

# Economics 308: Econometrics

## Professor Moody

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Text

Moody, *Basic Econometrics with Stata* (BES)

References on reserve:

Pindyck and Rubinfeld, *Econometric Models and Economic Forecasts* (PR)

Wooldridge, Jeffrey M., *Introductory Econometrics* (W)

Maddala, G.S. *Introduction to Econometrics*, Second Edition (M) HB139.M353.1992

Kennedy, Peter, *A Guide to Econometrics* (K) HB139 K45 2003

Belsley, Kuh, and Welsch, *Regression diagnostics* (BKW) QA278.2 .B44

Stock and Watson, *Introduction to Econometrics* (SW)

Some journal articles are available electronically in the Course Documents section of Blackboard.

Grading:

Midterm	20%
Final Exam	40%
Project	40%

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## Review: Correlation and Regression.

### Describing the relationship between two variables

Scatter diagrams

Correlation

Simple regression

Why is it called regression?

Reference: BES Ch. 7

Assignment 1: reproduce the regression on page 11 of BES.

Theory of Least Squares

## Properties of estimators

### Small sample properties

- bias
- efficiency
- mean square error
- relative efficiency
- robustness

### Large sample (asymptotic) properties

- consistency
- mean square error consistency
- asymptotic efficiency
- asymptotic unbiased

Note: consistency "carries over" transformations while unbiasedness does not

References: W 699-713, M Ch 2.6, PR 27-30, SW 56-60, BES Ch. 8, 58-60, W Ch. 19.

## Assignment 2

### **Gauss-Markov Theorem**

#### Gauss-Markov assumptions

$$Y_i = \alpha + \beta X_i + U_i$$

$$U_i \sim iid(0, \sigma^2)$$

Which implies that

$\hat{\beta}$  is a linear function of Y

$\hat{\beta}$  is random variable with a distribution (the sampling distribution of  $\beta$ )

$\hat{\beta}$  is an unbiased estimator of  $\beta$

Deriving the variance of beta:  $Var(\hat{\beta}) = \hat{\sigma}_u^2 / \Sigma x^2$

Gauss-Markov theorem: OLS is BLUE

OLS is also a maximum likelihood estimator

References: W Ch 1,2, SW 103-107, PR Ch.3, BES Ch. 8, 60-64.

### **Inference and Hypothesis Testing**

Assume the error term is distributed normally, then the sampling distribution of beta that is also normal with

$$E(\hat{\beta}) = \beta \text{ (the truth)}$$

$$\text{Var}(\hat{\beta}) = \hat{\sigma}_u^2 / \Sigma x^2$$

however, we must estimate the variance of u:  $\hat{\sigma}_u^2 = \Sigma e^2 / (n - 2)$

A note on the Normal, Chi-square, t, and F distributions

References: SW 32-39, BES 65-71.

Testing hypotheses concerning  $\beta$

References: PR Ch. 2; W 724-736, SW 108-117, BES Ch. 8, 65-75.

### **Maximum likelihood and the likelihood ratio test**

References: M 118-129, K Ch. 4.4, BES Ch.8, 76-78.

### **Multiple Regression**

Why? Because life is complicated: omitted variable bias

Three variable regression model

Interpretation of formulas

Goodness of fit:  $R^2$

References: W Ch 3-6, M Ch 4, PR Ch 4-5, SW Ch 5, BES Ch 8, 79-83

Assignment 3

### **Omitted variable bias and modelling**

Review: multiple regression formula determining the direction of bias.

There is only one way to be right and there are many ways to be wrong.

It is wrong to include an irrelevant variable (inefficiency)

and it is wrong to leave out a relevant variable (bias).

However, omitting a relevant variable whose value is less than its standard error will decrease mean square errors.

Proxy variables

References: M Ch 11.6, W Ch 9.2, PR Ch 7.3, 7.5.1; W Ch 3, SW Ch 5, BES Ch 8, 83-90.

Digression: torturing the data until it tells you what you want to hear.

Leamer, "Let's take the con out of econometrics," *American Economic Review*, March 1983, 31-43 (Blackboard).

### **Dummy Variables**

References: W Ch 7, PR 104-108, 121-123, M Ch 8.1-8.3, K Ch 13, SW 119-122, BES Ch 8 90-94.

Dey, Matthew S. "Racial Differences in National Basketball Association Players' Salaries: A New Look," *The American Economist*, 41, Fall 1997, 84-90 (Blackboard)

## Useful Tests

F-test  
Chow test  
Granger causality test  
J-test for non-nested hypotheses  
LM test

References: W Ch 4.5, 237-240; PR 110-112, 115-117, 216-219; M 393-394, 443-446;  
SW 165-70, 448-9, 468-9; BES Ch 8, 94-102.

## Regression Diagnostics

Influential Observations  
Multicollinearity  
References: BKW, M Ch 7; BES Ch 9.

Digression: torturing the data until it tells you what you want to hear: Leamer,  
"Let's Take the Con out of Econometrics" *American Economic Review*, March, 1983, 31-  
43. (Blackboard)

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# Econometrics: What if the Gauss-Markov Assumptions are Violated?

## Heteroskedasticity

Definition: nonconstant error variance, a common problem in cross sections

Effects: (1) ols estimates remain unbiased, but  
(2) inefficient,  
(3) standard errors and t-scores are incorrect

Tests: plot residuals, Breusch-Pagan, White

Cure: weighted least squares

1. known variances: weighted least squares
2. unknown variances: assume that the error variance is a function of an observable variable (the usual case)

Heteroskedastic consistent (robust) standard errors

References: M Ch 5, PR Ch 6.1, K Ch 7, SW 124-129, 139-140, 591-596; BES Ch 10

Assignment 3

## Specification Bias

Rule: if one or more of the explanatory variables in a regression are correlated with the error term,  
the resulting OLS estimates are biased and inconsistent

Causes of correlation between  $X$  and  $u$   
incorrect functional form  
omitted variables  
errors of measurement in the independent variables  
simultaneous equations

## **Errors in variables**

Definition

Effects: ols is biased and inconsistent

Cure: instrumental variables (two stage least squares)

Problems:

- (1) Choice between a biased but efficient estimator (ols)  
and an unbiased but inefficient estimator (IV)
- (2) Where are the instruments?

References: M Ch 11.1-11.3, 11.5-11.7, PR Ch 7; SW 248-250; BES Ch 11.

## **Simultaneous equations**

When an equation is part of a simultaneous equation system, such that causation runs from  $Y$  to  $X$  as well as  $X$  to  $Y$ ,  
then  $X$  is correlated with the error term and OLS is biased and inconsistent.

Example: the consumption function

Example: supply and demand

Endogenous and exogenous variables, structural versus reduced form

Consistent parameter estimation: instrumental variables (2sls)

Indirect Least Squares

The identification problem

The order condition for identification

Types of equation systems: general, recursive, block recursive

Strategies: ols, ols with lags, reduced form, 2sls, VAR

Standard tests

Hausman test for mis-specification

Basman test for over-identification restrictions

Bound-Jaeger-Baker test for weak instruments

System estimation methods: ZELS, 3SLS

References: M Ch 9, M Ch 12.10, PR Ch 11; KO Ch 7, K Ch 9; SW Ch 10; BES Ch 12.

Bound, Jaeger, and Baker, "Problems with Instrumental Variables Estimation When the Correlation Between the Instruments and the Endogenous Explanatory Variable is Weak." *Journal of the American Statistical Association* 90 (430) June 1995, pp. 443-450.

## Time Series Analysis

Time series data have advantage and disadvantages. The primary advantage is that we know time does not go backwards, so we can use lags to identify causal relationships (not possible in cross sections). The disadvantages are that we have to worry about certain problems that are unique to time series data, namely autocorrelation, unit roots, and cointegration.

### Linear Dynamic Models

Autoregressive Distributed Lag (ADL) model.

The L (lag) operator.

The following models are special cases of the ADL.

- Static model

- AR model

- Leading Indicator model

- First Difference model

- Distributed Lag model

- Partial Adjustment model

- VAR model

- Common Factor model

- Error Correction model

Note: the Error Correction model is not really a special case, since we did not restrict any coefficients. It is just a re-statement of the ADL after some algebra.

References: SW 443-336, 485-486; BES Ch 13.

### Autocorrelation

Definition:  $u(t)$  correlated with  $u(t-1)$  (and/or  $u(t-2)$ , etc.)

Effects:

- OLS remains unbiased

- variance of  $\hat{\beta}$  will not be minimum (loss of efficiency)

- standard errors will be underestimated and t-scores overestimated  
(second order bias)

- If regressors include a lagged dependent variable, then ols estimators will be biased and inconsistent as well as inefficient.

Tests: Durbin-Watson, Breush-Godfrey (LM).

There are two reasons for autocorrelation (1) serial correlation in the error term and (2) omitted variables with time components. If the autocorrelation is due to omitted lagged variables, then we can't fix it with Cochrane-Orcutt. We need to test to see if we have serial correlation or mis-specified dynamics.

Likelihood ratio test for mis-specified dynamics

Heteroskedasticity and autocorrelation consistent (HAC) standard errors (Newey-West)

References: M Ch 6, PR Ch 6.2, K Ch 7.4; SW 504-517, 530-531; BES Ch 14.

## **Analysis of non-stationary data**

Random walks and unit roots

Spurious regressions

Unit root tests: ADF, DF-GLS

References: SW 457-467, 545-552; BES Ch 15.

Assignment 6

## **Cointegration and long run equilibrium**

Short-run relationships: first differences

Cointegration and the long-run relationship

Testing for cointegration

Estimating the cointegrating regression

Error correction model

Dynamic Ordinary Least Squares

References: P&R Ch 15.3, 15.4; BES Ch 16

Granger "Introduction." (Blackboard)

Granger and Newbold, "Spurious Regressions in Econometrics" *Journal of Econometrics* 2, (1974) 111-120. (Blackboard)

## **Pooling Time Series and Cross Section Data**

Motivation: cure for one kind of omitted variable bias, efficient use of data, increases degrees of freedom

Fixed effects model

Time series issues

First difference model

References: PR Ch 9.4; W Ch 13, 14; SW Ch 8; BES Ch 17.

Optional (extra credit): Panel Data Exercise in the Course Documents section of the Blackboard site.

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