Business 35150 **John H. Cochrane**

Problem Set 4

Due by Sat 12:00, week 4

Part I readings. Give one-sentence answers.

1. Novy-Marx, The Profitability Premium. Preview: We see that gross profitability forecasts returns, a lot; its power is not explained by hml slopes (in fact, hml goes the wrong way.) A "profitability factor" digests a long list of anomalies, just as FF found for HML.
   (a) $p_t - d_t = E_t \sum \rho^{j-1} (\Delta d_{t+j} - r_{t+j})$. Does this sort of identity suggest that variables, such as current gross profitability, which have strong power to predict future dividends (or earnings; "good company" variables) should forecast returns better alone, or better in combination with book/market or similar valuation ratios? (If you run a regression $R_{t+1} = a + bx_t + \varepsilon_{t+1}$ and a regression $R_{t+1} = a + bx_t + cy_t + \varepsilon_{t+1}$, sometimes including y_t improves x's forecast power (raises b), and sometimes including y_t lowers $x's$ forecast power (lowers b). Which is it in this case?)
   (b) p.5. Fama and French found that profitability did not help to forecast returns. In a one-sentence nutshell (and inspired by the identity), why does Novy-Marx's measure work so much better?. (Start with, why is it different? Note, this "true economic profitability" stuff seems farfetched to me. There is something deeper at work.)
   (c) Table 1 Panel A. Are returns here regressed on contemporaneous values of the right hand variable, $R_t = a + bx_t + \varepsilon_t$, or lagged, $R_t = a + bx_{t-1} + \varepsilon_t$? What's the punchline of Panel A?
   (d) What danger does Novy-Marx worry about with Fama-MacBeth regressions, which motivates looking at portfolios? (A little graph might help.)
   (e) Table 2. More profitable firms will have higher prices, so just sorting on profitability can isolate low-return growth firms. If you sort just based on gross profitability, without controlling for B/M, do expected returns still rise with profitability, or do they go the other way? Do HML loadings explain the variation in expected returns?
   (f) Table 4. Does the power of profit - to asset sorts evaporate in the biggest firms, as "dissecting anomalies" suggested? (Where do we look?)
   (g) Table 6 (Important!) Is the profit effect in average returns strong while controlling for book/market? Is the value effect strong in average returns controlling for profits? Do hml betas (and alphas) explain the value dimension of average returns, controlling for profits? Do hml betas (and alphas) or other Fama French betas explain the profit dimension of returns controlling for book to market?
   (h) Table 10 (Important). Like Fama and French, Novy-Marx wants to know if a factor formed on his anomaly, PMU, can explain a zoo of other anomalies. How many anomalies in Table 10 are left unexplained by the FF+momentum model, that Novy-Marx model captures? Hint: What's the central column of Table 10?) (For counting purposes, we can use t statistics greater or less than two, despite my sermons about t statistics)

2. Fama and French Five Factor model. Reading notes. Fama and French spend a lot of time on showing you various different ways of doing things to show how it comes out the same. Don't get lost in the variations, first get the basic idea and figure out their point with one way of doing things. In particular, get the general idea of "factor definitions" section III but don't get too deep in the different versions. Section V sems the most important to me. I focused on the 32 portfolios and 2x2x2x2 factors.

(a) p.3 FF say "higher expected future earnings imply a higher expected return." But in a present value model, higher expected earnings can coexist with a constant expected return – it just generates a higher stock price. How can FF say this?

(b) What are RMW and CMA?

(c) How do FF define and measure "profitability" and "investment?" Are these in dollars or ratios somehow?

(d) p.8 "we would like to sort jointly on size, B/M, OP, and Inv". How did "dissecting anomalies" solve this problem? (Optional) Why don't they use the same approach here?

(e) Table 1. For given size (ME), do expected returns rise for more profitable firms? Or does the "good company/good stock" fallacy apply? Is there a difference between small and large firms?

(f) For given size, do firms that invest more have greater returns?

(g) Table 2. Is there a value effect in returns, holding profits constant? Is there a profits effect on returns, holding value constant?

(h) Table 4 C. (p.13-14) Are the factor returns pretty much uncorrelated?

(i) (Table 5 F) In portfolios formed on size, OP and inv, can we get by with just HML and one of RMW and CMA, or does it look like we really need both RMW and CMA factors to explain those sorts?

(j) Note: As suggested in Problem set 4, the way to see if you can drop a factor for pricing (not for R^2) is to run it on the other factors and see if there is an intercept. Reading Table 6 2x2x2x2, are there any of the 5 factors that we can drop for our description of expected returns?

3. Frazzini and Pedersen, Betting against Beta. Reading note: Skip the theory, let's get to the facts starting section III. (I think the theory is a bit silly anyway. Let them buy options. Let firms leverage. But you can't argue with facts.) Let's also focus on US equities. Focus on Table III and IV, and discussion on p. 21

   (a) In Table III, the average returns are the same across portfolios. How can there be a puzzle?

   (b) If the average returns are the same in row 1, how can the BAB strategy have a high average return in the last column. $E(R^{eA} - R^{eB}) = E(R^{eA}) - E(R^{eB})$, no?

   (c) How do we know that the betas will persist going forward? I.e. if we form a portfolio of betting against beta, how do we know that the differences in beta don't disappear going forward and we lose all our money? (Hint: In table III why are there two rows of beta?)

Part II Computer

1. Last week, you evaluated the CAPM in the Fama-French 25 portfolios. Now, replicate the FF 3 factor model. Start by using the 196301-199312 sample. You should get results that are close to FFs, but not exact – there has been some historical data cleanup since they wrote. (If you had trouble last week, feel free to use my tsregress function and code from last week.)

   (a) Run time series regressions

$$R_t^{ei} = \alpha_i + b_i rmrf_t + h_i hml_t + s_i smb_t + \varepsilon_t^i t = 1, 2, ...T$$

   for each i.Make 5 x 5 tables of $E(R^{ei}), \alpha, t(\alpha)$, b, h, s, R^2. (Basically, you're replicating table I of Fama and French.) If you had trouble last week, feel free to use my code, and modify it to the three-factor model.)

(b) (optional) 5 x 5 bar graphs of b, h, s will help you to see the patterns across assets.

(c) Make a plot of average excess returns $E(R^{ei})$ (y) vs. the predicted value from the FF model, $b_i E(rmrf) + h_i E(hml) + s_i E(smb)$ (x). This is the equivalent of an $E(R^{ei})$ vs. β_i plot we did for the CAPM. Without 4- dimensional graphs, you can't plot average returns against three different betas. But you can do the equivalent of $E(R^{ei})$ vs. $\beta_i \times E(R^{em})$. These "actual vs. predicted" graphs are popular ways to assess the fit of multifactor models. Optional: If you plot error bars with $\pm\sigma(\hat{\alpha})$ on each point, you will see the statistical significance of each average return.

2. It's been long enough that we can start to evaluate how well Fama and French work out of sample. Repeat your analysis using the 199401-today sample. Do Fama and French's patterns hold up out of sample? You won't get exactly FFs numbers. The question is whether the same overall patterns hold.

3. Now, do we really need three factors? Answer this in the full 1963-now sample. (Review the notes 1/24 update p.131 for details here)

   (a) Tabulate the mean of the factors, $E(rmrf)$ $E(hml)$ $E(smb)$, their Sharpe ratios and t-statistics. This gives you a sense of how good pure market, value and small investing does.

   (b) Run $smb_t = \alpha_s + \beta_s rmrf_t + e^s_t$ and (for comparison) $hml_t = \alpha_h + \beta_h rmrf_t + e^h_t$. Report the betas, the alphas and alpha t-statistics. Compare alphas to the means – how much of the mean return in each case is explained by market betas? According to this test, do we need smb in presence of rmrf, to describe mean returns? Do we need hml?

   (c) Compare the FF 3 factor model, a two factor model (rmrf, hml) and the pure CAPM, to get a sense of what is lost and gained by adding smb and hml to the CAPM. For each model, report the root mean square alpha $\sqrt{\frac{1}{N}\sum \alpha_i^2}$, (mean(alpha.^2)^0.5) the mean absolute alpha $\frac{1}{N}\sum_{i=1}^{N} \|\alpha_i\|$ (mean(abs(alpha)), and the average R^2 (mean (R2)). Why? We have 25 alphas and R2 to look at, and these are ways of boiling down model fit to one number. (You should have running models down to a function at this point so it's one line of code to run a model. See my tsregress and code for an example.) As we move from CAPM to 2 factor to 3 factor model, how much are alphas affected? ("model of average returns") How much are R2 affected ("model of returns")?

   (d) A few of you asked if we could boil the FF model down to a single factor. Here are two interesting single-factor models. First, compute the mean μ and covariance matrix Σ of the Fama-French factors. (f = [rmrf hml smb]; sigma = cov(f); mu = mean(f)';) Compute a set of weights $w = \Sigma^{-1}\mu \times 100$. (I multiply by 100 so you can see them better). Form a new factor combining the three Fama French factors by $f^1_t = w' f_t$, i.e. $f^1_t = w_1 rmrf_t + w_2 hml_t + w_3 smb_t$ (f1=f*w; This is a T x 1 vector).

      i. Use this single factor to price the Fama-French 25. $R^{ei}_t = \alpha_i + \beta_i f^1_t + \varepsilon^i_t$. How do its alphas and R^2 compare to the FF model?

      ii. Display w. What combination of market, hml, and smb is in this portfolio?

   (e) And a second idea. Compute the mean μ and covariance matrix Σ of the 25 portfolios. Σ is now 25 x 25 and μ is 25 x 1. (sigma = cov(rx); mu = mean(rx) where rx is the T x 25 matrix of FF excess returns). Again, compute $w = \Sigma^{-1}\mu \times 100$, form a new factor combining the 25 portfolios by $f^2_t = w' R^e_t$, (f2=rx*w; This is a T x 1 vector) and

      i. Use this single factor to price the Fama-French 25. $R^{ei}_t = \alpha_i + \beta_i f^2_t + \varepsilon^i_t$. How do its alphas and R^2 compare to the FF model?

      ii. Display w. (It's 25x1 so displaying it in a 5x5 box will be more intuitive) Does this look sensible?

(In parts d and e you are finding the ex-post mean-variance efficient combination of, in d, the factors, and in e, the original returns. Your answer gives an interesting property of mean-variance efficient portfolios. I kept this simple by only asking for alphas and R^2, but it's fun to look at the rest of these models – betas, actual vs. predicted plots, etc.)