**Chapter 5: Nonlinearity and Nonadditivity**

Preview Questions

1. What is nonlinearity and nonadditivity?
2. How do you detect nonlinearity and nonadditivity?
3. How do you deal with nonlinearity?
4. How do you deal with nonadditivity?
5. What should we be cautious about regarding nonlinear and nonadditive specifications?

Reading Summary

Introduction

* Linearity and additivity are implicit assumptions in the regression model.
* Linearity is the assumption that for each independent variable Xi the amount of change in associated with a unit increase in Xi while holding all other independent variables constant is the same regardless of the level of Xi.
* Additivity is the assumption that for each independent variable Xi the amount of change in associated with a unit increase in Xi while holding all other independent variables constant is the same regardless of the other independent variables in the equation.
  + Don’t have to specify at which constant values the other independent variables are held.
* With nonlinearity and nonadditivity the relationship between the dependent variable and independent variables varies according to context.
  + Nonlinearity the relationship varies with the value of the independent variable.
  + With nonadditivity the relationship varies with the value of other independent variables.
* Many nonlinear and nonadditive equations can be converted to linear and additive form by performing transformations on the variables.
  + Nonlinear and nonadditive in terms of the variables but linear and additive in terms of the parameters.

Detecting Nonlinearity and Nonadditivity

* General process:
  + Use the theory underlying the model to hypothesize about the form of the nonlinearity and nonadditivity relationship
  + Specify the model reflecting this form
  + Estimate the parameters of the model
  + Use the statistics for the regression to evaluate the hypothesis
* Questions for evaluating nonlinearity
  + Can the slope of the relationship be expected to have the same sign for all values of the independent variable?
  + At what level of the independent variable can the sign be expected to change?
  + Should we expect the magnitude of the slope to increase or decrease?
* Similar questions can be asked about nonadditivity
* There are tests to detect nonlinearity and nonadditivity even when the precise nature of the relationship can’t be ascertained beforehand.
  + Scatter plot of dependent variable against the independent variable for visual inspection.
  + Divide the observations into subsamples, perform regression on each subsample, and compare slopes of the variables.
    - For sample divided in ns samples
      * ns – 1 dichotomous variables must be created
      * 2(ns – 1) terms included as independent variables in the test regression along with X
      * Easy to reject null hypothesis of linearity if ns is large.
      * If ns is small relative to n it is extremely difficult to reject the null hypothesis of linearity
  + Conduct a single regression using dummy variables.

Dealing with Nonlinearity