

**KSE**

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Kyiv  
School of  
Economics

# Econometric Tests

*Ass. Prof. Andriy Stavytskyy*

## Agenda

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- Econometric tests
- Hypothesis testing example

# Linear regression

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$$y_t = \beta_0 + \beta_1 x_{1t} + \beta_2 x_{2t} + \dots + \beta_{k-1} x_{k-1t} + \varepsilon_t, t = \overline{1, n}$$

$y_t$  - dependent variable;

$x_{1t}, x_{2t}, \dots, x_{k-1t}$  - independent variables;

$\varepsilon_t$  - residuals.

# Multiple Regression Tests

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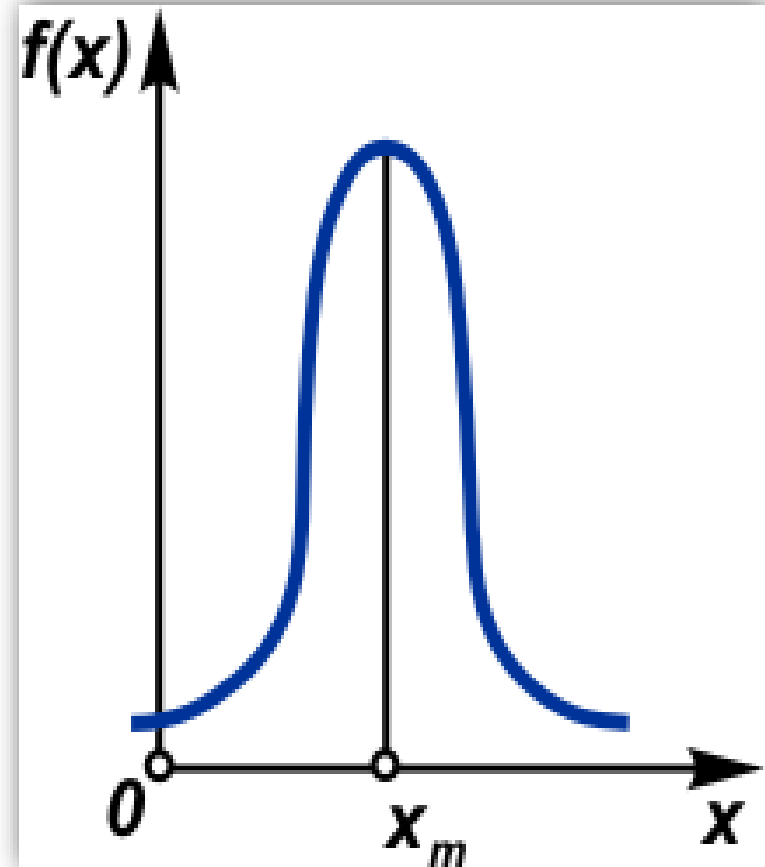
- Test residual for normality
- Test parameter significance
  - Overall model
  - Individual coefficients
- Test for multicollinearity
- Test for model stability
- Test for residuals autocorrelation
- Test for residuals homoscedasticity
- Test for specification
- Test for stationary process

# Test residual for normality

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Check normality of residuals:

- Jarque-Bera statistics
- Shapiro–Wilk test



## Jarque-Bera statistics

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$$JB = \frac{n}{6} \left( S^2 + \frac{1}{4} \left( (K - 3)^2 \right) \right)$$

$$S = \frac{\hat{\mu}_3}{\hat{\sigma}^3} = \frac{\frac{1}{n} \sum_{i=1}^n (x_i - \bar{x})^3}{\left( \frac{1}{n} \sum_{i=1}^n (x_i - \bar{x})^2 \right)^{3/2}}$$

$$K = \frac{\hat{\mu}_4}{\hat{\sigma}^4} = \frac{\frac{1}{n} \sum_{i=1}^n (x_i - \bar{x})^4}{\left( \frac{1}{n} \sum_{i=1}^n (x_i - \bar{x})^2 \right)^2}$$

- S is the sample skewness,
- K is the sample kurtosis.

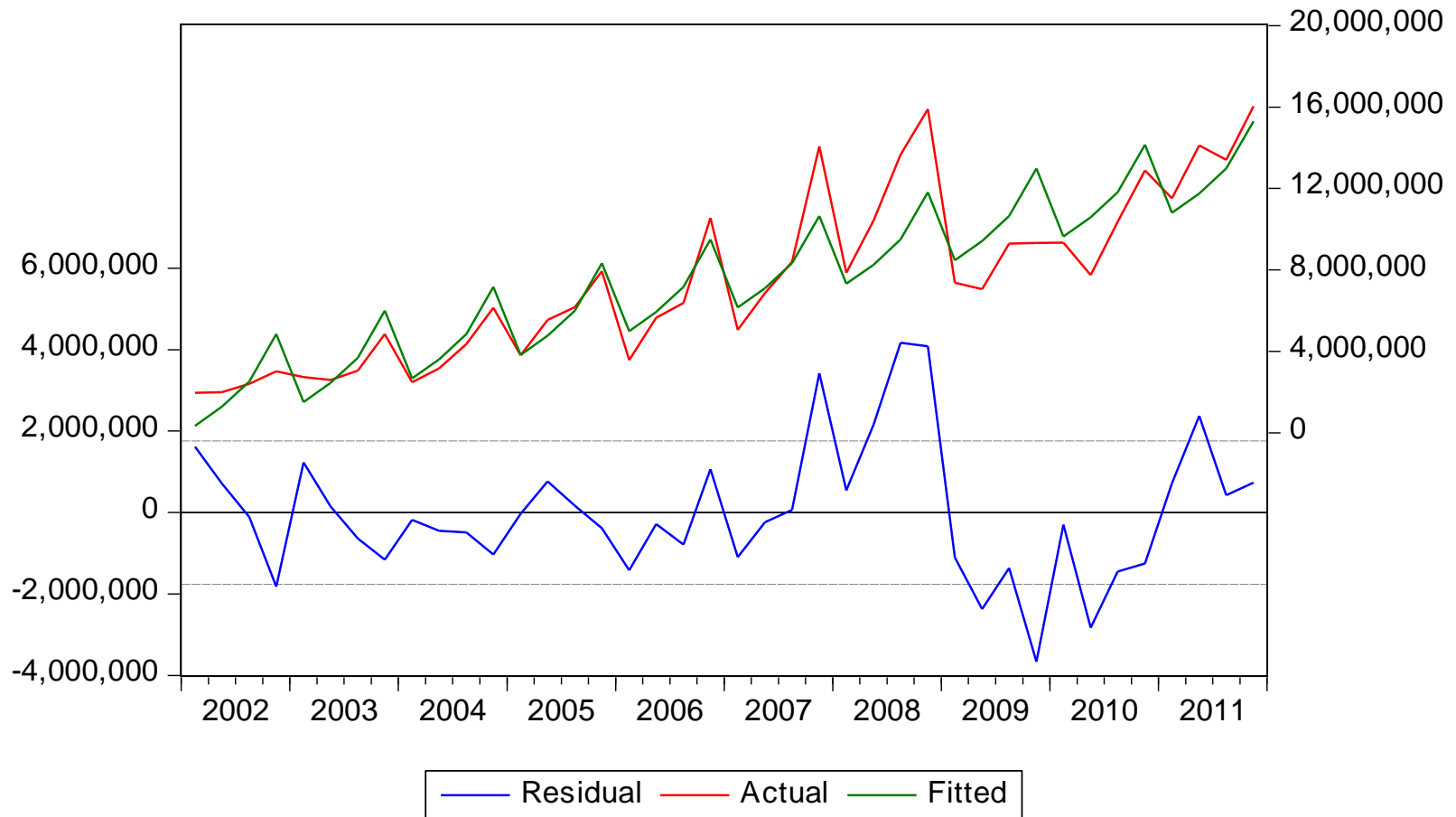
# Example

Dependent Variable: TAX\_ENT  
 Method: Least Squares  
 Date: 12/09/12 Time: 20:49  
 Sample: 2002Q1 2011Q4  
 Included observations: 40

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	3973770.	754540.7	5.266475	0.0000
@TREND	290525.1	24239.34	11.98568	0.0000
@SEAS(1)	-3627516.	791034.8	-4.585786	0.0001
@SEAS(2)	-2975920.	789175.7	-3.770922	0.0006
@SEAS(3)	-2032456.	788058.1	-2.579068	0.0143

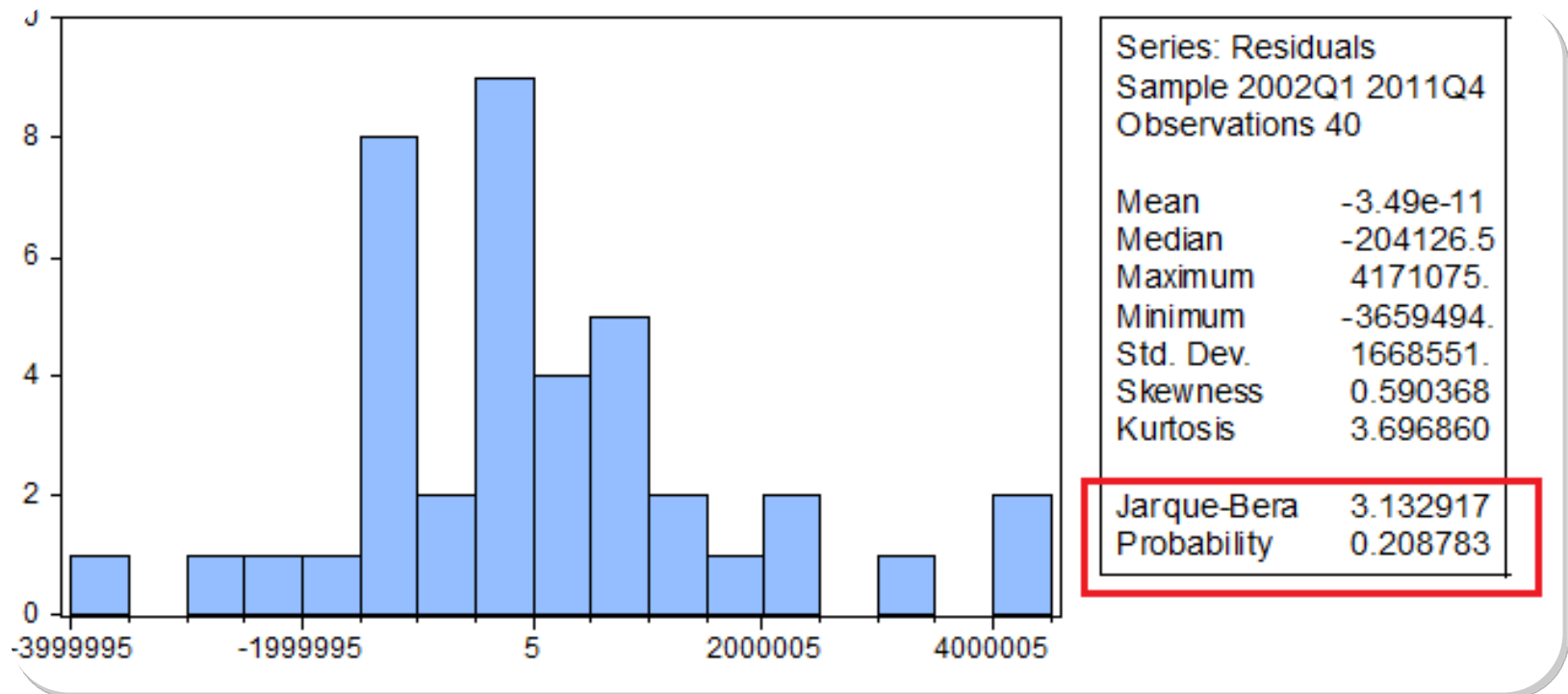
R-squared	0.837415	Mean dependent var	7480035.
Adjusted R-squared	0.818834	S.D. dependent var	4138083.
S.E. of regression	1761318.	Akaike info criterion	31.71749
Sum squared resid	1.09E+14	Schwarz criterion	31.92860
Log likelihood	-629.3498	Hannan-Quinn criter.	31.79382
F-statistic	45.06800	Durbin-Watson stat	1.123746
Prob(F-statistic)	0.000000		

## Residuals





# Check for normality



# Test parameter significance: Overall model

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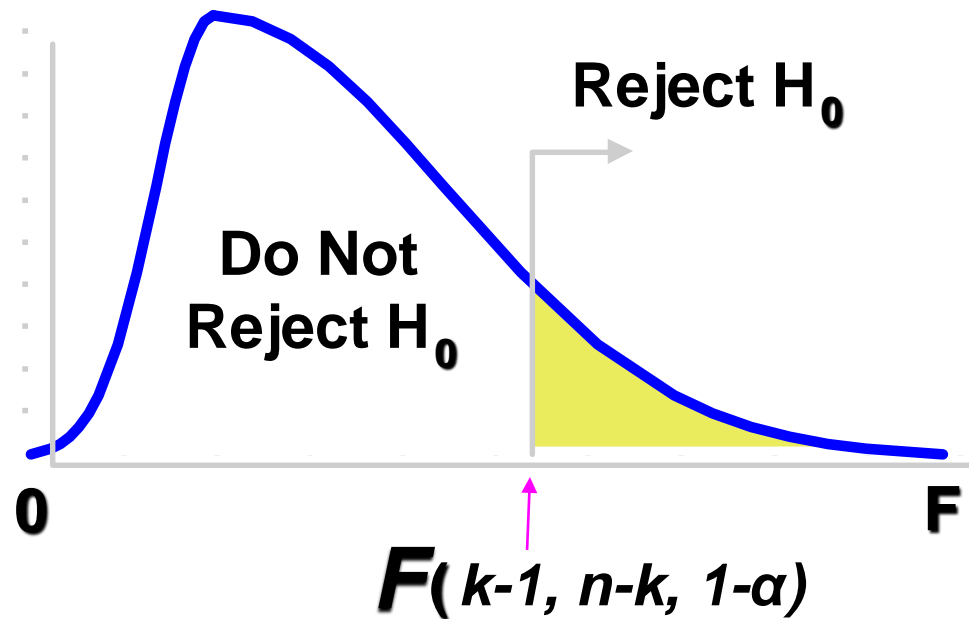
- Hypotheses
  - $H_0: \beta_1 = \beta_2 = \dots = \beta_{k-1} = 0$ 
    - No Linear Relationship
  - $H_a$ : At Least One Coefficient Is Not 0
    - At Least One X Variable linearly Affects Y

$$F = \frac{RSS / (k - 1)}{ESS / (n - k)} = \frac{R^2 / (k - 1)}{(1 - R^2) / (n - k)} \stackrel{H_0}{\sim} F_{k-1, n-k}$$

# Overall Significance Rejection Rule

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- Reject  $H_0$  in favor of  $H_a$  if  $F_{\text{calc}}$  falls in colored area



- Reject  $H_0$  for  $H_a$  if P-value =  $P(F > F_{\text{calc}}) < \alpha$

## Example

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Included observations: 40				
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F-statistic	45.06800	Durbin-Watson stat	1.123746	
Prob(F-statistic)	0.000000			

# Test of slope coefficients

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- Hypothesis
  - $H_0: \beta_i = m$
  - $H_a: \beta_i \neq m$

# Slope Coefficient Test Statistic

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$$t = \frac{\hat{\beta}_i - m}{S_{\hat{\beta}_i}}$$

$$\text{where } S_{\hat{\beta}_i} = \frac{S}{\sqrt{\sum_{i=1}^n X_i^2 - \frac{\left(\sum_{i=1}^n X_i\right)^2}{n}}}$$

$$\text{with } S = \hat{\sigma} = \sqrt{\frac{RSS}{n-k}}$$

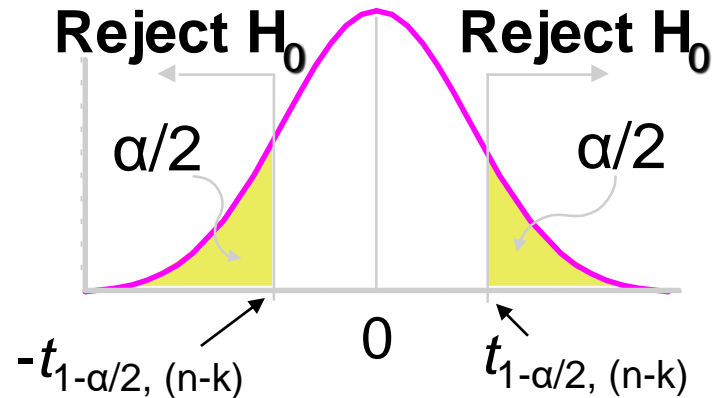
$$\text{and } RSS = \sum_{i=1}^n (Y_i - \hat{Y}_i)^2 = \sum_{i=1}^n \left[ Y_i - \left( \hat{\beta}_0 + \sum_{i=1}^{k-1} \hat{\beta}_i X_i \right) \right]^2$$

# Test of Slope Coefficient

## Rejection Rule

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- Reject  $H_0$  in favor of  $H_a$  if  $t$  falls in colored area



$$T = t_{(n-k)}$$

- Reject  $H_0$  for  $H_a$  if P-value =  $P(T > |t|) < \alpha$

## Special case: significance of coefficient

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- Hypothesis
  - $H_0: \beta_i=0$
  - $H_a: \beta_i \neq 0$

$$t = \frac{\hat{\beta}_i}{S_{\hat{\beta}_i}}$$



## Example

Dependent Variable: TAX\_ENT

Method: Least Squares

Date: 12/09/12 Time: 20:49

Sample: 2002Q1 2011Q4

Included observations: 40

Variable	Coefficient	Std. Error	t-Statistic	Prob.
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F-statistic	45.06800	Durbin-Watson stat	1.123746	
Prob(F-statistic)	0.000000			

## Wald test

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Null Hypothesis:  $H_0 : \beta_1 = \beta_2 = \beta_3 = 0$

Alternative hypothesis  $H_1 : \beta_1$  or  $\beta_2$  or  $\beta_3$

or any two of them or all are nonzero.

At least one of them is significant.

In matrix notation

$$\text{Hypothesis: } Rb = r \Rightarrow \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \beta_1 \\ \beta_2 \\ \beta_3 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}$$

Test statistics with J numbers of restriction

$$F = \frac{(Rb - r)' [R \text{cov}(b) R']^{-1} (Rb - r)}{\frac{J}{\frac{RSS}{n - k}}}$$

Calculate F and compare it with the critical values  $F(J, n-k)$  from the Table.

# Test for multicollinearity

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- High correlation between X variables
- Coefficients measure combined effect
- Leads to unstable coefficients depending on X variables in model
- Always exists; matter of degree
- Example: Using both total number of rooms and number of bedrooms as explanatory variables in same model

# Detecting Multicollinearity

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- Farrar-Glauber Multicollinearity
- VIF-test
  
- Few remedies
  - Obtain new sample data
  - Eliminate one correlated X variable
  - Standardize your independent variables.

## Example

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$$\hat{s}_t = 0.4 + 0.8y_t + 0.2li_t - 0.1si_t$$

(0.9) (1.2) (0.4) (0.1)

$\bar{R}^2 = 0.98$ , (standard errors in parentheses)

(n = 60). where:

$s_t$  – stock prices

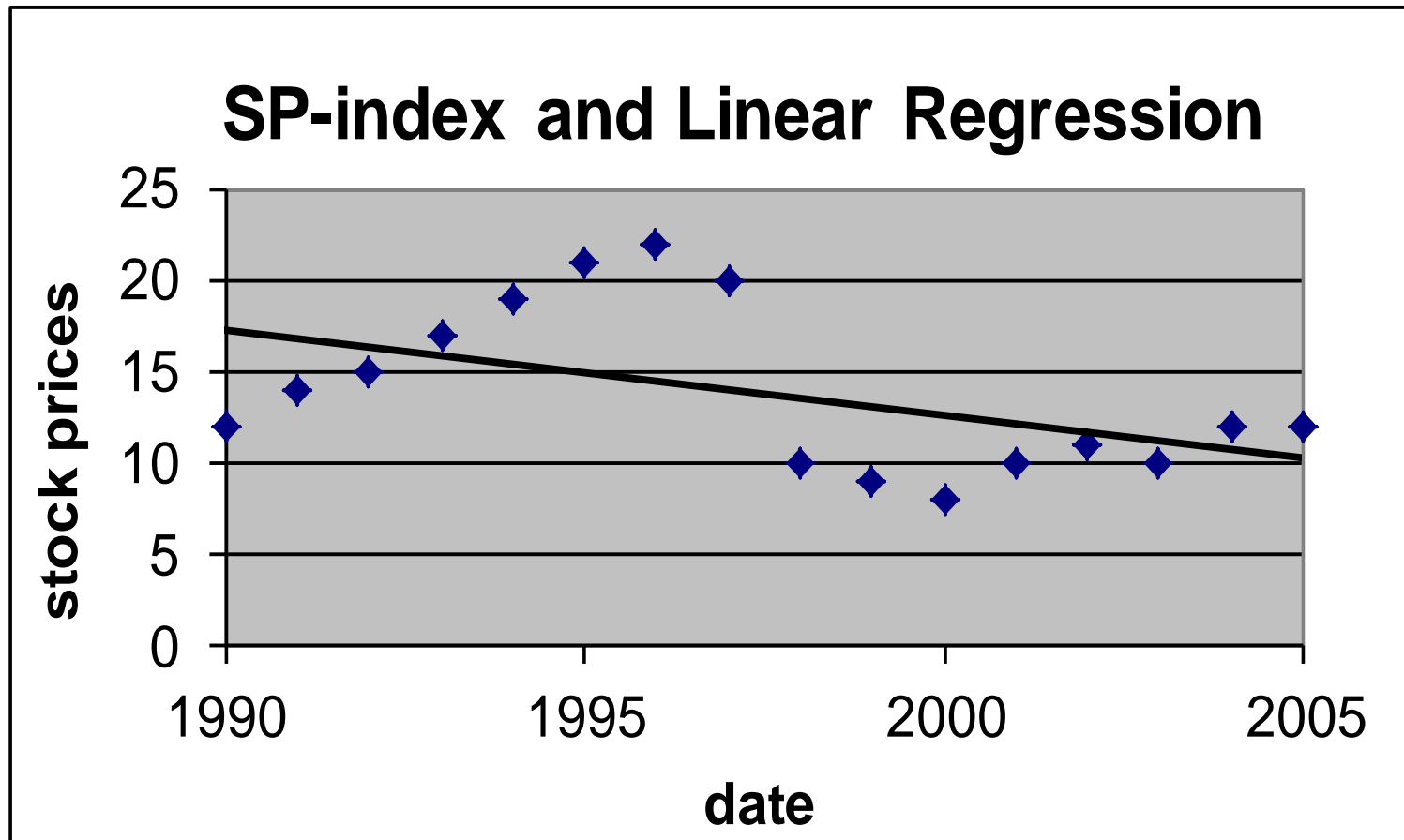
$y_t$  – output

$li_t$  – long-run interest rates

$si_t$  – short-run interest rates

# Test for structural breaks

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# Chow Test

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- Tests whether the coefficients in two linear regressions on different data sets are equal.

$$F = \frac{RSS_c - (RSS_1 + RSS_2) / k}{(RSS_1 + RSS_2) / n - 2k} \sim F_{k, n-2k}$$

$RSS_c$  – combined \_RSS

$RSS_1$  – pre – break \_RSS

$RSS_2$  – post – break \_RSS

# Test for residuals autocorrelation

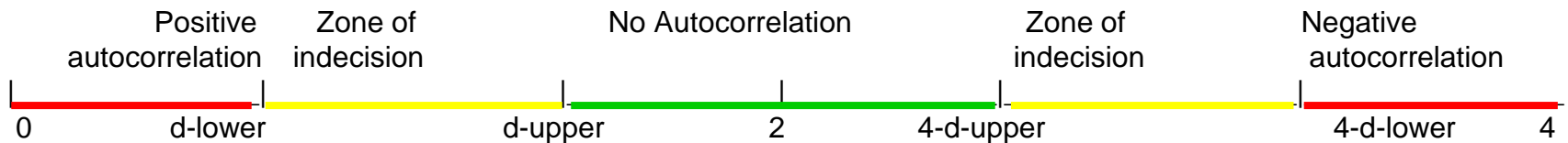
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- Durbin-Watson test (only checks for first order serial correlation in residuals)
- Breusch-Godfrey Test (checks for higher order autocorrelation  $AR(q)$  in residuals)



## Durbin-Watson statistic

$$d = \frac{\sum (e_i - e_{i-1})^2}{\sum e_i^2}, \text{ for } n \text{ and } K - 1 \text{ d.f.}$$



- Autocorrelation is clearly evident
- Ambiguous – cannot rule out autocorrelation
- Autocorrelation is not evident

# Breusch-Godfrey Test

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Higher Order Autocorrelation model : AR(p)

$$\mu_t = \rho_1 \mu_{t-1} + \rho_2 \mu_{t-2} + \dots + \rho_p \mu_{t-p} + \varepsilon_t$$

Null Hypothesis

$$H_0 : \rho_1 = \rho_2 = \dots = \rho_p = 0$$

Test Model :

$$\hat{\mu}_t = \delta_1 + \delta_2 X_{2t} + \dots + \delta_k X_{kt} + \lambda_1 \hat{\mu}_{t-1} + \dots + \lambda_p \hat{\mu}_{t-p} + \omega_t$$

Test Statistic

$$LM = (n - p) * R_{\text{aux}}^2 \sim \chi_p^2$$

# Tests for Heteroskedasticity

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- There are two types of tests:
  - Tests for continuous changes in variance: White test, Breusch–Pagan tests, etc.
  - Tests for discrete (lumpy) changes in variance: the Goldfeld–Quandt test

Divide the  $n$  observations into  $h$  groups, of sizes  $n_1..n_h$

Choose two groups, say 1 and 2.

$$H_0 : \sigma_1^2 = \sigma_2^2 \quad \text{against} \quad H_a : \sigma_1^2 \neq \sigma_2^2$$

# Test for specification

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$$F_{n-m-k+1}^k \sim \frac{\frac{R_1^2 - R_0^2}{k}}{\frac{1 - R_1^2}{n - m - k}}$$

# Stationary process

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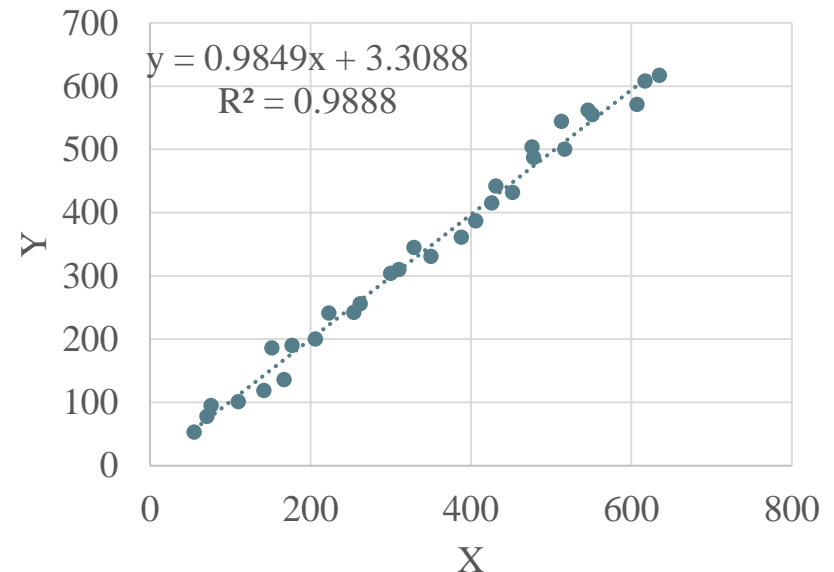
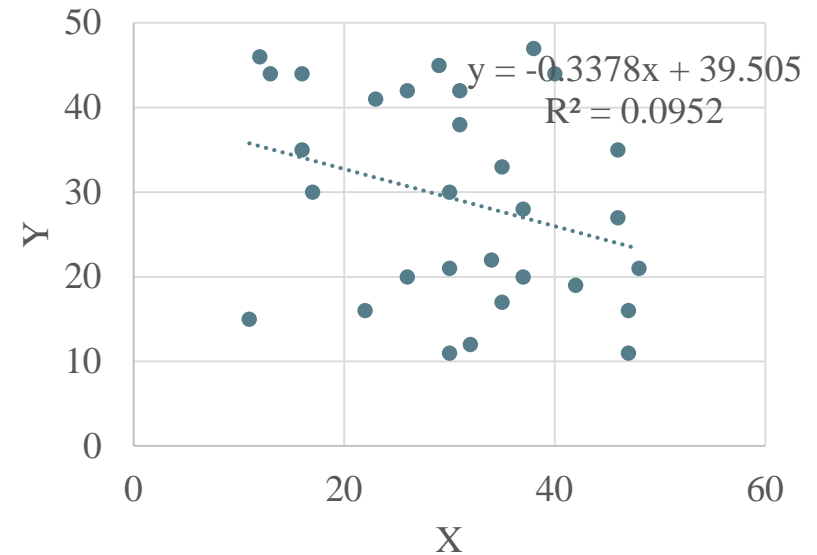
- A stationary process is a stochastic process whose joint probability distribution does not change when shifted in time.
- Parameters such as the mean and variance, if they are present, also do not change over time and do not follow any trends.

Solutions:

- Taking differences (Dickey-Fuller test)
- Trend-stationary processes

## Why stationarity is important?

No	X	Y	T	X*	Y*
1	35	33	20	55	53
2	31	38	40	71	78
3	16	35	60	76	95
4	30	21	80	110	101
5	42	19	100	142	119
6	47	16	120	167	136
7	12	46	140	152	186
8	17	30	160	177	190
9	26	20	180	206	200
10	23	41	200	223	241
11	34	22	220	254	242
12	22	16	240	262	256
13	40	44	260	300	304
14	30	30	280	310	310
15	29	45	300	329	345
16	30	11	320	350	331
...					
30	35	17	600	635	617



## Question

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*“What should we do, if we fail to find an appropriate model that satisfy all tests?”*



# Hypothesis testing Example



## File: Basics.wf1

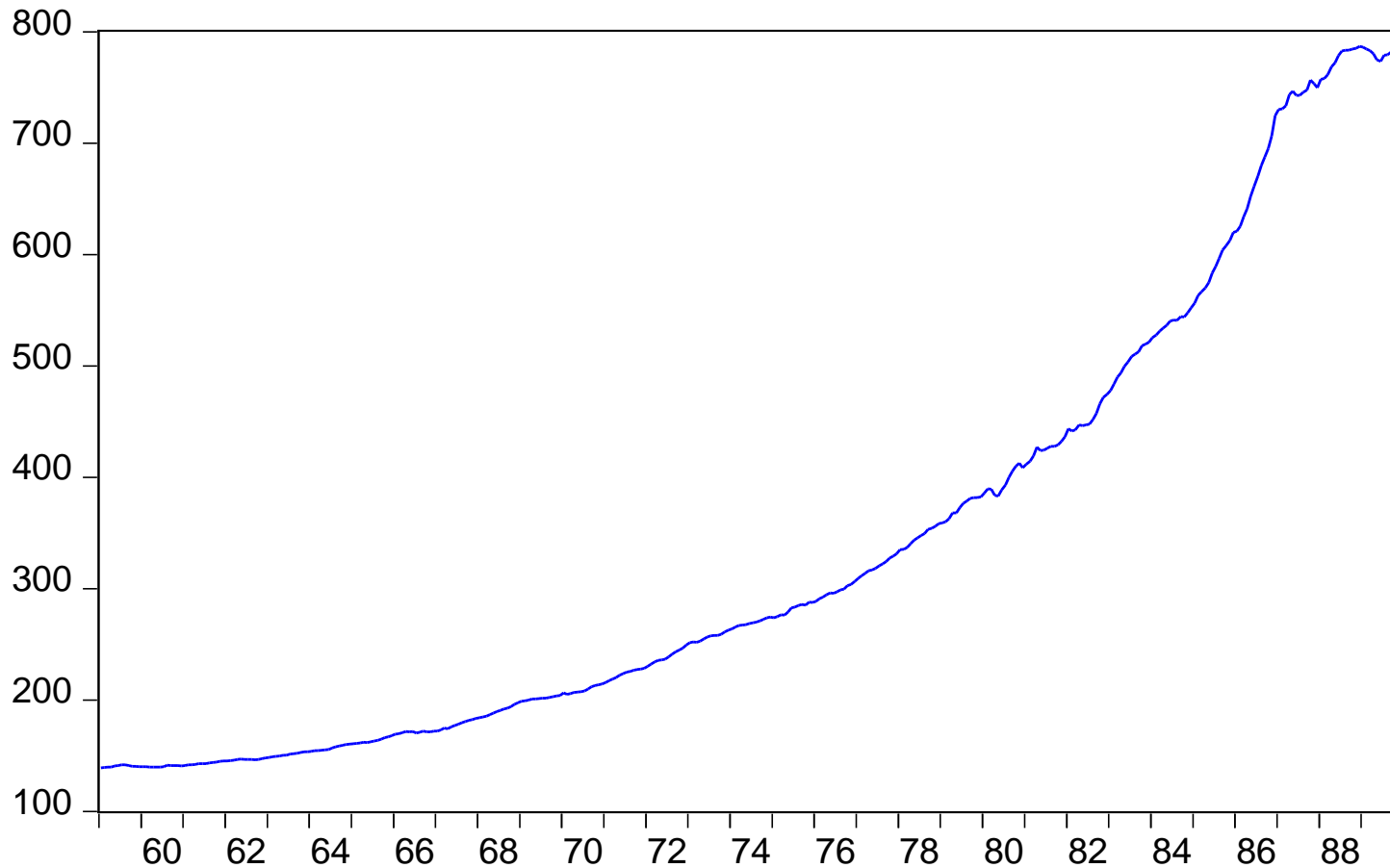
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- M1 – Money stock: M1 (BIL\$,SA)
- IP - Industrial production: total index (1987=100,SA)
- Interest rate: U.S.Treasury bills (% PER ANN,NSA)

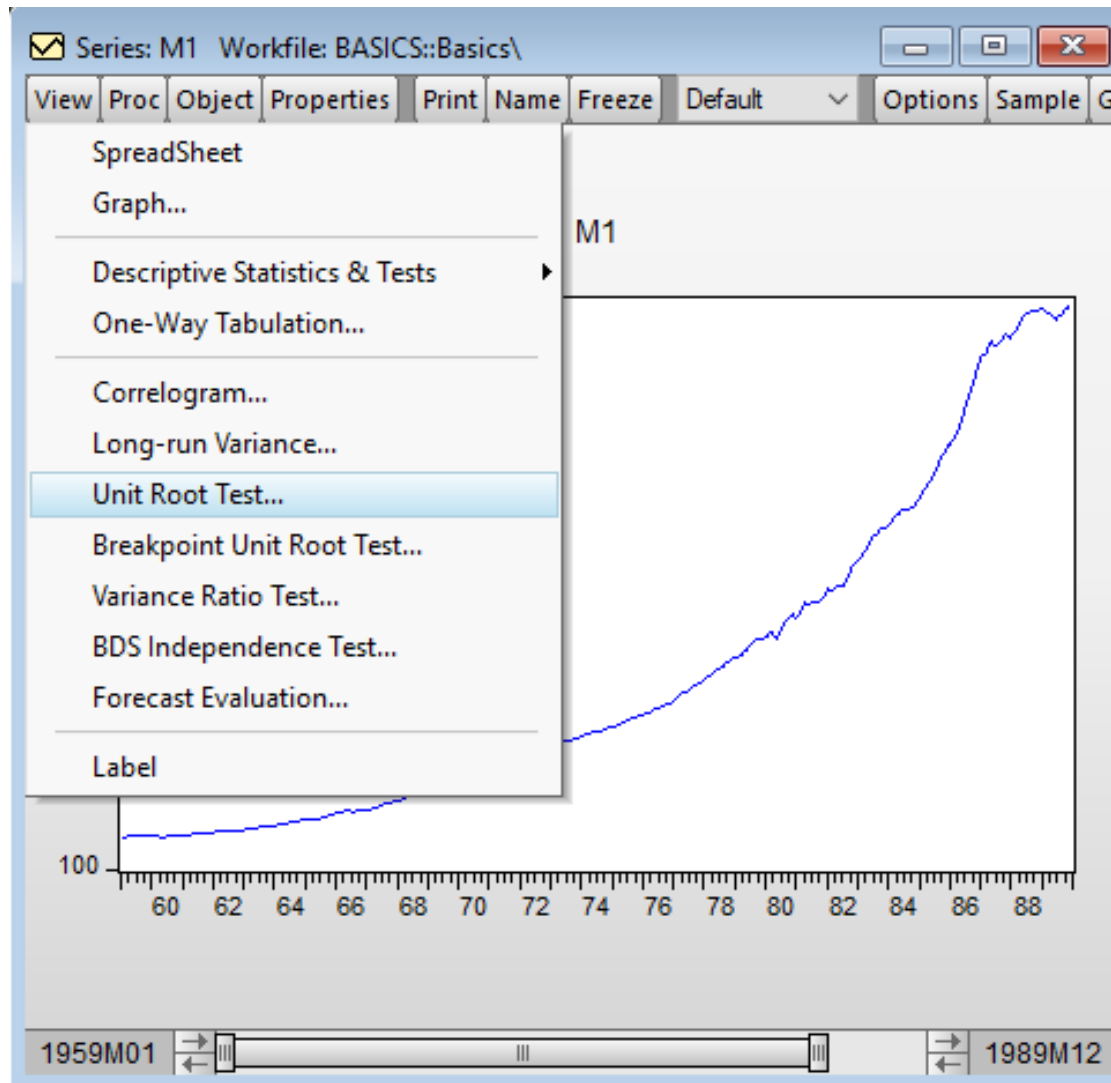
## Variable-View-Graph-Line

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M1



# Variable-View-Unit Root Test - 1



## Variable-View-Unit Root Test - 2

Unit Root Test X

Test type  
Augmented Dickey-Fuller v

Test for unit root in

Level  
 1st difference  
 2nd difference

Include in test equation

Intercept  
 Trend and intercept  
 None

Lag length

Automatic selection:  
Schwarz Info Criterion v  
Maximum lags:

User specified:

## Variable-View-Unit Root Test - 3

Series: M1 Workfile: BASICS::Basics\

View Proc Object Properties Print Name Freeze Sample Genr Sheet Graph Stat

**Augmented Dickey-Fuller Unit Root Test on M1**

Null Hypothesis: M1 has a unit root  
 Exogenous: Constant  
 Lag Length: 5 (Automatic - based on SIC, maxlag=16)

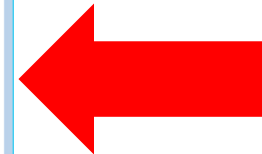
	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	2.498644	1.0000
Test critical values:		
1% level	-3.448012	
5% level	-2.869219	
10% level	-2.570928	

\*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation  
 Dependent Variable: D(M1)  
 Method: Least Squares  
 Date: 10/16/17 Time: 18:46  
 Sample (adjusted): 1959M07 1989M12  
 Included observations: 366 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
M1(-1)	0.001619	0.000648	2.498644	0.0129
D(M1(-1))	0.436352	0.051476	8.476805	0.0000
D(M1(-2))	-0.145160	0.056213	-2.582320	0.0102
D(M1(-3))	0.305890	0.054705	5.591649	0.0000
D(M1(-4))	-0.147148	0.056519	-2.603509	0.0096
D(M1(-5))	0.253626	0.052082	4.869752	0.0000
C	-0.002398	0.201834	-0.011882	0.9905

R-squared	0.438654	Mean dependent var	1.784153
Adjusted R-squared	0.429273	S.D. dependent var	2.559361
S.E. of regression	1.933508	Akaike info criterion	4.175489
Sum squared resid	1342.105	Schwarz criterion	4.250130
Log likelihood	-757.1146	Hannan-Quinn criter.	4.205149
F-statistic	46.75580	Durbin-Watson stat	1.957798
Prob(F-statistic)	0.000000		



## Variable-View-Unit Root Test - 4

Unit Root Test ✕

Test type  
Augmented Dickey-Fuller ▼

Test for unit root in

Level

1st difference

2nd difference

Include in test equation

Intercept

Trend and intercept

None

Lag length

Automatic selection:

Schwarz Info Criterion ▼

Maximum lags:

User specified:

## Variable-View-Unit Root Test - 5

Series: M1 Workfile: BASICS::Basics\

View Proc Object Properties Print Name Freeze Sample Genr Sheet Graph Stat

**Augmented Dickey-Fuller Unit Root Test on D(M1)**

Null Hypothesis: D(M1) has a unit root  
 Exogenous: Constant  
 Lag Length: 4 (Automatic - based on SIC, maxlag=16)

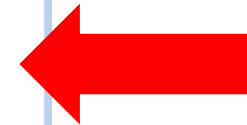
	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-3.682409	0.0047
Test critical values:		
1% level	-3.448012	
5% level	-2.869219	
10% level	-2.570928	

\*Mackinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation  
 Dependent Variable: D(M1,2)  
 Method: Least Squares  
 Date: 10/16/17 Time: 18:49  
 Sample (adjusted): 1959M07 1989M12  
 Included observations: 366 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(M1(-1))	-0.194938	0.052938	-3.682409	0.0003
D(M1(-1),2)	-0.345464	0.063177	-5.468229	0.0000
D(M1(-2),2)	-0.476505	0.063106	-7.550824	0.0000
D(M1(-3),2)	-0.148444	0.057970	-2.560720	0.0109
D(M1(-4),2)	-0.281378	0.051253	-5.489976	0.0000
C	0.368130	0.137911	2.669336	0.0079

R-squared	0.358007	Mean dependent var	0.015301
Adjusted R-squared	0.349090	S.D. dependent var	2.413934
S.E. of regression	1.947537	Akaike info criterion	4.187266
Sum squared resid	1365.445	Schwarz criterion	4.251244
Log likelihood	-760.2697	Hannan-Quinn criter.	4.212689
F-statistic	40.15071	Durbin-Watson stat	1.964051
Prob(F-statistic)	0.000000		



## Model

Equation: EQ1 Workfile: BASICS::Basics\

View Proc Object Print Name Freeze Estimate Forecast Stats Resids

Dependent Variable: LOG(M1)  
 Method: Least Squares  
 Date: 10/16/17 Time: 18:53  
 Sample: 1959M01 1989M12  
 Included observations: 372

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-1.699912	0.164954	-10.30539	0.0000
LOG(IP)	1.765866	0.043546	40.55199	0.0000
TB3	-0.011895	0.004628	-2.570016	0.0106

R-squared	0.886416	Mean dependent var	5.663717
Adjusted R-squared	0.885800	S.D. dependent var	0.553903
S.E. of regression	0.187183	Akaike info criterion	-0.505429
Sum squared resid	12.92882	Schwarz criterion	-0.473825
Log likelihood	97.00979	Hannan-Quinn criter.	-0.492878
F-statistic	1439.848	Durbin-Watson stat	0.008687
Prob(F-statistic)	0.000000		



## Normality test – 1

The screenshot shows the EViews software interface. The main window title is 'Equation: EQ1 Workfile: BASICS::Basics\'. The 'Stats' menu is open, and the 'Residual Diagnostics' option is selected. A sub-menu is displayed, showing the path: Residual Diagnostics > Histogram - Normality Test.

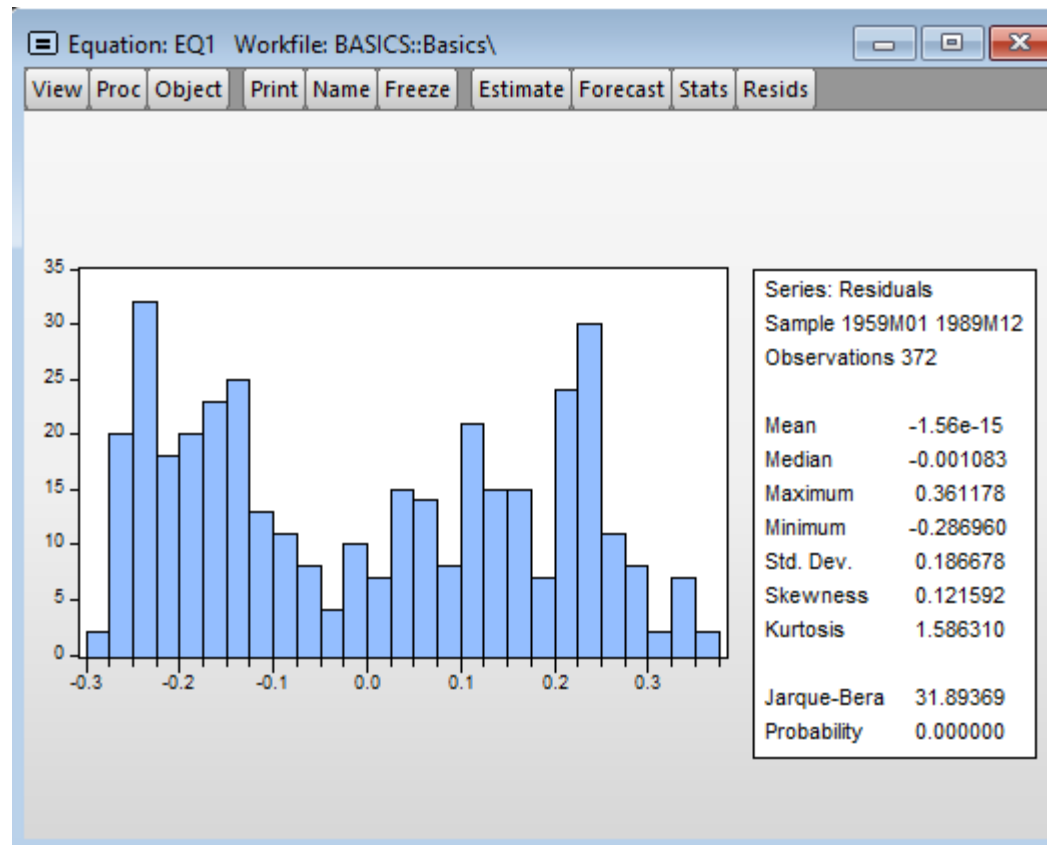
Below the menu, a table of statistics is visible:

	Std. Error	t-Statistic	Prob.
	0.164954	-10.30539	0.0000
	0.043546	40.55199	0.0000

At the bottom of the window, a summary table is partially visible:

Sum squared resid	12.92882
Log likelihood	97.00979
F-statistic	1439.848
Prob(F-statistic)	0.000000

# Normality test – 2



## Wald test – 1

The screenshot shows the EViews software interface for an equation named 'EQ1'. The 'View' menu is open, and the 'Wald Test- Coefficient Restrictions...' option is selected. The main window displays a table of coefficient statistics.

	Std. Error	t-Statistic	Prob.
	0.164954	-10.30539	0.0000

Below the table, the following statistics are displayed:

Sum squared resid	12.92882
Log likelihood	97.00979
F-statistic	1439.848
Prob(F-statistic)	0.000000

The 'View' menu options include: Representations, Estimation Output, Actual, Fitted, Residual, ARMA Structure..., Gradients and Derivatives, Covariance Matrix, **Coefficient Diagnostics**, Residual Diagnostics, Stability Diagnostics, and Label. The 'Wald Test- Coefficient Restrictions...' option is highlighted in the submenu.

## Wald test – 2

Equation: EQ1 Workfile: BASICS::Basics\

View Proc Object Print Name Freeze Estimate Forecast Stats Resids

Dependent Variable: LOG(M1)  
 Method: Least Squares  
 Date: 10/16/17 Time: 18:56  
 Sample: 1959M01 1989M12  
 Included observations: 372

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-1.699912	0.164954	-10.30539	0.0000
LOG(IP)	1.765866	0.043546	40.55199	0.0000
TB3	-0.011895	0.004628	-2.570016	0.0106

R-squared	0.886
Adjusted R-squared	0.885
S.E. of regression	0.187
Sum squared resid	12.92
Log likelihood	97.00
F-statistic	1439.
Prob(F-statistic)	0.000

Wald Test

Coefficient restrictions separated by commas

C(2)=2, c(3)=0

Examples  
 C(1)=0, C(3)=2\*C(4)

OK Cancel

# Wald test – 3

Equation: EQ1 Workfile: BASICS::Basics\

View Proc Object Print Name Freeze Estimate Forecast Stats Resids


Wald Test:  
Equation: EQ1

Test Statistic	Value	df	Probability
F-statistic	52.15538	(2, 369)	0.0000
Chi-square	104.3108	2	0.0000

Null Hypothesis:  $C(2)=2, C(3)=0$   
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
-2 + C(2)	-0.234134	0.043546
C(3)	-0.011895	0.004628

Restrictions are linear in coefficients.



## Omitted Variable Test – 1

The screenshot shows the EViews software interface for an equation named EQ1. The 'View' menu is open, and the 'Omitted Variables Test - Likelihood Ratio...' option is highlighted. The 'Estimate' tab is active, displaying a table with the following data:

	Std. Error	t-Statistic	Prob.
	0.164954	-10.30539	0.0000

Below the table, the following statistics are displayed:

Sum squared resid	12.92662
Log likelihood	97.00979
F-statistic	1439.848
Prob(F-statistic)	0.000000

The 'View' menu options include: Representations, Estimation Output, Actual, Fitted, Residual, ARMA Structure..., Gradients and Derivatives, Covariance Matrix, Coefficient Diagnostics (selected), Residual Diagnostics, Stability Diagnostics, and Label. The 'Omitted Variables Test - Likelihood Ratio...' option is highlighted in the submenu.

## Omitted Variable Test – 2

Equation: EQ1 Workfile: BASICS::Basics\

View Proc Object Print Name Freeze Estimate Forecast Stats Resids

Dependent Variable: LOG(M1)  
 Method: Least Squares  
 Date: 10/16/17 Time: 18:56  
 Sample: 1959M01 1989M12  
 Included observations: 372

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-1.699912	0.164954	-10.30539	0.0000
LOG(IP)	1.765866	0.043546	40.55199	0.0000
TB3	-0.011895	0.004628	-2.570016	0.0106

R-squared	0.886416
Adjusted R-squared	0.885800
S.E. of regression	0.187183
Sum squared resid	12.92882
Log likelihood	97.00979
F-statistic	1439.848
Prob(F-statistic)	0.000000

Omitted Variables Test

One or more test series to add

urate

OK Cancel

## Omitted Variable Test – 3

Equation: EQ1 Workfile: BASICS::Basics\

View Proc Object Print Name Freeze Estimate Forecast Stats Resids

Omitted Variables Test  
 Null hypothesis: URATE are jointly significant  
 Equation: EQ1  
 Specification: LOG(M1) C LOG(IP) TB3  
 Omitted Variables: URATE

	Value	df	Probability
t-statistic	11.28111	368	0.0000
F-statistic	127.2635	(1, 368)	0.0000
Likelihood ratio	110.4866	1	0.0000

F-test summary:

	Sum of Sq.	df	Mean Squares
Test SSR	3.322206	1	3.322206
Restricted SSR	12.92882	369	0.035037
Unrestricted SSR	9.606613	368	0.026105

LR test summary:

	Value	df
Restricted LogL	97.00979	369
Unrestricted LogL	152.2531	368



## Redundant Variable Test – 1

The screenshot shows the EViews software interface. The window title is "Equation: EQ1 Workfile: BASICS::Basics\". The "Estimate" tab is selected, and the "Coefficient Diagnostics" menu is open. The menu options include:

- Representations
- Estimation Output
- Actual, Fitted, Residual
- ARMA Structure...
- Gradients and Derivatives
- Covariance Matrix
- Coefficient Diagnostics** (highlighted)
- Residual Diagnostics
- Stability Diagnostics
- Label
- Scaled Coefficients
- Confidence Intervals...
- Confidence Ellipse...
- Variance Inflation Factors
- Coefficient Variance Decomposition
- Wald Test- Coefficient Restrictions...
- Omitted Variables Test - Likelihood Ratio...
- Redundant Variables Test - Likelihood Ratio...** (highlighted)
- Factor Breakpoint Test...

In the background, a table of statistics is visible:

	Std. Error	t-Statistic	Prob.
	0.164954	-10.30539	0.0000

Below the table, the following statistics are displayed:

Sum squared resid	12.92682
Log likelihood	97.00979
F-statistic	1439.848
Prob(F-statistic)	0.000000

## Redundant Variable Test – 2

Equation: EQ1 Workfile: BASICS::Basics\

View Proc Object Print Name Freeze Estimate Forecast Stats Resids

Dependent Variable: LOG(M1)  
 Method: Least Squares  
 Date: 10/16/17 Time: 18:56  
 Sample: 1959M01 1989M12  
 Included observations: 372

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-1.699912	0.164954	-10.30539	0.0000
LOG(IP)	1.765866	0.043546	40.55199	0.0000
TB3	-0.011895	0.004628	-2.570016	0.0106

R-squared	0.886416	Mean dependent var	5.663717
Adjusted R-squared	0.885800	S.D. dependent var	0.553903
S.E. of regression	0.187183		
Sum squared resid	12.92882		
Log likelihood	97.00979		
F-statistic	1439.848		
Prob(F-statistic)	0.000000		

Redundant Variables Test

One or more test series to remove

tb3

OK Cancel

## Redundant Variable Test – 3

Equation: EQ1 Workfile: BASICS::Basics\

View Proc Object Print Name Freeze Estimate Forecast Stats Resids

Redundant Variables Test  
 Null hypothesis: TB3 are jointly insignificant  
 Equation: EQ1  
 Specification: LOG(M1) C LOG(IP) TB3  
 Redundant Variables: TB3

	Value	df	Probability
t-statistic	2.570016	369	0.0106
F-statistic	6.604981	(1, 369)	0.0106
Likelihood ratio	6.599788	1	0.0102

F-test summary:

	Sum of Sq.	df	Mean Squares
Test SSR	0.231422	1	0.231422
Restricted SSR	13.16024	370	0.035568
Unrestricted SSR	12.92882	369	0.035037

LR test summary:

	Value	df
Restricted LogL	93.70989	370
Unrestricted LogL	97.00979	369

## Multicollinearity test – 1

Equation: EQ1 Workfile: BASICS::Basics\

View Proc Object Print Name Freeze Estimate Forecast Stats Resids

- Representations
- Estimation Output
- Actual, Fitted, Residual
- ARMA Structure...
- Gradients and Derivatives
- Covariance Matrix
- Coefficient Diagnostics**
- Residual Diagnostics
- Stability Diagnostics
- Label

	Std. Error	t-Statistic	Prob.
	0.164954	-10.30539	0.0000

- Scaled Coefficients
- Confidence Intervals...
- Confidence Ellipse...
- Variance Inflation Factors**
- Coefficient Variance Decomposition
- Wald Test- Coefficient Restrictions...
- Omitted Variables Test - Likelihood Ratio...
- Redundant Variables Test - Likelihood Ratio...
- Factor Breakpoint Test...

Sum squared resid	12.92882
Log likelihood	97.00979
F-statistic	1439.848
Prob(F-statistic)	0.000000

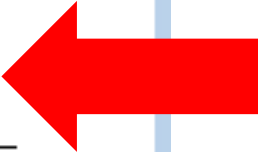
## Multicollinearity test – 2

Equation: EQ1 Workfile: BASICS::Basics\

View Proc Object Print Name Freeze Estimate Forecast Stats Resids

Variance Inflation Factors  
Date: 10/16/17 Time: 19:25  
Sample: 1959M01 1989M12  
Included observations: 372

Variable	Coefficient Variance	Uncentered VIF	Centered VIF
C	0.027210	288.8911	NA
LOG(IP)	0.001896	359.1504	1.910668
TB3	2.14E-05	10.92754	1.910668



## Autocorrelation test – 1

The screenshot shows the EViews software interface for an equation named 'EQ1' in the workfile 'BASICS::Basics'. The 'View' menu is open, and the 'Residual Diagnostics' option is selected, which has opened a sub-menu. In this sub-menu, the 'Serial Correlation LM Test...' option is highlighted. The main window also displays a table of coefficient statistics.

	Std. Error	t-Statistic	Prob.
	0.164954	-10.30539	0.0000
	0.043546	40.55199	0.0000

Sum of squared resid	12.92882
Log likelihood	97.00979
F-statistic	1439.848
Prob(F-statistic)	0.000000

## Autocorrelation test – 2

Equation: EQ1 Workfile: BASICS::Basics\

View Proc Object Print Name Freeze Estimate Forecast Stats Resids

Dependent Variable: LOG(M1)  
 Method: Least Squares  
 Date: 10/16/17 Time: 18:56  
 Sample: 1959M01 1989M12  
 Included observations: 372

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-1.699912	0.164954	-10.30539	0.0000
LOG(IP)	1.765866	0.043546	40.55199	0.0000
TB3	-0.011895	0.004628	-2.570016	0.0106

R-squared	0.886416	Mean dependent variable
Adjusted R-squared	0.885800	S.D. dependent variable
S.E. of regression	0.187183	Akaike info criterion
Sum squared resid	12.92882	Schwarz criterion
Log likelihood	97.00979	Hannan-Quinn criterion
F-statistic	1439.848	Durbin-Watson statistic
Prob(F-statistic)	0.000000	

Lag Specification

Lags to include:

OK Cancel

## Autocorrelation test – 3

Equation: EQ1 Workfile: BASICS::Basics\

View Proc Object Print Name Freeze Estimate Forecast Stats Resids


Breusch-Godfrey Serial Correlation LM Test:

F-statistic	10507.56	Prob. F(2,367)	0.0000
Obs*R-squared	365.6150	Prob. Chi-Square(2)	0.0000

Test Equation:  
 Dependent Variable: RESID  
 Method: Least Squares  
 Date: 10/16/17 Time: 19:07  
 Sample: 1959M01 1989M12  
 Included observations: 372  
 Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.017484	0.021706	0.805476	0.4211
LOG(IP)	-0.005885	0.005735	-1.026106	0.3055
TB3	0.001250	0.000613	2.038284	0.0422
RESID(-1)	1.076292	0.052085	20.66407	0.0000
RESID(-2)	-0.083710	0.052223	-1.602952	0.1098

R-squared	0.982836	Mean dependent var	-1.56E-15
Adjusted R-squared	0.982649	S.D. dependent var	0.186678
S.E. of regression	0.024590	Akaike info criterion	-4.559625
Sum squared resid	0.221908	Schwarz criterion	-4.506952
Log likelihood	853.0903	Hannan-Quinn criter.	-4.538707
F-statistic	5253.782	Durbin-Watson stat	1.470545
Prob(F-statistic)	0.000000		





## Autocorrelation test – 4

Equation: EQ1 Workfile: BASICS::Basics\

View Proc Object Print Name Freeze Estimate Forecast Stats Resids

Dependent Variable: LOG(M1)  
 Method: Least Squares  
 Date: 10/16/17 Time: 18:53  
 Sample: 1959M01 1989M12  
 Included observations: 372

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-1.699912	0.164954	-10.30539	0.0000
LOG(IP)	1.765866	0.043546	40.55199	0.0000
TB3	-0.011895	0.004628	-2.570016	0.0106

R-squared	0.886416	Mean dependent var	5.663717
Adjusted R-squared	0.885800	S.D. dependent var	0.553903
S.E. of regression	0.187183	Akaike info criterion	-0.505429
Sum squared resid	12.92882	Schwarz criterion	-0.473825
Log likelihood	97.00979	Hannan-Quinn criter.	-0.492878
F-statistic	1439.848	Durbin-Watson stat	0.008687
Prob(F-statistic)	0.000000		

Durbin-Watson test statistic  $d$  : 5% significance points of  $d_L$  and  $d_U$ .

n	k'=1		k'=2		k'=3		k'=4		k'=5	
	$d_L$	$d_U$	$d_L$	$d_U$	$d_L$	$d_U$	$d_L$	$d_U$	$d_L$	$d_U$
15	1.08	1.36	0.95	1.54	0.82	1.75	0.69	1.97	0.56	2.21
16	1.10	1.37	0.98	1.54	0.86	1.73	0.74	1.93	0.62	2.15
17	1.13	1.38	1.02	1.54	0.90	1.71	0.78	1.90	0.67	2.10
18	1.16	1.39	1.05	1.53	0.93	1.69	0.82	1.87	0.71	2.06
19	1.18	1.40	1.08	1.53	0.97	1.68	0.86	1.85	0.75	2.02
20	1.20	1.41	1.10	1.54	1.00	1.68	0.90	1.83	0.79	1.99
21	1.22	1.42	1.13	1.54	1.03	1.67	0.93	1.81	0.83	1.96
22	1.24	1.43	1.15	1.54	1.05	1.66	0.96	1.80	0.86	1.94
23	1.26	1.44	1.17	1.54	1.08	1.66	0.99	1.79	0.90	1.92
24	1.27	1.45	1.19	1.55	1.10	1.66	1.01	1.78	0.93	1.90
25	1.29	1.45	1.21	1.55	1.12	1.66	1.04	1.77	0.95	1.89
26	1.30	1.46	1.22	1.55	1.14	1.65	1.06	1.76	0.98	1.88
27	1.32	1.47	1.24	1.56	1.16	1.65	1.08	1.76	1.01	1.86
28	1.33	1.48	1.26	1.56	1.18	1.65	1.10	1.75	1.03	1.85
29	1.34	1.48	1.27	1.56	1.20	1.65	1.12	1.74	1.05	1.84
30	1.35	1.49	1.28	1.57	1.21	1.65	1.14	1.74	1.07	1.83
31	1.36	1.50	1.30	1.57	1.23	1.65	1.16	1.74	1.09	1.83
32	1.37	1.50	1.31	1.57	1.24	1.65	1.18	1.73	1.11	1.82
33	1.38	1.51	1.32	1.58	1.26	1.65	1.19	1.73	1.13	1.81
34	1.39	1.51	1.33	1.58	1.27	1.65	1.21	1.73	1.15	1.81
35	1.40	1.52	1.34	1.58	1.28	1.65	1.22	1.73	1.16	1.80
36	1.41	1.52	1.35	1.59	1.29	1.65	1.24	1.73	1.18	1.80
37	1.42	1.53	1.36	1.59	1.31	1.66	1.25	1.72	1.19	1.80
38	1.43	1.54	1.37	1.59	1.32	1.66	1.26	1.72	1.21	1.79
39	1.43	1.54	1.38	1.60	1.33	1.66	1.27	1.72	1.22	1.79
40	1.44	1.54	1.39	1.60	1.34	1.66	1.29	1.72	1.23	1.79
45	1.48	1.57	1.43	1.62	1.38	1.67	1.34	1.72	1.29	1.78
50	1.50	1.59	1.46	1.63	1.42	1.67	1.38	1.72	1.34	1.77
55	1.53	1.60	1.49	1.64	1.45	1.68	1.41	1.72	1.38	1.77
60	1.55	1.62	1.51	1.65	1.48	1.69	1.44	1.73	1.41	1.77
65	1.57	1.63	1.54	1.66	1.50	1.70	1.47	1.73	1.44	1.77
70	1.58	1.64	1.55	1.67	1.52	1.70	1.49	1.74	1.46	1.77
75	1.60	1.65	1.57	1.68	1.54	1.71	1.51	1.74	1.49	1.77
80	1.61	1.66	1.59	1.69	1.56	1.72	1.53	1.74	1.51	1.77
85	1.62	1.67	1.60	1.70	1.57	1.72	1.55	1.75	1.52	1.77
90	1.63	1.68	1.61	1.70	1.59	1.73	1.57	1.75	1.54	1.78
95	1.64	1.69	1.62	1.71	1.60	1.73	1.58	1.75	1.56	1.78
100	1.65	1.69	1.63	1.72	1.61	1.74	1.59	1.76	1.57	1.78

$n$  = number of observations

$k'$  = number of explanatory variables

## Heteroskedasticity Tests – 1

The screenshot shows the EViews software interface for an equation named 'EQ1' in a workfile 'BASICS::Basics\'. The 'Resids' tab is active, and the 'Residual Diagnostics' menu is open, with 'Heteroskedasticity Tests...' selected. The main window displays a table of regression statistics.

	Std. Error	t-Statistic	Prob.
	0.164954	-10.30539	0.0000
	0.043546	40.55199	0.0000

Sum squared resid	12.92882
Log likelihood	97.00979
F-statistic	1439.848
Prob(F-statistic)	0.000000

# Heteroskedasticity Tests – 2

Equation: EQ1 Workfile: BASICS::Basics\

View Proc Object Print Name Freeze Estimate Forecast Stats Resids

Dependent Variable: LOG(M1)  
 Method: Least Squares  
 Date: 10/16/17 Time: 18:56  
 Sample: 1959M01 1989M12  
 Included observations: 372

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.000000	0.164951	10.00000	0.0000
LOG(IP)				
TB3				

R-squared  
 Adjusted R-squared  
 S.E. of regression  
 Sum squared resid  
 Log likelihood  
 F-statistic  
 Prob(F-statistic)

Heteroskedasticity Tests

Specification

Test type:

- Breusch-Pagan-Godfrey
- Harvey
- Glejser
- ARCH
- White
- Custom Test Wizard...

Dependent variable: RESID^2

The White Test regresses the squared residuals on the cross product of the original regressors and a constant.

Include White cross terms

OK Cancel

## Heteroskedasticity Tests – 3

Equation: EQ1 Workfile: BASICS::Basics\

View Proc Object Print Name Freeze Estimate Forecast Stats Resids


Heteroskedasticity Test: White

F-statistic	41.85316	Prob. F(5,366)	0.0000
Obs*R-squared	135.3233	Prob. Chi-Square(5)	0.0000
Scaled explained SS	39.03343	Prob. Chi-Square(5)	0.0000

Test Equation:  
 Dependent Variable: RESID^2  
 Method: Least Squares  
 Date: 10/16/17 Time: 19:14  
 Sample: 1959M01 1989M12  
 Included observations: 372

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	4.052206	0.335758	12.06881	0.0000
LOG(IP)^2	0.277804	0.023907	11.62025	0.0000
LOG(IP)*TB3	-0.041623	0.004999	-8.326359	0.0000
LOG(IP)	-2.129227	0.180169	-11.81793	0.0000
TB3^2	0.000203	0.000166	1.221508	0.2227
TB3	0.177205	0.020435	8.671671	0.0000

R-squared	0.363772	Mean dependent var	0.034755
Adjusted R-squared	0.355081	S.D. dependent var	0.026648
S.E. of regression	0.021400	Akaike info criterion	-4.834841
Sum squared resid	0.167616	Schwarz criterion	-4.771633
Log likelihood	905.2804	Hannan-Quinn criter.	-4.809739
F-statistic	41.85316	Durbin-Watson stat	0.114550
Prob(F-statistic)	0.000000		



## Stability test – 1

The screenshot shows the EViews software interface. The main window title is "Equation: EQ1 Workfile: BASICS::Basics\". The menu bar includes "View", "Proc", "Object", "Print", "Name", "Freeze", "Estimate", "Forecast", "Stats", and "Resids". The "View" menu is open, showing options like "Representations", "Estimation Output", "Actual, Fitted, Residual", "ARMA Structure...", "Gradients and Derivatives", "Covariance Matrix", "Coefficient Diagnostics", "Residual Diagnostics", "Stability Diagnostics", and "Label". The "Stability Diagnostics" option is selected, opening a sub-menu with options: "Chow Breakpoint Test...", "Quandt-Andrews Breakpoint Test...", "Multiple Breakpoint Test...", "Chow Forecast Test...", "Ramsey RESET Test...", "Recursive Estimates (OLS only) ...", "Leverage Plots...", and "Influence Statistics...".

	Std. Error	t-Statistic	Prob.
	0.164954	-10.30539	0.0000
	0.043546	40.55199	0.0000
	0.004628	-2.570016	0.0106

Label	
Sum squared resid	12.92882
Log likelihood	97.00979
F-statistic	1439.848
Prob(F-statistic)	0.000000

## Stability test – 2

Equation: EQ1 Workfile: BASICS::Basics\

View Proc Object Print Name Freeze Estimate Forecast Stats Resids

Dependent Variable: LOG(M1)  
 Method: Least Squares  
 Date: 10/16/17 Time: 18:56  
 Sample: 1959M01 1989M12  
 Included observations: 372

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-1.699912	0.164954	-10.30539	0.0000
LOG(IP)	1.765866	0.043546	40.55199	0.0000
TB3	-0.0			

R-squared 0.8  
 Adjusted R-squared 0.8  
 S.E. of regression 0.1  
 Sum squared resid 12  
 Log likelihood 97  
 F-statistic 14  
 Prob(F-statistic) 0.0

Chow Tests

Enter one or more breakpoint dates

1980M1

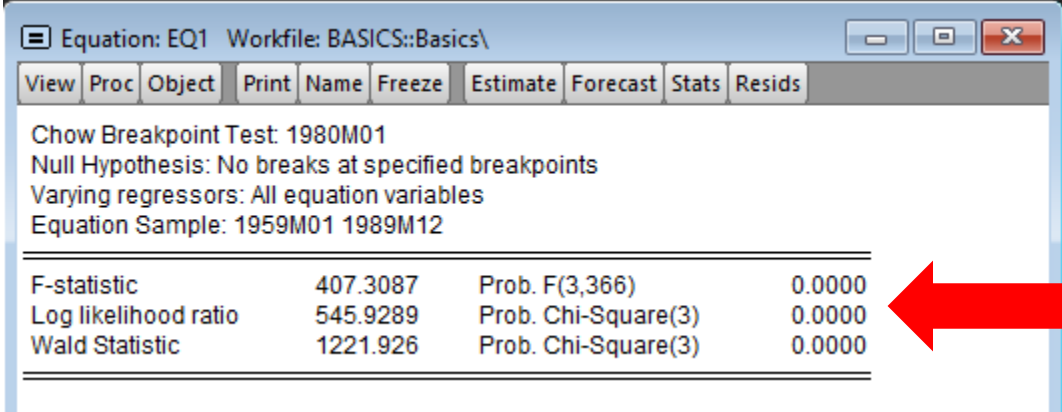
Regressors to vary across breakpoints

c log(p) tb3

OK Cancel

# Stability test – 3

---



Equation: EQ1 Workfile: BASICS::Basics\

View Proc Object Print Name Freeze Estimate Forecast Stats Resids

Chow Breakpoint Test: 1980M01  
Null Hypothesis: No breaks at specified breakpoints  
Varying regressors: All equation variables  
Equation Sample: 1959M01 1989M12

F-statistic	407.3087	Prob. F(3,366)	0.0000
Log likelihood ratio	545.9289	Prob. Chi-Square(3)	0.0000
Wald Statistic	1221.926	Prob. Chi-Square(3)	0.0000

## Stability test – 4

The screenshot shows the EViews software interface. The main window title is 'Equation: EQ1 Workfile: BASICS::Basics\'. The menu bar includes 'View', 'Proc', 'Object', 'Print', 'Name', 'Freeze', 'Estimate', 'Forecast', 'Stats', and 'Resids'. The 'View' menu is open, and 'Stability Diagnostics' is selected. A sub-menu is displayed with the following options:

- Chow Breakpoint Test...
- Quandt-Andrews Breakpoint Test...
- Multiple Breakpoint Test...
- Chow Forecast Test...**
- Ramsey RESET Test...
- Recursive Estimates (OLS only) ...
- Leverage Plots...
- Influence Statistics...

In the background, a table of test results is visible:

Prob. F(3,366)	0.0000
Prob. Chi-Square(3)	0.0000
Prob. Chi-Square(3)	0.0000



## Stability test – 5

Equation: EQ1 Workfile: BASICS::Basics\

View Proc Object Print Name Freeze Estimate Forecast Stats Resids

Dependent Variable: LOG(M1)  
 Method: Least Squares  
 Date: 10/16/17 Time: 18:56  
 Sample: 1959M01 1989M12  
 Included observations: 372

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-1.699912	0.164954	-10.30539	0.0000
LOG(IP)	1.765866	0.043546	40.55199	0.0000
TB3	-0.011895	0.004628	-2.570016	0.0106

R-squared 0.886416 Mean dependent var 5.663717  
 Adjusted R-squared 0.885900 S.D. dependent var 0.552903  
 S.E. of regression 0.429  
 Sum squared res 825  
 Log likelihood 878  
 F-statistic 687  
 Prob(F-statistic)

Chow Tests

Enter a breakpoint date

1988M7

OK Cancel

# Stability test – 6

Equation: EQ1 Workfile: BASICS::Basics\

View Proc Object Print Name Freeze Estimate Forecast Stats Resids

Chow Forecast Test  
Equation: EQ1  
Specification: LOG(M1) C LOG(IP) TB3  
Test predictions for observations from 1988M07 to 1989M12

	Value	df	Probability
F-statistic	1.818605	(18, 351)	0.0220
Likelihood ratio	33.16964	18	0.0159


F-test summary:

	Sum of Sq.	df	Mean Squares
Test SSR	1.102906	18	0.061273
Restricted SSR	12.92882	369	0.035037
Unrestricted SSR	11.82591	351	0.033692

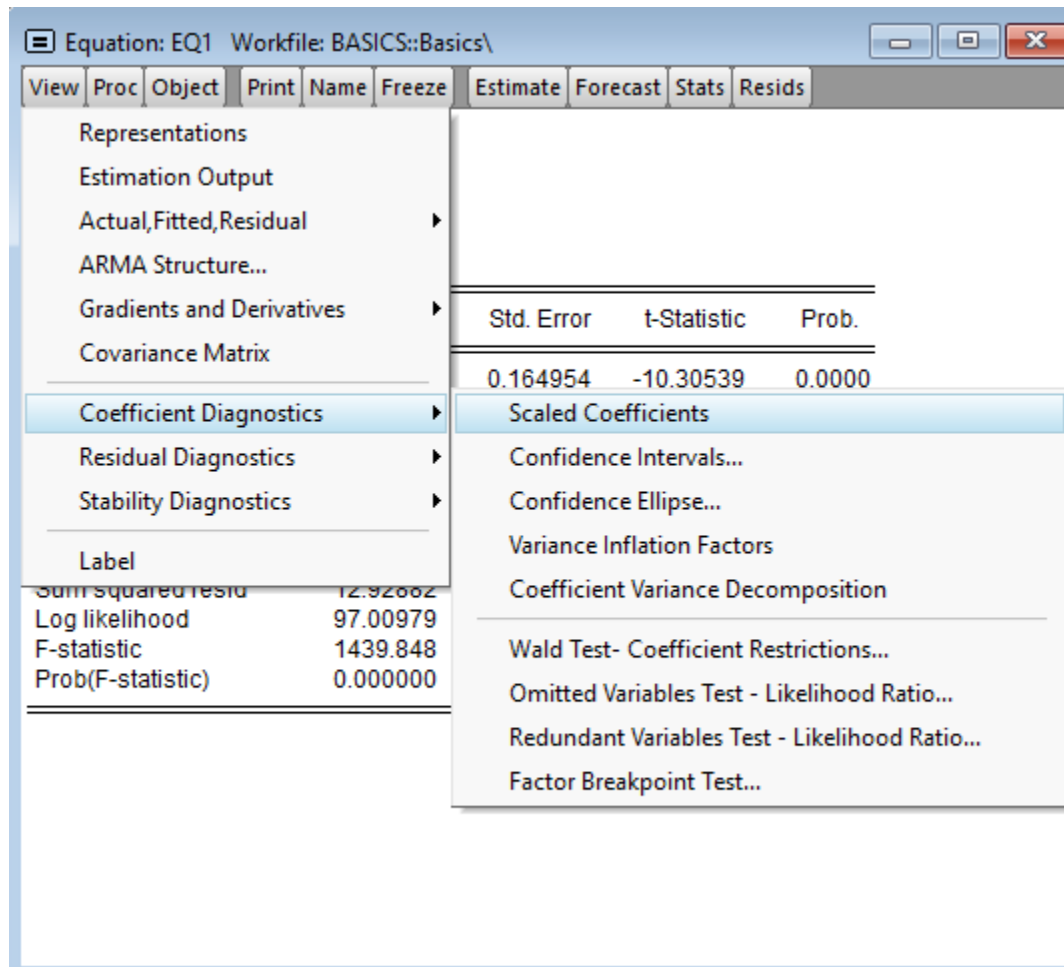
LR test summary:

	Value	df
Restricted LogL	97.00979	369
Unrestricted LogL	113.5946	351

Unrestricted log likelihood adjusts test equation results to account for observations in forecast sample



# Elasticity and normalized coefficients – 1



The screenshot shows the EViews software interface. The main window title is "Equation: EQ1 Workfile: BASICS::Basics\". The menu bar includes "View", "Proc", "Object", "Print", "Name", "Freeze", "Estimate", "Forecast", "Stats", and "Resids". The "Estimate" menu is open, showing options like "Representations", "Estimation Output", "Actual,Fitted,Residual", "ARMA Structure...", "Gradients and Derivatives", "Covariance Matrix", "Coefficient Diagnostics", "Residual Diagnostics", "Stability Diagnostics", and "Label". The "Coefficient Diagnostics" option is selected, opening a sub-menu with options: "Scaled Coefficients", "Confidence Intervals...", "Confidence Ellipse...", "Variance Inflation Factors", "Coefficient Variance Decomposition", "Wald Test- Coefficient Restrictions...", "Omitted Variables Test - Likelihood Ratio...", "Redundant Variables Test - Likelihood Ratio...", and "Factor Breakpoint Test...".

Sum of squared resid	12.92882
Log likelihood	97.00979
F-statistic	1439.848
Prob(F-statistic)	0.000000

	Std. Error	t-Statistic	Prob.
	0.164954	-10.30539	0.0000

# Elasticity and normalized coefficients – 2

Equation: EQ1 Workfile: BASICS::Basics\

View Proc Object Print Name Freeze Estimate Forecast Stats Resids

Scaled Coefficients  
Date: 10/16/17 Time: 19:28  
Sample: 1959M01 1989M12  
Included observations: 372

Variable	Coefficient	Standardized Coefficient	Elasticity at Means
C	-1.699912	NA	-0.300141
LOG(IP)	1.765866	0.983445	1.313365
TB3	-0.011895	-0.062327	-0.013224

# Review

# Linear regression

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$$y_t = \beta_0 + \beta_1 x_{1t} + \beta_2 x_{2t} + \dots + \beta_{k-1} x_{k-1t} + \varepsilon_t, t = \overline{1, n}$$

$y_t$  - dependent variable;

$x_{1t}, x_{2t}, \dots, x_{k-1t}$  - independent variables;

$\varepsilon_t$  - residuals.

# Multiple Regression Tests

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- Test residual for normality
- Test parameter significance
  - Overall model
  - Individual coefficients
- Test for multicollinearity
- Test for model stability
- Test for residuals autocorrelation
- Test for residuals homoscedasticity
- Test for specification
- Test for stationary process

Thank you for attention!