Long-Run Elasticity
Long-Run Multiplier
Long-Run Propensity (LRP)
Seasonal Dummy Variables
Seasonality
Seasonally Adjusted
Serial Correlation
Short-Run Elasticity
Spurious Regression Problem
Static Model
Stochastic Process
Strictly Exogenous
Time Series Process
Time Trend

# Problems

1. Decide if you agree or disagree with each of the following statements and give a brief explanation of your decision:
   (i) Like cross-sectional observations, we can assume that most time series observations are independently distributed.
   (ii) The OLS estimator in a time series regression is unbiased under the first three Gauss-Markov assumptions.
   (iii) A trending variable cannot be used as the dependent variable in multiple regression analysis.
   (iv) Seasonality is not an issue when using annual time series observations.

2. Suppose that, for a province or district, the crime rate, $crime_t$, is a two-year distributed lag of the clear-up rate (percentage of crimes resulting in a conviction):

$$crime_t = \alpha_0 + \delta_0 clearup_t + \delta_1 clearup_{t-1} + \delta_2 clearup_{t-2} + u_t,$$

where $u_t$ is uncorrelated with $clearup_t$, $clearup_{t-1}$, $clearup_{t-2}$, and all other past values of the arrest rate. Suppose that, through expenditures on law enforcement, the clear-up rate can be made to react to last year's crime rate:

$$clearup_t = \gamma_0 + \gamma_1 crime_{t-1} + v_t.$$

   (i) Explain, in behavioral terms, what $\gamma_1 > 0$ means.
   (ii) If $v_t$ is uncorrelated with all past values of $clearup_t$ and $u_t$, argue that $clearup_t$ and $u_{t-1}$ must be correlated. (*Hint:* Lag the first equation one period and substitute for $crime_{t-1}$ in the second equation.)
   (iii) Which Gauss-Markov assumption does $\text{Corr}(clearup_t, u_{t-1}) \neq 0$ violate?

3. Suppose $y_t$ follows a second order FDL model:

$$y_t = \alpha_0 + \delta_0 z_t + \delta_1 z_{t-1} + \delta_2 z_{t-2} + u_t.$$

Let $z^*$ denote the *equilibrium value* of $z_t$ and let $y^*$ be the equilibrium value of $y_t$, such that

$$y^* = \alpha_0 + \delta_0 z^* + \delta_1 z^* + \delta_2 z^*.$$

Show that the change in $y^*$, due to a change in $z^*$, equals the long-run propensity times the change in $z^*$:

$$\Delta y^* = LRP \cdot \Delta z^*.$$

This gives an alternative way of interpreting the LRP.

4 When the three event indicators *befile6*, *affile6*, and *afdec6* are dropped from equation (10.22), we obtain $R^2 = .281$ and $\bar{R}^2 = .264$. Are the event indicators jointly significant at the 10% level?

5 Suppose you have quarterly data on new housing starts, interest rates, and real per capita income. Specify a model for housing starts that accounts for possible trends and seasonality in the variables.

6 In Example 10.4, we saw that our estimates of the individual lag coefficients in a distributed lag model were very imprecise. One way to alleviate the multicollinearity problem is to assume that the $\delta_j$ follow a relatively simple pattern. For concreteness, consider a model with four lags:

$$y_t = \alpha_0 + \delta_0 z_t + \delta_1 z_{t-1} + \delta_2 z_{t-2} + \delta_3 z_{t-3} + \delta_4 z_{t-4} + u_t.$$

Now, let us assume that the $\delta_j$ follow a quadratic in the lag, $j$:

$$\delta_j = \gamma_0 + \gamma_1 j + \gamma_2 j^2,$$

for parameters $\gamma_0$, $\gamma_1$, and $\gamma_2$. This is an example of a *polynomial distributed lag (PDL) model*.

(i) Plug the formula for each $\delta_j$ into the distributed lag model and write the model in terms of the parameters $\gamma_h$, for $h = 0,1,2$.

(ii) Explain the regression you would run to estimate the $\gamma_h$.

(iii) The polynomial distributed lag model is a restricted version of the general model. How many restrictions are imposed? How would you test these? (*Hint:* Think $F$ test.)

7 In Example 10.4, we wrote the model that explicitly contains the long-run propensity, $\theta_0$, as

$$gfr_t = \alpha_0 + \theta_0 pe_t + \delta_1(pe_{t-1} - pe_t) + \delta_2(pe_{t-2} - pe_t) + u_t,$$

where we omit the other explanatory variables for simplicity. As always with multiple regression analysis, $\theta_0$ should have a ceteris paribus interpretation. Namely, if $pe_t$ increases by one (dollar) holding $(pe_{t-1} - pe_t)$ and $(pe_{t-2} - pe_t)$ fixed, $gfr_t$ should change by $\theta_0$.

(i) If $(pe_{t-1} - pe_t)$ and $(pe_{t-2} - pe_t)$ are held fixed but $pe_t$ is increasing, what must be true about changes in $pe_{t-1}$ and $pe_{t-2}$?

(ii) How does your answer in part (i) help you to interpret $\theta_0$ in the above equation as the LRP?

## Computer Exercises

In October 1979, the Federal Reserve changed its policy of targeting the money supply and instead began to focus directly on short-term interest rates. Using the data in INTDEF.RAW, define a dummy variable equal to 1 for years after 1979. Include this dummy in equation (10.15) to see if there is a shift in the interest rate equation after 1979. What do you conclude?

Use the data in BARIUM.RAW for this exercise.

(i) Add a linear time trend to equation (10.22). Are any variables, other than the trend, statistically significant?

(ii) In the equation estimated in part (i), test for joint significance of all variables except the time trend. What do you conclude?