Gentlemen:

My apologies for my tardiness; that seems to be endemic to me in 2024. I'm finding this a bit harder than I had anticipated; I think there is some more stuff I want to teach you, and an interactive session, either online or perhaps on campus would be good. I know you are nearing the end of the semester, so your time is probably less open than mine, but if there are some times you could meet, let me know and we'll try to work things out. In the meantime...

Let's start looking for early warning signals (EWS). We'll go quickly through the standard approaches - there's an R package, *EWSmethods*, that we'll use - and then jump into the three things that I'm most interested in: cross-correlations, entropy, and some machine learning (ML)/artificial intelligence (AI). (I must confess that I am largely a ML/AI skeptic as it is mostly non-interpretable and I'm a scientist who needs connection to theory. However, we'll look at some of the work of Cynthia Rudin and collaborators down at Duke; she works in interpretable ML/AI and also shows when interpretable is better than non-interpretable. As finance people, you will probably be different than me in your stance towards ML/AI; that's okay. Quantitative traders, for instance, don't really care if they can explain *why* some stock price is going to go up or down; they just want to be able to predict changes better than the next guy. For more on this, you might want to check out: <https://bookdown.org/kochiuyu/technical-analysis-with-r-second-edition2/>.)

The attached scripts have a lot of stuff in them, and you should work your way through them. The first script, ews.Rmd, covers the EWSmethods package and talks about simulating data. Simulating data is important because it allows us to know the answer ahead of time, which can be useful in developing intuition. However, one shouldn't base much on simulated results, for a variety of reasons. The second script, entropy.Rmd, introduces entropy and related methods. Because the second script has equations in it (not many, but there are some definitions), you will probably want to "knit" that script to get the equations well-formatted. (You can hover your mouse over the equation and it should popup in a formatted version, but you might find that one lacking).

Two warnings about these and future scripts: First, Some of them will take some time to run/knit so be patient. (Or be like me...use the time to play with your dogs for a few minutes, or load the dishwasher, go get a cup of tea, etc., etc.) I'll try to mark which chunks take more than 10 or 15 seconds, but I'll forget from time to time. If you want, at some point we can talk about parallel processing or integrating C++, either of which will speed things up. (Note: a lot of quantitative finance people work in python nowadays, but both R and Python are interpreted languages; a compiled language like C++ can be 10-100 times faster than either of those. You'll probably want to learn some Python to get a job, but if you really want speed, Python is not the way to go.) Second, the way I write R code is pretty idiosyncratic; I hope it doesn't bother you too much. (For example, I write my arrows backwards from almost everyone else. For example, most people write "x <- 2" while I usually write "2 -> x". Same result, but the latter fits my brain better.) You should adopt a style that helps you, though. As a long-time teacher, I'm used to reading other's code so I'll deal with it.

Also, please send me your GitHub account names so I can set up our collaboration space.

Barney