) Design a test to see if MOM captures TSMOM and vice versa. Run that test and show your results and interpret the findings. What do you conclude?

Part 3: Hedge funds

The hedge fund indices are long only portfolios so you will need to subtract off a riskless interest rate. Just use the U.S. T-bill rate which has been provided for you in the last column of this spreadsheet.

n) Using the hedge fund portfolios run time series regressions for each portfolio and compute the GRS *F*-test for the joint significance of the alphas using the following factor models:

Model 1) CAPM using *RMRF* as single factor
Model 2) CAPM using *RMRF* and *RMRF(lagged a month)*
Model 3) Fama-French 4-factor model: *RMRF, RMRF(lag), SMB, HML, UMD*
Model 4) Asness-Moskowitz-Pedersen 3-factor model: *RMRF, RMRF(lag), $VAL^{everywhere}$, $MOM^{everywhere}$*
Model 5) Asness-Moskowitz-Pedersen 3-factor model + *TSMOM*
Model 6) Asness-Moskowitz-Pedersen 3-factor model + *TSMOM +LTREV+STR*
Model 7) Asness-Moskowitz-Pedersen 3-factor model + *TSMOM +LTREV+STR+BAB+Qual/Def+Carry*

Report the individual alphas and *R*-squares from each regression as well.

Which model performs the best at pricing the hedge fund portfolios and why? (Take into account both the alphas and the *R*-squares when making this assessment)
What factors do the various hedge fund strategies load on? Do these make sense? Is there anything surprising?
What does the loading on the lagged market return tell you?

Part 4: Putting it all together

Using the following factors: RMRF, SMB, $VAL^{everywhere}$, $MOM^{everywhere}$, BAB, Qual/Defensive, Carry, STREV, LTREV

o) Calculate the in-sample tangency portfolio of all the factors and plot the efficient frontier of all the factors. What is the Sharpe ratio of this tangency portfolio and what weights are placed on the factors?

p) Now, repeat the tangency portfolio exercise above using even months to compute tangency portfolio weights and then applied to odd-month returns and vice versa to generate an out-of-sample tangency portfolio of all the factor portfolios. Plot this on the efficient frontier you created in o). How different are the results? What is the Sharpe ratio and portfolio weights of this portfolio? How close do you get to the ex post optimal efficient frontier?