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Properties of Regression Coefficients and Hypothesis Testing

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Elements of Econometrics, Russell Square International College, Mumbai

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Different Types of Data

- Cross-sectional Data
 - observations on individuals, households, enterprises etc at one moment in time
 - reasonable assumption of random sampling can be made

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Different Types of Data

Cross-sectional Data

- observations on individuals, households, enterprises etc at one moment in time
- reasonable assumption of random sampling can be made
- Time Series Data
 - Observations on income, consumption etc over number of periods in time (years, quarters, months...)
 - samples are correlated in time, they are not independent

Different Types of Data

Cross-sectional Data

 observations on individuals, households, enterprises etc at one moment in time

Different Types of Data

reasonable assumption of random sampling can be made

Time Series Data

- Observations on income, consumption etc over number of periods in time (years, quarters, months...)
- samples are correlated in time, they are not independent

Panel Data

- Observations on one cross-section of individuals, enterprises etc over number of time periods
- can assume random sampling across cross-section but not across time dimension

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Types of Models

- Classical Linear Regression Model
 - regressors are assumed to be fixed or non-random, only error term is random
 - rules out the possibility of interaction between error and regressors

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Types of Models

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- Linear Regression Model
 - regressors are now assumed to be stochastic and random sampling assumption holds
 - can explicitly talk about interaction of error term with explainatory variables
 - it is easier to derive asymptotic properties of regression coefficients

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Types of Models

Classical Linear Regression Model

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Linear Regression Model

- regressors are now assumed to be stochastic and random sampling assumption holds
- can explicitly talk about interaction of error term with explainatory variables
- it is easier to derive asymptotic properties of regression coefficients

Time Series Model

- complex relationship between explainatory variables across time is modeled
- many standard assumptions of linear regression model do not hold

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- Assumption.1
 - The model is correctly specified and is linear in parameters

$$Y = \beta_1 + \beta_2 X + u$$
, It is correct model!

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 - Their is some variance in the regressors in the sample
 - We are not looking at constant values

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- Assumption.2
 - Their is some variance in the regressors in the sample
 - We are not looking at constant values
- Assumption.3
 - The disturbance term has zero expectation
 - This is reasonable assumption when intercept term is used
 - It means inherent error in the model for generating Y is on an average zero

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- Assumption.4
 - The disturbance term is Homoscedastic
 - Error in generating Y doesnt depend on X value

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Assumptions of CLRM

Assumption.4

- The disturbance term is Homoscedastic
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Assumption.5

- Disturbance terms have independent distributions
- Error terms are independent across X values

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Assumptions of CLRM

Assumption.4

- The disturbance term is Homoscedastic
- Error in generating Y doesnt depend on X value

Assumption.5

- Disturbance terms have independent distributions
- Error terms are independent across X values

Assumption.6

- Disturbance term has normal distribution
- Effect of all factors other than X can be modeled as following normal distribution

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 We can see how assumptions of CLRM lead to unbiased regression coefficients

Unbiased Coefficients

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Unbiased Coefficients

 We can see how assumptions of CLRM lead to unbiased regression coefficients

Fitted Model:
$$\hat{Y} = \hat{\beta}_1 + \hat{\beta}_2 X$$

$$\hat{\beta}_2 = \beta_2 + \frac{\sum (X_i - X)u_i}{\sum_{j=1}^n (X_j - \overline{X})^2}$$

$$E(\hat{\beta_2}) = \beta_2$$

• Also OLS estimator is efficient of all the estimators, though with same bias (zero)

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Monte Carlo Experiment

- Monte Carlo experiment is generally used to derive distributions
- We can use same method to see that the error term is infact following normal distribution as specified in our assumption

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Please refer Dougherty Slides on Monte Carlo experiment

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Precision of Regression estimates

• OLS regression estimators being RVs have variance given by,

$$Var\hat{\beta}_2 = \sigma_{\hat{\beta}_2}^2 = \frac{\sigma_u^2}{nMSD(X)}$$

where
$$MSD(X) = \frac{\sum_{i=1}^{n} (X_i - \overline{X})^2}{n}$$

• Clearly, variance of coefficient depends on following:

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- Clearly, variance of coefficient depends on following:
 - MSD, mean square distance of x, which is a measure of dispersion of x values
 - Variance of error term itself, which is just inherent noise in the model

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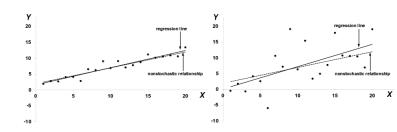
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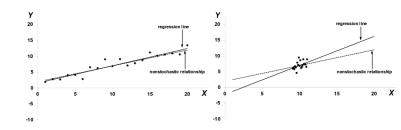
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Standard Errors of Coefficients

• Variance of error term is not available,

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Standard Errors of Coefficients

- Variance of error term is not available,
 - we can use residual errors as reasonable estimator for error variance

$$\hat{\sigma_u}^2 = \frac{\sum_{i=1}^n \hat{u}^2}{n-2}$$

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• Thus standard error (s.e) of regression coefficients is given by,

$$s.e(\beta_1) = \hat{\sigma_u} \sqrt{\frac{1}{n} + \frac{\overline{X}^2}{\sum_{i=1}^n (X_i - \overline{X})^2}}$$

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 Lower the standard error, more precise the regression line approximation

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"In God we trust, all others bring data."

William Edwards Deming (1900 - 1993).