Economics 618B: Time Series Analysis
Department of Economics
State University of New York at Binghamton

Problem Set #1

1. Generate $n = 500$ random numbers from both the uniform $\frac{1}{b-a}$ ($U[0,1]$, uniform between zero and one) and exponential $\lambda \exp(-\lambda x)$ (set $\lambda = 2$ and let $x \sim U[0,1]$) distributions. Plot the histograms of each of the variables. What are the true and estimated means and variances?

2. Generate a random variable with $n = 500$ from the mixed normal distribution with $P[x \sim N(-3,1)] = P[x \sim N(3,1)] = 0.5$. Plot the histogram. Note that this should be a bimodal distribution. Do not add the two variables together. This will lead to a unimodal density with mean near zero.

3. Generate a random variable with $n = 500$ from the Student-t distribution with 5 degrees of freedom, t_5. Plot the histogram.

4. Generate a random variable with $n = 500$ from the χ^2 distribution with 1 degree of freedom. Plot the histogram.

5. Generate a random variable with $n = 500$ from the Normal distribution with mean 1 and variance 0.5. Plot the histogram.

6. This problem will show you how the central limit theorem works. Using a programming software show how the CLT works for the sample mean with the five separate distributions. Use $n = 10, 50$, and 100 with $m = 100, 200$, and 500 Monte Carlo replications. Plot histograms of the sample means for each distribution and each sample size.

   (a) Standard normal, $N(0,1)$
   (b) Uniform, $U[0,1]$
   (c) Mixed Normal, $P[x \sim N(-3,1)] = P[x \sim N(3,1)] = 0.5$
   (d) Exponential, $\lambda \exp(-\lambda x)$ (set $\lambda = 2$ and let $x \sim U[0,1]$)
   (e) Student-t, t_5

7. This problem is to conduct a Monte Carlo experiment to examine the finite sample performance of a test in size ($P(reject\ H_0 : H_0\ is\ true)$) and power ($P(reject\ H_0 : H_0\ is\ false)$).

   (a) Size: Generate a random sample $x_1, x_2, \ldots, x_n$ of size $n = 50$, with $\mu = 0$ and $\sigma^2 = 1$ from two distributions, (i) normal and (ii) uniform. Pretend you do not know the mean and variance. Then test the null hypothesis that $\mu = 0$ against the alternative that it is not equal to zero. Use Monte Carlo experiments with 500 replications to evaluate the size of the test statistic t. Use the asymptotic critical value at the 5% level (1.96). Repeat with $n = 100$ and 200. What do you find?

   (b) Power: Repeat part (a) with $\mu = 0.1, 0.3, -0.1$, and -0.3. Plot the power function (include $\mu = 0$ in the plot).

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Problem Set #2

1. The file entitled SIM_2.XLS contains simulated data sets. The first series, denoted Y1, contains 100 values of a simulated AR(1) process. Use this series to perform the following tasks.

   (a) Plot the sequence against time. Does the series appear to be stationary?

   (b) Plot the ACF and PACF.

   (c) Estimate the AR(1), AR(2), ARMA(1,1), ARMA(1,(1,4)), ARMA(2,1) and ARMA(2,(0,4)) models.

   (d) Estimate the series as both an AR(2) and ARMA(1,1) process without an intercept.

   (e) Use MSE, AIC and SBC to choose the best model from parts (c) and (d).

   (f) Obtain the one-step-ahead forecast and one-step-ahead forecast error from model. Which model performs the best? Is this surprising?

   (g) The second series in SIM_2.XLS, denoted Y2, contains 100 values of a simulated ARMA(1,1) process. Repeat steps (a-f) with the series Y2.

   (h) The third series in SIM_2.XLS, denoted Y3, contains 100 values of a simulated AR(2) process. Repeat steps (a-f) with the series Y3.

2. The file QUARTERLY.XLS contains demand deposits reported by commercial banks ($DDNSA$). The series is not seasonally adjusted. The series is quarterly averages over the period 1960:Q1 to 2002:Q1. Be sure to briefly explain the relevance of each step.

   (a) Plot the $DDNSA$ sequence against time. Does the series appear to be stationary?

   (b) Plot the ACF and PACF of $DDNSA$.

   (c) Create the growth rate series $\log(DDNSA_t/DDNSA_{t-1})$ and plot this series against time. Does the series appear to be stationary?

   (d) Plot the ACF and PACF of $\log(DDNSA_t/DDNSA_{t-1})$.

   (e) Seasonally difference demand deposits using $\log(DDNSA_t/DDNSA_{t-4})$. Does this series appear to be stationary?

   (f) Plot the ACF and PACF of $\log(DDNSA_t/DDNSA_{t-4})$

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Problem Set #3

1. The file QUARTERLY.XLS contains data on the U.S. Producer Price Index (PPI) and M1 ($M1NSA$). Here the goal is to model both simultaneously using a VAR. The series are quarterly averages over the period 1960:Q1 to 2002:Q1.

   (a) Construct the rate of growth of the money supply and the inflation rate as measured by the PPI as

$$\begin{aligned} m_t &= \log\left(M1NSA_t / M1NSA_{t-1}\right) \\ \pi_t &= \log\left(PPI_t / PPI_{t-1}\right) \end{aligned}$$

   (b) Plot each series. Is there evidence of seasonality?

   (c) Estimate the VAR with seasonal dummies D_1, D_2, and D_3 where $D_i = 1$ in the i-th quarter of each year and zero otherwise

$$\begin{aligned} m_t &= a_1 + \delta_{11} D_1 + \delta_{21} D_2 + \delta_{31} D_3 + a_{11} m_{t-1} + a_{21} \pi_{t-1} + e_{1t} \\ \pi_t &= a_2 + \delta_{12} D_1 + \delta_{22} D_2 + \delta_{32} D_3 + a_{12} m_{t-1} + a_{22} \pi_{t-1} + e_{2t} \end{aligned}$$

   (d) Estimated the VAR model in (b) using 12 lags of each variable and save the residuals.

   (e) Explain why the estimation in (d) cannot begin earlier than 1963:Q2.

   (f) Estimated the VAR model in (b) using 8 lags of each variable and save the residuals.

   (g) Construct a likelihood ratio test for the null hypothesis of 8 lags versus 12 lags.

   (h) Repeat the procedure to see if it is possible to further restrict the system to 4 lags of each variable.

   (i) Determine whether m_t Granger causes π_t.

   (j) Determine whether π_t Granger causes m_t.

   (k) Show that each variable Granger causes itself.

   (l) Some argue that it would be better to estimate the VAR using log-levels of the variables instead of the logarithmic first differences. Estimate an eight-lag model with seasonal using the log-levels of the variables.

   (m) Do the causality tests using undifferenced data differ from those using differenced data?

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Problem Set #4

1. The file QUARTERLY.XLS contains the real GDP data (GDP). The series is measured over the period 1960:Q1 to 2002:Q1.

   (a) Plot the GDP sequence against time. Does the series appear to be stationary?

   (b) Regress the series on an intercept and a third-order polynomial of time (t, t^2, and t^3).

   (c) Plot the ACF and PACF of the residuals from the model estimated in (b). What can be said about the residuals?

   (d) Perform the Dickey-Fuller test on the GDP sequence.

   (e) Perform the Augmented Dickey-Fuller test on the GDP sequence.

   (f) Construct the rate of growth of GDP as $dlrgdp_t = \log(GDP_t/GDP_{t-1})$.

   (g) Plot the $dlrgdp$ sequence against time. Does the series appear to be stationary?

   (h) Model $dlrgdp$ as an AR(2) process.

   (i) Plot the ACF and PACF of the residuals from the model estimated in (h). What can be said about the residuals?

   (j) Perform the Dickey-Fuller test on the $dlrgdp$ sequence.

   (k) Perform the Augmented Dickey-Fuller test on the $dlrgdp$ sequence.

   (l) It is often argued that the oil price shock in 1973 reduced the trend growth rate of real U.S. GDP. Perform the Perron test to determine whether the series is trend stationary with a break occurring in mid-1973.

   (m) Decompose the real GDP series into the temporary and permanent components using the HP filter. Plot the transitory component that you obtain from the HP filter.

   (n) Suppose that real GDP is trend stationary with a break occurring in mid-1973. Let the deviations from trend constitute the transitory component of the series. How does this transitory component compare with your answer found in part (m)?

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Problem Set #5

1. The file COINT_PPP.XLS contains quarterly values of Canadian, German and Japanese wholesales prices and bilateral exchange rates with the United States. The file also contains the U.S. wholesale price level. The names of the individual series should be self-evident. For example, p_US is the U.S. price level and ex_g is the German exchange rate with the United States. All variables except the mark/dollar exchange rates run from 1973:Q4 to 2001:Q4 and all have been normalized to equal 100 in 1973:Q4.

   (a) Form the log of each variable. Estimate the long-run relationship between Canada and the United States

   $$\log(ex\_ca) = \alpha + \beta_1 \log(p\_ca) + \beta_2 \log(p\_us) + \varepsilon$$

   (b) Do the point estimates of the slope coefficients seem to be consistent with long-run PPP?

   (c) Let $\widehat{\varepsilon}$ denote the residuals from the long-run relationship. Use these residuals to perform the Engle-Granger test for cointegration. Use three lagged changes.

   (d) Perform a t-test on the coefficient for $\Delta\widehat{\varepsilon}_{t-1}$. Explain how a rejection of this null of significance indicates that long-run PPP fails.

   (e) Repeat parts (a-d) with Germany.

   (f) Repeat parts (a-d) with Japan.

2. The file INT_RATES.XLS contain interest rates paid on U.S. 3-month, 3-year and 10-year U.S. government securities. The data run from 1954:7 to 2002:12. These columns are labeled TBILL, R3 and R10, respectively.

   (a) Pretest the variables to show that the rates all act as unit processes. Specifically, perform augmented Dicky-Fuller tests using the lag length selected by AIC. Include and intercept, but no time trend.

   (b) Estimate the cointegrating relationships using the Engle-Grange procedure. Perform augmented Dickey-Fuller tests on the residuals. Use T-Bill as the left-hand-side variable with an intercept and the remaining two securities on the right-hand-side.

   (c) Repeat part (b) using R10 as the left-hand-side variable.

   (d) Repeat part (b) using R3 as the left-hand-side variable.

   (e) Estimate an error-correction model using 12 lags of each variable. Use the residuals from part (b) as the error-correction term and do not include a separate intercept.

   (f) Do the residuals from part (e) appear to be white noise?

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Problem Set #6

1. The file QUARTERLY.XLS contains the quarterly values of the U.S. producer price index. Use the data to construct the logarithmic change as $\pi_t = \log(PPI_t/PPI_{t-1})$.

   (a) Use the entire sample period to estimate

   $$\pi_t = \alpha + \phi\pi_{t-1} + \varepsilon_t + \theta_1\varepsilon_{t-1} + \theta_4\varepsilon_{t-4}$$

   (b) Perform diagnostic checks to determine whether or not the residuals appear to be white noise.

   (c) Plot the ACF and PACF of the squares residuals. Do these appear to be white noise?

   (d) Estimate the model in (a) assuming an ARCH(4) error process.

   (e) Estimate the model in (a) assuming an ARCH(8) error process.

   (f) Estimate the model in (a) assuming an ARCH-M(4) error process.

   (g) Estimate the model in (a) assuming a GARCH(1,1) error process.

   (h) Estimate the model in (a) assuming a GARCH(2,2) error process.

   (i) Estimate the model in (a) assuming an IGARCH(1,1) error process.

   (j) Estimate the model in (a) assuming a TGARCH(1,1) error process.

   (k) Estimate the model in (a) assuming an EGARCH(1,1) error process.

   (l) Test for joint significance of the right-hand-side terms in (d-k) for the various ARCH and GARCH specifications.