Empirical Methods in Finance
Homework 7

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Problem 1: Applying the Box-Jenkins methodology[1]

In PPIFGS.xls you will find quarterly data for the Producer Price Index. Our goal is to develop a quarterly model for the PPI, so we can come up with forecasts. Our boss needs forecasts of inflation, because she wants to hedge inflation exposure. There is not a single 'correct' answer to this problem. Well-trained econometricians can end up choosing different specifications even though they are confronted with the same sample. However, there definitely are some wrong answers.

1. We look for a covariance-stationary version of this series. Using the entire sample, make a graph with four subplots:

   (a) Plot the PPI in levels.

   (b) Plot ΔPPI

   (c) Plot $\log PPI$

   (d) Plot $\Delta \log PPI$.

2. Which version of the series looks covariance-stationary to you and why? Let's call the covariance stationary version $y_t = f(PPI_t)$.

[1] In Matlab, there is an **Econometrics Toolbox** and a series of functions : 'arima, estimate, forecast, infer, simulate, lbqtest' that can help you solve this problem. Alternatively, you can download Kevin Sheppard's **MFE toolbox**, which is freely available. You can just Google this and find it. In *R* there is a package called 'MTS' for *Multivariate Time Series*, by Ruey Tsay. This is a very useful package, that we will also use when estimating time-varying volatility models.

3. Plot the ACF of y_t for 12 quarters. What do you conclude? If the ACF converges very slowly, re-think whether y_t really is covariance stationary.

4. Plot the PACF of y_t for 12 quarters. What do you conclude?

5. On the basis of the ACF and PACF, select four different ARMA model specifications.

   (a) Using the entire sample, estimate each one of these. Report the coefficient estimates and standard errors. Check for stationarity of the parameter estimates.

   (b) Plot the residuals. (Note: the residuals will have conditional heteroskedasticity or 'GARCH effects'. We will talk about this in Lecture 12. However, in well-specified models, the residuals should not be autocorrelated.)

   (c) Report the Q-statistic for the residuals for 8 and 12 quarters, as well as the AIC and BIC. Select a preferred model on the basis of these diagnostics. Explain your choice.

6. Re-estimate the 4 models using only data up to the end of 2005 and compute the MSPE (mean squared prediction error) on the remainder of the sample for one-quarter ahead forecasts:

$$\frac{1}{H}\sum_{t=1}^{H} v_t^2$$

   where H is the length of the hold-out sample, and v_i is the one-step ahead prediction error. Also report the MSPE assuming there is no predictability in y_t, i.e. assuming y_t follows a random walk. What do you conclude?

Problem 2: Year-on-year quarterly data and ARMA dynamics

Assume the true quarterly log market earnings follow:

$$\begin{aligned} e_t &= e_{t-1} + x_t, \\ x_t &= \phi x_{t-1} + \varepsilon_t, \end{aligned}$$

where $var\,(\varepsilon_t) = \sigma_\varepsilon^2 = 1$ and ε_t is i.i.d. over time t.

The earnings data you are given is year-on-year earnings growth, which in logs is:

$$y_t \equiv e_t - e_{t-4}.$$

1. Assume $\phi = 0$. Derive autocovariances of order 0 through 5 for y_t. I.e., $cov\left(y_t, y_{t-j}\right)$ for $j = 0, ..., 5$.

2. Assume $\phi = 0$. Determine the number of AR lags and MA lags you need in the ARMA(p,q) process for y_t. Give the associated AR and MA coefficients.

3. Optional: assume $1 > \phi > 0$. Repeat 1. and 2. under this assumption.