Chapter 10: Heteroskedasticity

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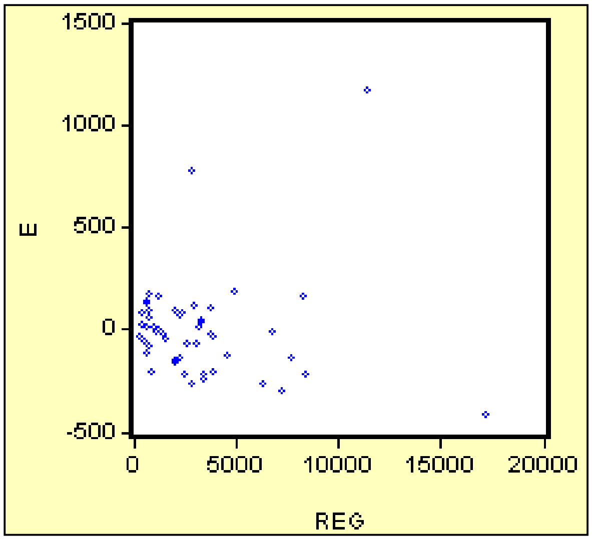
The petroleum consumption example specified in *UE* 10.5 will be used to demonstrate all aspects of heteroskedasticity covered in this guide. Data for this problem is found in EViews workfile named *Gas10.wf1* and printed in Table 10.1 (*UE*, p. 371).

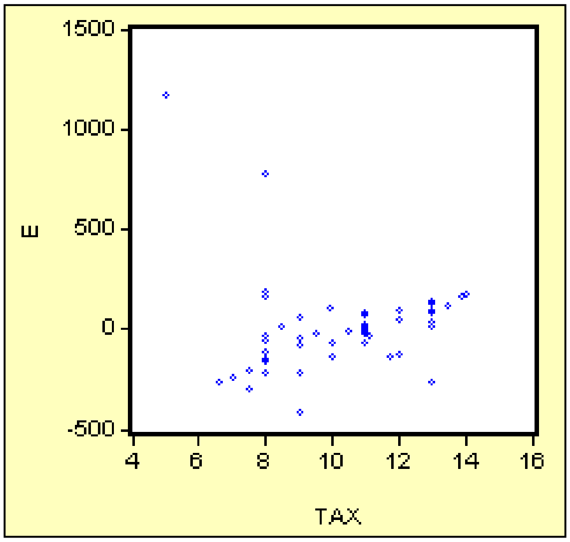
Graphing to detect heteroskedasticity (*UE* 10.1):

Figures 10.1, 10.2, and 10.3 in *UE* 10.1 demonstrate the value of a graph in detecting and identifying the source of heteroskedastic error. By graphing the residual from a regression against suspected variables, the researcher can often observe whether the variance of the error term changes systematically as a function of that variable.

Follow these steps to graph the residual from a regression against each of the independent variables in a model:

Step 1. Open the EViews workfile named *Gas10.wf1*.
Step 2. Select **Objects/New Object/Equation** on the workfile menu bar, enter *PCON C REG TAX* in the Equation Specification: window, and. click **OK**.
Step 3. Select **Name** on the equation menu bar, enter *EQ01* in the Name to identify object: window, and click **OK**.
Step 4. Make a residual series named *E* and save the workfile.
Step 5. Make a Simple Scatter graph of *E* against *REG* to get the graph on the left below.
Step 6. Make a Simple Scatter graph of *E* against *TAX* to get the graph on the right below.





Testing for heteroskedasticity: the Park test (*UE* 10.3.2):

Complete **Steps 1-3** of the section entitled Graphing to detect heteroskedasticity before attempting this section. Follow these steps to complete the Park test for heteroskedasticity:

Step 1. Open the EViews workfile named *Gas10.wf1*.

Step 2. Select **Objects/New Object/Equation** on the workfile menu bar, enter *log(E^2) C log(REG)* in the Equation Specification: window, and click **OK** to reveal the EViews output on the right.

Step 3. Test the significance of the coefficient on log(REG).

Dependent Variable: LOG(E^2)
Method: Least Squares
Date: 06/19/00 Time: 15:34
Sample: 1 50
Included observations: 50

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.650264	2.374467	0.695004	0.4904
LOG(REG)	0.951920	0.308303	3.087609	0.0033

R-squared	0.165701	Mean dependent var	8.925457
Adjusted R-squared	0.148320	S.D. dependent var	2.248987
S.E. of regression	2.075512	Akaike info criterion	4.337470
Sum squared resid	206.7719	Schwarz criterion	4.413951
Log likelihood	-106.4368	F-statistic	9.533326
Durbin-Watson stat	1.759936	Prob(F-statistic)	0.003349

Testing for heteroskedasticity: White's test (*UE* 10.3.3 & *UE*, Equation 10.12):

Complete **Steps 1-3** of the section entitled Graphing to detect heteroskedasticity before attempting this section. Follow these steps to complete White's test for heteroskedasticity:

Step 1. Open the EViews workfile named *Gas10.wf1*.

Step 2. Select **Objects/New Object/Equation** on the workfile menu bar and enter PCON C REG TAX in the Equation Specification: window. Click **OK**.

Step 3. To carry out White's heteroskedasticity test for the regression in **Step 2**, select **View/Residual Tests/White Heteroskedasticity (cross terms)** to get the output on the right. EViews reports two test statistics from the test regression. The Obs*R-squared statistic highlighted in yellow and boxed in red, is White's test statistic. It is computed as the number of

White Heteroskedasticity Test:

F-statistic	17.43051	Probability	0.000000
Obs*R-squared	33.22564	Probability	0.000003

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 06/19/00 Time: 15:49
Sample: 1 50
Included observations: 50

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1098291.	556502.1	1.973561	0.0547
REG	140.5628	39.92468	3.520699	0.0010
REG^2	-0.000515	0.001060	-0.485573	0.6297
REG*TAX	-12.84508	3.604180	-3.563939	0.0009
TAX	-237873.0	103340.2	-2.301844	0.0261
TAX^2	12346.99	4688.527	2.633449	0.0116

R-squared	0.664513	Mean dependent var	60168.93
Adjusted R-squared	0.626389	S.D. dependent var	207477.4
S.E. of regression	126817.9	Akaike info criterion	26.45106
Sum squared resid	7.08E+11	Schwarz criterion	26.68050
Log likelihood	-655.2764	F-statistic	17.43051
Durbin-Watson stat	2.250069	Prob(F-statistic)	0.000000

observations (n) times the R^2 from the test regression. White's test statistic is asymptotically distributed as a χ^2 with degrees of freedom equal to the number of slope coefficients, excluding the constant, in the test regression (five in this example).

Step 4. The critical χ^2 value can be calculated in EViews by typing the following formula in the EViews command window: *=@qchisq(.95,5)*.[1] After typing the formula and hitting **Enter** on the keyboard, Scalar = 11.0704976935 appears in the lower left of the EViews screen (the same value found in *UE*, Table B-8). Since the nR^2 value of *33.2256393731* is greater than the 5% critical χ^2 value of *11.0704976935*, we can reject the null hypothesis of no heteroskedasticity. The probability printed to the right of the nR^2 value in the EViews output for White's heteroskedasticity test (i.e., *0.000003*) represents the probability that you would be incorrect if you rejected the null hypothesis of no heteroskedasticity.[2] The F-statistic is an omitted variable test for the joint significance of all cross products, excluding the constant. It is printed above White's test statistic for comparison purposes.

Remedies for heteroskedasticity: weighted least squares (*UE* 10.4.1):

Follow these steps to estimate the weighted least squares using *REG* as the proportionality factor:

Step 1. Open the EViews workfile named *Gas10.wf1*.

Step 2. Select **Objects/New Object/Equation** on the workfile menu bar, enter *PCON/REG 1/REG REG/REG TAX/REG* in the Equation Specification: window, and click **OK**. Note the coefficients highlighted in yellow.

Dependent Variable: PCON/REG
Method: Least Squares
Date: 06/20/00 Time: 07:16
Sample: 1 50
Included observations: 50

Variable	Coefficient	Std. Error	t-Statistic	Prob.
1/REG	218.5395	48.10330	4.543129	0.0000
REG/REG	0.167831	0.013675	12.27294	0.0000
TAX/REG	-17.38900	4.682179	-3.713870	0.0005

R-squared	0.360003	Mean dependent var	0.198373
Adjusted R-squared	0.332770	S.D. dependent var	0.082386
S.E. of regression	0.067296	Akaike info criterion	-2.501302
Sum squared resid	0.212852	Schwarz criterion	-2.386581
Log likelihood	65.53256	F-statistic	13.21895
Durbin-Watson stat	1.921759	Prob(F-statistic)	0.000028

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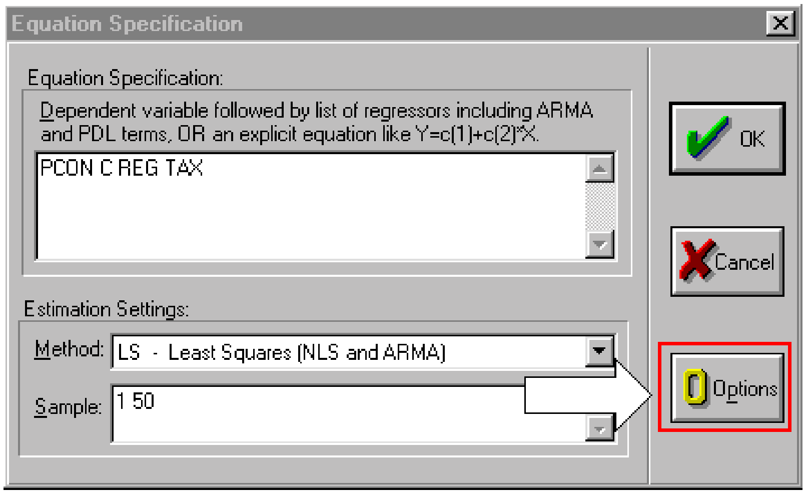
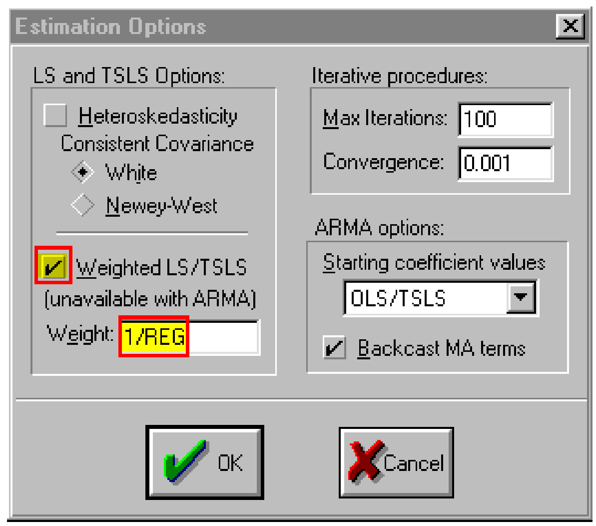
[1] *c=@qchisq(p,v)* calculates the percentile of the χ^2 distribution . The formula finds the value c such that the prob(χ^2 with v degrees of freedom is $\le c) = p$. In this case, the prob(χ^2 with 5 degrees of freedom is $\le$ *11.0704976935) =95%*. In other words, 95% of the area of a χ^2 distribution, with v=5 degrees of freedom, is in the range from *0* to *11.0704976935* and 5% is in the range from *11.0704976935* to ∞ (in the tail).

[2] The probability value is calculated with the formula *=@chisq(x,v)*, which returns the probability that a chi-squared statistic with v degrees of freedom exceeds x. To verify this, type the formula *=@chisq(33.2256393731,5)* in the EViews command window and read the value of *3.39442964858e-06* on the lower left of the EViews screen.

Step 3. Select **Objects/New Object/Equation** on the workfile menu bar and enter *PCON C REG TAX* in the Equation Specification: window, and select the O Options button (see the arrow pointing toward the red box area in the graphic on the right).



Step 4. Check the **Weighted LS/TSLS** box and enter *1/REG* in the Weight: window (see the yellow highlighted and red boxed areas in the graphic on the right).



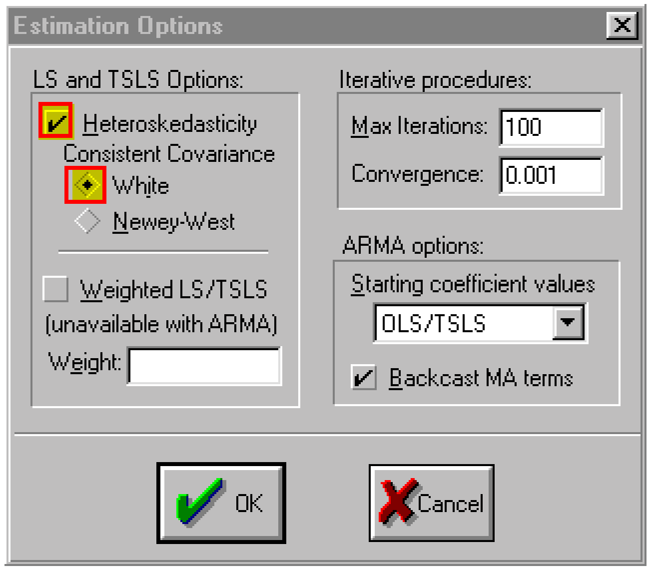
Step 5. Select **OK** to accept the options and select **OK** again to estimate the equation**.** Note that the weighted least squares coefficients found in **Step 2** are the same as the coefficients found in **Step 5** using the EViews weighted least squares option.[3]

[3] EViews performs weighted least squares by first dividing the weight series by its mean, then multiplying all of the data for each observation by the scaled weight series. The scaling of the weight series is a normalization that has no effect on the parameter results, but makes the weighted residuals more comparable to the un-weighted residuals. The normalization does imply, however, that EViews weighted least squares is not appropriate in situations where the scale of the weight series is relevant, as in frequency weighting.

Remedies for heteroskedasticity: heteroskedasticity corrected standard errors (*UE* 10.4.2):

Follow these steps to estimate heteroskedasticity corrected standard errors regression:

Step 1. Open the EViews workfile named *Gas10.wf1*.
Step 2. Select **Objects/New Object/Equation** on the workfile menu bar and enter *PCON C REG TAX* in the Equation Specification: window, and select the O Options button.
Step 3. Check the **Heteroskedasticity Consistent Covariances (White)** box (see the yellow highlighted and red boxed areas in the graphic on the right).



Step 4. Select **OK** to accept the options and select **OK** again to estimate the equation**.**
Step 5. Compare the Estimation Output from the regression with the Heteroskedasticity Consistent Covariance on the lower left with the Estimation Output from the uncorrected OLS regression on the lower right (*EQ01*). Note that the coefficients are the same but the uncorrected std. error is smaller. This means that the Heteroskedasticity Consistent Covariance correction has reduced the size of the t-statistics for the coefficients, a typical result. However, in this case both of the slope coefficients remain significant at the 5% level but the *TAX* variable coefficient is no longer significant at the 1% level.

Dependent Variable: PCON
Method: Least Squares
Date: 06/20/00 Time: 08:28
Sample: 1 50
Included observations: 50
White Heteroskedasticity-Consistent Standard Errors & Covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	551.6880	237.1574	2.326252	0.0244
REG	0.186132	0.021533	8.644038	0.0000
TAX	-53.59101	23.89750	-2.242536	0.0297

R-squared	0.866368	Mean dependent var	603.7000
Adjusted R-squared	0.860682	S.D. dependent var	677.8267
S.E. of regression	253.0010	Akaike info criterion	13.96279
Sum squared resid	3008447.	Schwarz criterion	14.07751
Log likelihood	-346.0697	F-statistic	152.3567
Durbin-Watson stat	2.197170	Prob(F-statistic)	0.000000

Dependent Variable: PCON
Method: Least Squares
Date: 06/20/00 Time: 08:31
Sample: 1 50
Included observations: 50

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	551.6880	186.2709	2.961750	0.0048
REG	0.186132	0.011719	15.88302	0.0000
TAX	-53.59101	16.85588	-3.179365	0.0026

R-squared	0.866368	Mean dependent var	603.7000
Adjusted R-squared	0.860682	S.D. dependent var	677.8267
S.E. of regression	253.0010	Akaike info criterion	13.96279
Sum squared resid	3008447.	Schwarz criterion	14.07751
Log likelihood	-346.0697	F-statistic	152.3567
Durbin-Watson stat	2.197170	Prob(F-statistic)	0.000000

Remedies for heteroskedasticity: redefining variables (*UE* 10.4.3):

Follow these steps to estimate *UE*, Equation 10.30, p. 374:

Step 1. Open the EViews workfile named *Gas10.wf1*.
Step 2. Select **Objects/New Object/Equation** on the workfile menu bar, enter *PCON/POP C REG/POP TAX* in the Equation Specification: window, and click **OK**.

Exercises:

5. Create an EViews workfile and enter the average income and average consumption data from the table printed in Exercise 5, p.378.
   a. Refer to Testing for heteroskedasticity: the Park test.
   b. Refer to Testing for heteroskedasticity: the Park test.
   c.
   d. Refer to Remedies for heteroskedasticity: heteroskedasticity corrected standard errors.

9. Open the EViews file named *Books10.wf1*.
   a.
   b.
   c. Refer to Testing for heteroskedasticity: the Park test and Testing for heteroskedasticity: White's test.
   d. Refer to Remedies for heteroskedasticity: weighted least squares.
   e. Refer to Remedies for heteroskedasticity: heteroskedasticity corrected standard errors or Remedies for heteroskedasticity: redefining variables.

15. Open the EViews file named *Bid10.wf1*.
   a. Refer to Estimate a multiple regression model using EViews and Serial Correlation (Chapter 9).
   b. Refer to Serial Correlation (Chapter 9).
   c.
   d. Refer to Testing for heteroskedasticity: the Park test and Testing for heteroskedasticity: White's test.
   e. Refer to Testing for heteroskedasticity: the Park test and Testing for heteroskedasticity: White's test.
   f.