0) **Former student Duncan: "Why does Ruppert run a PCA on the first differences of the yields in his examples but uses returns for his examples of equities/indices?"**

Ernie: "The simplest answer is that it depends on what we want to predict. In the case of equities/indices, we want to predict the returns, not the changes. In case of yields, people like to predict changes, not % changes.

The second answer is related to the question of standardization as explained at bottom of page 445. We want to ensure that all the variables have similar magnitude. Changes in equities prices can vary a lot, depending on whether you are trading penny stocks, or BRK-A. But changes in yields are of similar magnitudes."

Duncan: "I get that & I could see using first differences with yields that are fairly close on the curve. However, as a quick example, I think that there is a big difference in the way the two year moves when compared to the ten year. Would I lose anything by using returns on yield rather than the differences when running a PCA? Is there some trade-off there to be aware of?"

Ernie: "Actually, it doesn't matter so much if the numbers differ in magnitude over different time frames. It matters much more their magnitudes are similar at the same time instant (cross-sectional similarity). That's because covariance calculations typically only use only data from a fixed lookback window (e.g. last 1 year). But sure, if you plan to use data from a long lookback, and the magnitudes vary a lot in that lookback, by all means use %."

2) ***Often, we do not need accurate prediction of stock returns from a factor model to profit from it - the model only need to correctly predict their*** *relative returns****. How do we generate profit from a portfolio of stocks if we can only predict their relative returns r_i - r_j, for all pairs of stocks i and j?***

We can profit by buying the stock with the higher relative return and shorting the one with the lower relative return.

Former student Cassie: "If we know the rank ordering we can be profitable by simply short selling lower rank stocks and taking long positions on higher ranked ones."

3) ***Note the distinction between*** *time-series* ***vs.*** *cross-sectional* ***factor models. Which kind does PCA belong to? Which kind do the models in 3) and 4) belong?***

PCA is a cross-sectional model. The eigenvectors produced by diagonalizing the covariance matrices are factor loadings: they are observable and they have different values for each stock. The factors need to be calculated from a regression of returns (at one snapshot in time) against these eigenvector, and they are the same across all stocks. Just think of the statistical factor loadings resulting from PCA as equivalent to the fundamental factor loadings such as ROE or B/M, and the factors like market return, HML, or SMB. This procedure was not shown in Ruppert, by the way, but is detailed in my new book due out in 2017. For now, you can google Infantino and Itzhaki, 2010. "Developing High-Frequency Equities Trading Models".

The Greenblatt factors (return-on-capital and earnings yield) are observable factors loadings since they vary with each stock, and this is a cross-sectional model.

The previous-1-day-return is an observable factor loading which happens to have dimension of returns (an exception among factor loadings). Hence this is a cross-sectional model.

4) Are the principal components which are eigenvectors of the covariance matrix factors or factor loadings?

Factor loadings: see above. Hence PCA can be regarded as a cross-sectional model, since the factor loadings are observable, but the factors (which have dimension of returns) need to be inferred from linear regression.

5) Former student Joe observed that PCA can be applied to other factor models as well:

"Consider a model with 3 Fama-French like factors: (1) HML as originally defined (using B/E ratio) (2) HML using the P/E ratio (3) HML using the PEG ratio. We will use these to explain the return of a single stock.

Return_t=beta1*HML(B/E)_t + beta2*HML(P/E)_t + beta3*HML(PEG)_t + intercept

We naively define this model not knowing the similarities in our factors.

We could use PCA to reduce these 3 dimensions to 1 dimension (interpreted as composite "macro-level valuation" metric) by constructing a 3x3 covariance matrix between the 3 factors over some time period, and regressing to find the Returns' sensitivity to this 1 factor.

For me, it started to make the most sense when I equated PCA with a covariance and forgot about the details. Covariance only makes sense over some constant time increment. Covariance may change dynamically across time increments, but PCA only works on 1 covariance matrix at a time within a discrete time increment. "

6) Former student Myron linked to a good article on the explanatory power of various factors: http://www.mscibarra.com/research/articles/barra/connorfactor.pdf

7) Former student Eric pointed out that

" I see two obvious choices for predicting future returns. 1) offset the contemporaneous dataset so that they predicted value is one period ahead of the factor values and use regression 2) use multivarite ARMA to predict forward period factor values and then apply contemporaneous model to predict stock prices."

My response:

"For fundamental and macroeconomic factors, they do not change much daily or even weekly. So assuming that tomorrow's factor is the same as today's may not make much difference. This in turn means that the contemporaneous factor model may be good enough for prediction too."

8) Former student Mike observed that

"On page 457, the author notes:

'Notice that GE now has a positive relationship with HML, not the negative relationship seen in Figure 17.7.' …. because the other variables (RF and SMB) are now accounted for in conjuction with HML."

My response:

"When GE is regressed against a single factor HML, it shows a negative factor loading, indicating it is a growth stock. But that is because the regression model is underspecified. Underspecification in linear regression causes biased estimates. (A good primer on this issue can be found here: https://onlinecourses.science.psu.edu/stat501/node/328). As you suggested, once other factors such as RF and SMB are included, GE shows a positive factor loading with HML, indicating it is a value stock."

9) Former student Steven read that

"Using the Fama French model can help in generating a profit on a portfolio of stocks based on relative returns. For example, selecting stocks on the basis of a high HML score will help in identifying value stocks, which are shown to outperform non-value stocks. Here is an interesting paper from Clifford S Asness about trading on the basis of momentum vs. value:

https://www.aqr.com/library/journal-articles/the-interaction-of-value-and-momentum-strategies

Here is a brief summary of it:
"Looks at interaction between momentum and value factors in long-term stock returns. Finds value and momentum factors negatively correlated, but both effective. Value strategy tends to work best when its forced NOT to short momentum (as it tends to naively), and holding value constant tends to lead to a superior momentum strategy. Value works, in general, but fails on firms with strong momentum. Momentum works, in general, but is strongest for expensive (poor value) firms. Also looks at holding momentum constant and finds dividend yield to be very predictive of high returns for all but recent winner (high momentum)."
Another way to look at this is by industry. In a study by Moskowitz and Grinblatt published in the The Journal of Finance 1999: "The authors use CRSP and Compustat data from July 1963 to July 1995 divided into 20 value-weighted industry portfolios, non of which ever has less than 25 stocks. They decompose the return on a stock at some time as a sum of: (1) the risk free rate (2) linear loadings on non-diversifiable factors which may have non-zero expected return (the Fama-French (FF) factors proxy for these) (3) loadings on zero-mean diversifiable factors (industry factors) (4) idiosyncratic (epsilon) variance. Using the usual notation R_i(t) = return to stock i in month t, R_M(t) = market return, the average over ALL stocks of the quantity E[(R_i(t) - R_M(t)) * (R_i(t-1) - R_M(t-1))] can be expressed as (1) The variance of unconditional expected returns (from differences in loadings FF factors) (2) autocovariance in the FF factor returns (3) autocovariance in the industry factor returns (4) idiosyncratic autocovariace. They claim momentum returns come from (3): autocovariance in industry returns, since they find negligible autocovariance in the FF Factors at the 6 month horizon.

Anyway, they claim the 6-month formation period, 6-month holding period (henceforth 6-6) strategy applied to individual stocks, buying the top 30% by past 6-month return and shorting the

bottom 30% by past 6 month return, earns 0.43% per month [this is smaller than the Jegadeesh Titman result since J-T go long-short the top and bottom decile by past return]. The authors find that a long-short strategy long the top 3 industries (by past 6 month return) and short the bottom 3, held for six month, also earns 0.43% per month: thus they argue that persistence in idiosyncratic components of individual stock return [item (4) in above paragraph] doesn't drive momentum strategy profitability, and in fact persistence in industry factors does drive individual stock momentum returns (hence they are the same magnitude). Industry momentum profits remain 0.29% per month after accounting for size, but individual stock momentum profits are only .13% per month after accounting for industry momentum, and even less if accounting for size also."
Source: https://sites.google.com/site/cdmurray80/tradingstrategies"

10) Former student Amy read this enlightening paper: "Long–Short Strategies May Not Be Factor-Neutral" http://www.cfapubs.org/doi/pdf/10.2469/dig.v35.n1.1602

11) Chris came across this article: "When doing extra research into Fama-French models, I came across this article from January 2014 talking about a new version of the Fama-French model that now includes 2 new factors: Profitablility and Investment.

Do you have any insight into if this new model is 'better' or if we will continue to use the same 3 factor for the long haul?

http://www.forbes.com/sites/phildemuth/2014/01/20/whats-up-with-fama-frenchs-new-5-factor-model-the-mysterious-new-factor-v/"

My response: "Researchers constantly come up with new factors. Sometimes they are debunked after further careful research that revealed deficiencies in the data or methodology. Others are found to correlate with existing factors and not really something new. Yet others were found to disappear after a while, meaning that they are actually "alphas", not "factors". ("Alphas" are practically riskless and can be arbitraged away, "factors" come with both risks and returns and may never be arbitraged away. I will discuss this distinction in my last Sync Session.) So whether Profitability and Investment should be inducted into the Factors Hall of Fame will take some time to decide.

For example, here is a recent humorously-titled paper by the famous hedge fund manager Cliff Asness who debunked the debunking of the size factor:
http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2553889."

Chris also found this paper which is useful for doing Assignment 9 part 4:
http://ccsenet.org/journal/index.php/ijef/article/viewFile/22527/14888

12) A fundamental, cross-sectional, 2-factor model proposed by a trio of academic researchers can be found here: Chattopadhyay, Akash, Lyle, Matthew R., and Wang, Charles C. Y. 2015. Accounting Data, Market Values, and the Cross Section of Expected Returns Worldwide. Harvard Business School

Accounting & Management Unit Working Paper No. 15-092. Available at ssrn.com/abstract=2613366. (Prof. Lyle is at Northwestern's Kellogg School of Management.)

The two factors are the log of return-on-equity (ROE) and the log of book-to-market ratio (BM). ROE is defined as

ROE(i,s)=1+(X(i,s))/Book(i-1,s)

where X(i,s) is the Net Income before Extraordinary Items from the most recent financial quarter i that has been reported, and Book(i-1,s) is the book value from the quarter prior to the i-th.

Unlike the Greenblatt's 2-factor model, this model is carefully and rigorously backtested and described in the paper.

13) Robert wrote: "… one thing I've never been clear about with factor-based investing is how investors get comfortable assuming that recent factor relative performance will continue in the future. It isn't so difficult subsetting the market into growth versus value for example. Yet in certain periods value stocks outperform growth, and in certain periods they underperform. Factor investing seems to me more about "description" versus "prediction" as you describe in this week's sync session given factor descriptions are backwards-looking. What am I missing in this week's topic that allows one to generate predictions about future performance based on these factors, or is it just a matter of assuming that recent relative trends will continue into the future? And if so, doesn't that seem like a naive assumption? Or is this another example of a model that is refreshed every day only to inform one's view of the next day (i.e. for statistical or time-series factor models)?"

I answered: "You are correct that factors do not stay constant either in magnitude nor sign from one period to another. The market values stocks differently in 2009 than 2017. Hence factor investors are braced for losses over some period of time when the market turns against them. E.g. Value investors like Warren Buffet suffered years of underperformance during the dotcom bubble in the late 90's. However, factor investors have long investment horizons. For e.g. Value investors believe market eventually comes to prefer high B/M stocks - that's equivalent to saying the sign of a factor is the same over long horizon, despite occasional flipping to the wrong side.

You are also correct in stating that often factor models are not used for prediction. They are used for descriptive purpose to understand what just happened in the last period (i.e. why one fund lost so much while another gained). They are also used for risk management purposes in predicting the variance of returns. As usual, the variance of returns tend to vary much less than the actual returns. So what's descriptive is similar to what's predictive."

14) Scott observed that "I have to run Brinson attribution all the time .... How often to you use Brinson attribution, if at all, and do you see any value in it from a portfolio management perspective? I get mixed feelings from our PMs on it's use. It seems more backward looking and helpful to review before a client/prospect meeting."

My response “We don't use attributions because our holdings are so short-term, but I do see value in it for longer term holdings. It lets the portfolio manager explains performance to clients, as you pointed out, which is important! Factor models can seldom be used for predictive purpose, despite the suggestion of this week's assignment!”

15) Stella asked “Very intriguing 'Magic Formula', has anyone tested it in real life?”

My reply “The blog that I linked to discussed how well the Magic Formula performed against the S&P 500 index. It did beat the index in-sample (up to 2009). However, I am unable to find research to ascertain whether it does so consistently out-of-sample, which is where it counts! (Beware that practically anybody can come up with her own magic formula that beats the market in-sample: one just have to adjust a few parameters!)”

Stella: “Whenever I see such 'magic' formulas or tricks, there would be something at the back of my mind saying they are 'too good to be true' and often times, they are!

Prof Chan you made a good point that the results are in-sample and the formula may not work as well out of sample. What's also striking to me is that S&P has a CAGR of almost 10%, I now wonder what a trader's CAGR should look like to be above average.”

My reply “The objective of quantitative trading is actually not to beat the index in terms of returns, but in Sharpe ratio or other risk adjusted measures. If all one wants is to beat the returns, one just need to buy and hold the index ETF but with 2x leverage! But in that case, what happens if we enter a bear market? No, the objective of quantitative trading is to maintain a positive return at most times, independent of market regimes. That return will no doubt be smaller than the index return during a bull market like 2009-2018, but should be much larger during 2007-8!”

16) Kevin has created a very succinct summary of time series vs cross sectional factor models:

Time Series	Cross Sectional
params estimated with one asset at a time, over multiple holding periods	params estimated with one holding period, over multiple assets
factors are known/directly measured and loadings are estimated	loadings are known/directly measured and factors are estimated