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1. Which of the following can cause the usual OLS t statistics to be invalid (that is, not to have t distributions under H_0)?

i. Heteroskedasticity.

ii. A sample correlation coefficient of .95 between two independent variables that are in the model.

iii. Omitting an important explanatory variable.

i) Heteroskedasticity

- If the data appears to be heteroskedastic, it means that random variables do not have a constant error term or variance, thus the OLS t-statistics will be invalid.

iii) Omitting an important explanatory variable

If the omitted x is correlated to other independent variables, $E(U|X)=0$ is violated

2. Consider an equation to explain salaries of CEOs in terms of annual firm sales, return on equity (*roe*, in percentage form), and return on the firm's stock (*ros*, in percentage form):

$$\log(salary) = \beta_0 + \beta_1 \log(sales) + \beta_2 roe + \beta_3 ros + u.$$

i. In terms of the model parameters, state the null hypothesis that, after controlling for *sales* and *roe*, *ros* has no effect on CEO salary. State the alternative that better stock market performance increases a CEO's salary.

ii. Using the data in CEOSAL1, the following equation was obtained by OLS:

$$\widehat{\log(salary)} = \underset{(.32)}{4.32} + \underset{(.035)}{.280}\log(sales) + \underset{(.0041)}{.0174}\,roe + \underset{(.00054)}{.00024}\,ros$$

$$n = 209,\ R^2 = .283.$$

By what percentage is *salary* predicted to increase if *ros* increases by 50 points? Does *ros* have a practically large effect on *salary*?

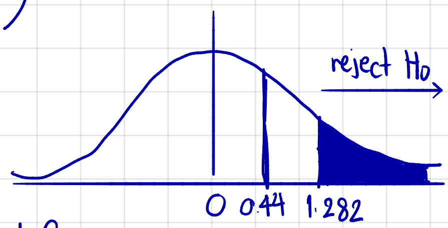
iii. Test the null hypothesis that *ros* has no effect on *salary* against the alternative that *ros* has a positive effect. Carry out the test at the 10% significance level.

i) $H_0 : \beta_3 = 0$
$H_a : \beta_3 > 0$

ii) $0.00024 \times 50 = 0.012$

Salary is expected to increase by 1.2%. Therefore ros has a small effect on salary.

iii)



$d.f. = n-k-1$
$= 209-3-1 = 205$

$t = \dfrac{\hat\beta_3 - a_j}{s.e.\ \hat\beta_3} = \dfrac{0.00024}{0.0054}$

$= 0.444$

- Since the critical value is 1.282, we fail to reject H_0 at 10% sig level

iv. Would you include *ros* in a final model explaining CEO compensation in terms of firm performance? Explain.

IV) In order to decide whether we should include ros in the final model, we use t-test. In this case, it shows that t is lower than 1.96 which means that ros does not have a significant impact on salary at 5%. Therefore, we can decide not to include ros in the final model

C6. Use the data in WAGE2 for this exercise.

i. Consider the standard wage equation

$$\log(wage) = \beta_0 + \beta_1 educ + \beta_2 exper + \beta_3 tenure + u.$$

State the null hypothesis that another year of general workforce experience has the same effect on $\log(wage)$ as another year of tenure with the current employer.

ii. Test the null hypothesis in part (i) against a two-sided alternative, at the 5% significance level, by constructing a 95% confidence interval. What do you conclude?

i) $H_0 : \beta_2 = \beta_3$ $\quad$ $H_0 : \beta_2 - \beta_3 = 0$

$H_a : \beta_2 \neq \beta_3$ $\quad$ $H_a : \beta_2 - \beta_3 \neq 0$

```
. regress lwage educ exper tenure

      Source |       SS           df       MS      Number of obs   =       935
-------------+----------------------------------   F(3, 931)       =     56.97
       Model |  25.6953242         3  8.56510806   Prob > F        =    0.0000
    Residual |  139.960959       931  .150334005   R-squared       =    0.1551
-------------+----------------------------------   Adj R-squared   =    0.1524
       Total |  165.656283       934  .177362188   Root MSE        =    .38773

------------------------------------------------------------------------------
       lwage |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        educ |   .0748638   .0065124    11.50   0.000      .062083    .0876446
       exper |   .0153285   .0033696     4.55   0.000     .0087156    .0219413
      tenure |   .0133748   .0025872     5.17   0.000     .0082974    .0184522
       _cons |   5.496696   .1105282    49.73   0.000     5.279782    5.713609
------------------------------------------------------------------------------
```

Since $n \geq 30$, it has approximately standard normal distribution

$$Z = \frac{(\beta_2 - \beta_3) - 0}{s.e.(\beta_2 - \beta_3)}$$

$$\hat{\theta}_1 = \hat{\beta}_2 - \hat{\beta}_3$$

$$Z = \frac{\hat{\theta}_1 - 0}{s.e.(\hat{\theta}_1)} = \frac{\hat{\theta}_1}{s.e.(\hat{\theta}_1)}$$

Now, $\hat{\beta}_2 = \hat{\theta}_1 + \hat{\beta}_3$

or $\beta_2 = \theta_1 + \beta_3$

Sub in the main regression and get

$$y = \beta_0 + \beta_1 educ + (\theta_1 + \beta_3) exper + \beta_3 tenure + u$$

$$= \beta_0 + \beta_1 educ + \theta_1 exper + \beta_3 exper + \beta_3 tenure + u$$

$$= \beta_0 + \beta_1 educ + \theta_1 exper + \beta_3 (exper + tenure) + u$$

Now, the explanatory variables are going to be educ, exper, exper + tenure

we can calculate $\dfrac{\hat{\theta}_1 - 0}{s.e.\ \hat{\theta}_1}$

```
. gen new = exper+tenure

. reg lwage educ exper new
```

Source	SS	df	MS			
Model	25.6953242	3	8.56510806	Number of obs	=	935
Residual	139.960959	931	.150334005	F(3, 931)	=	56.97
				Prob > F	=	0.0000
				R-squared	=	0.1551
				Adj R-squared	=	0.1524
Total	165.656283	934	.177362188	Root MSE	=	.38773

lwage	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
educ	.0748638	.0065124	11.50	0.000	.062083	.0876446
exper	.0019537	.0047434	0.41	0.681	-.0073554	.0112627
new	.0133748	.0025872	5.17	0.000	.0082974	.0184522
_cons	5.496696	.1105282	49.73	0.000	5.279782	5.713609

$$t = \frac{0.0019537}{0.004734} = 0.4119 < 1.96$$

Therefore Ho cannot be rejected at 5% level of significance

C8. The data set 401KSUBS contains information on net financial wealth (*nettfa*), age of the survey respondent (*age*), annual family income (*inc*), family size (*fsize*), and participation in certain pension plans for people in the United States. The wealth and income variables are both recorded in thousands of dollars. For this question, use only the data for single-person households (so $fsize = 1$).

i. How many single-person households are there in the data set?

ii. Use OLS to estimate the model

$$nettfa = \beta_0 + \beta_1 inc + \beta_2 age + u,$$

and report the results using the usual format. Be sure to use only the single-person households in the sample. Interpret the slope coefficients. Are there any surprises in the slope estimates?

iii. Does the intercept from the regression in part (ii) have an interesting meaning? Explain.

iv. Find the *p*-value for the test $H_0: \beta_2 = 1$ against $H_1: \beta_2 < 1$. Do you reject H_0 at the 1% significance level?

v. If you do a simple regression of *nettfa* on *inc*, is the estimated coefficient on *inc* much different from the estimate in part (ii)? Why or why not?

i) 2017 households

ii)

```
. reg nettfa inc age if fsize == 1
```

Source	SS	df	MS			
Model	544916.989	2	272458.495	Number of obs	=	2,017
Residual	4021048.06	2,014	1996.54819	F(2, 2014)	=	136.46
				Prob > F	=	0.0000
				R-squared	=	0.1193
				Adj R-squared	=	0.1185
Total	4565965.05	2,016	2264.86361	Root MSE	=	44.683

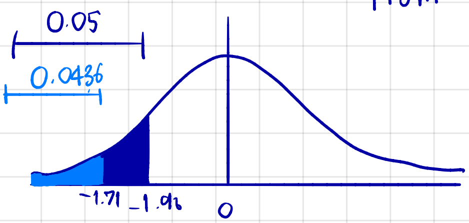
nettfa	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
inc	.7993167	.0597307	13.38	0.000	.6821762	.9164572
age	.8426563	.0920169	9.16	0.000	.6621982	1.023115
_cons	-43.03981	4.080393	-10.55	0.000	-51.04204	-35.03758

• Assuming ceteris paribus, if income increases by 1 unit, net total finanancial asset is expected to increase by 0.799. Similarly, if age increases by 1, nettfa is expected to increase by 0.8426

iii) The intercept found is negative. The estimated nettfa is -43 when inc = 0 and

iv) $H_0 : \beta_2 = 1$
$H_a : \beta_2 < 1$

$$t = \frac{\beta_2 - a_j}{s.e.(\beta_2)} = \frac{0.8426563 - 1}{0.0920169} = -1.7099 \approx -1.71$$



From the z table, the p-value of the value -1.71 is 0.0436

Since the p-value < significance level (0.05), we reject H_0 at 5% level of significance

```
. reg nettfa inc

      Source |       SS           df       MS      Number of obs   =     9,275
-------------+----------------------------------   F(1, 9273)      =   1532.38
       Model |  5381009.18         1  5381009.18   Prob > F        =    0.0000
    Residual |  32562380.3     9,273  3511.52597   R-squared       =    0.1418
-------------+----------------------------------   Adj R-squared   =    0.1417
       Total |  37943389.5     9,274  4091.3726    Root MSE        =    59.258

------------------------------------------------------------------------------
      nettfa |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         inc |   .9999113   .0255433    39.15   0.000     .9498408    1.049982
       _cons |  -20.17948   1.176434   -17.15   0.000    -22.48555   -17.87341
------------------------------------------------------------------------------
```

- When we do a simple regression of nettfa on inc, the estimated β_1 is close to 1. In comparison to the estimate in part ii which is almost close to 0.8, this is not much different.

C1. The following model can be used to study whether campaign expenditures affect election outcomes:

$$voteA = \beta_0 + \beta_1 \log(expendA) + \beta_2 \log(expendB) + \beta_3 prtystrA + u,$$

where *voteA* is the percentage of the vote received by Candidate A, *expendA* and *expendB* are campaign expenditures by Candidates A and B, and *prtystrA* is a measure of party strength for Candidate A (the percentage of the most recent presidential vote that went to A's party).

i. What is the interpretation of β_1 ?

ii. In terms of the parameters, state the null hypothesis that a 1% increase in A's expenditures is offset by a 1% increase in B's expenditures.

iii. Estimate the given model using the data in VOTE1 and report the results in usual form. Do A's expenditures affect the outcome? What about B's expenditures? Can you use these results to test the hypothesis in part (ii)?

iv. Estimate a model that directly gives the *t* statistic for testing the hypothesis in part (ii). What do you conclude? (Use a two-sided alternative.)

i) $\Delta vote\ A = \beta_1 \log(expend\ A)$

$= \frac{\beta_1}{100} (100 \times \Delta \log (expend A))$

$= \frac{\beta_1}{100} (\% \Delta \log expend A)$

$\frac{\beta_1}{100}$ is the percentage point change in percentage of vote received when campaign expenditure by candidate A when campaign expenditure increases by 1%

ii) $H_0 :- \beta_1 = \beta_2$
$H_a :- \beta_1 \neq \beta_2$

```
reg voteA lexpendA lexpendB prtystrA
```

Source	SS	df	MS			
Model	38405.1096	3	12801.7032	Number of obs	=	173
Residual	10052.1389	169	59.480112	F(3, 169)	=	215.23
				Prob > F	=	0.0000
Total	48457.2486	172	281.728189	R-squared	=	0.7926
				Adj R-squared	=	0.7889
				Root MSE	=	7.7123

voteA	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lexpendA	6.083316	.38215	15.92	0.000	5.328914	6.837719
lexpendB	-6.615417	.3788203	-17.46	0.000	-7.363246	-5.867588
prtystrA	.1519574	.0620181	2.45	0.015	.0295274	.2743873
_cons	45.07893	3.926305	11.48	0.000	37.32801	52.82985

$$y = 45.07 + 6.08 \log(\text{expendA}) - 6.62 \log(\text{expend B}) + 0.15 (\text{prtystr A})$$

The coefficients on log(expend A) and log(expend B) are very significant, as shown by the t-statistics significantly greater than 2.57. The estimates show that a 1000 increase in expenditure by candidate A increases the percentage of votes by 6%, On the other hand, a 1000 increase in expenditure by candidate B reduces vote A by 6%

Since the coefficients are opposit in sign, we can reject H_0

iv) $H_0: -\beta_1 = \beta_2$

$H_0: 0 = \beta_1 + \beta_2$

$$t = \frac{(\beta_1 + \beta_2) - 0}{s.e.(\beta_1 + \beta_2)} = \frac{\beta_1 - \beta_2}{s.e.(\beta_1 + \beta_2)}$$

$$\theta_1 = \beta_1 + \beta_2$$
$$\theta_1 - \beta_2 = \beta_1$$

$$\text{Vote A} = \beta_0 + (\theta_1 - \beta_2) \log(\text{expendA}) + \beta_2 \log(\text{expendB}) + \beta_3 (\text{prtystrA}) + u$$
$$= \beta_0 + \theta_1 \log(\text{expendA}) - \beta_2 \log(\text{expendA}) + \beta_2 \log(\text{expendB}) + \beta_3 (\text{prtystrA}) + u$$
$$= \beta_0 + \theta_1 \log(\text{expendA}) + \beta_2 (\log(\text{expend B}) - \log(\text{expendA})) + \beta_3 (\text{prtystrA}) + u$$

Now, the explanatory variables are log(expend A), log(expend B) - log(expend A), prty strA

lexpend B - lexpendA

```
. reg voteA lexpendA new prtystrA
```

Source	SS	df	MS			
Model	38405.1097	3	12801.7032	Number of obs	=	173
Residual	10052.1388	169	59.4801115	F(3, 169)	=	215.23
				Prob > F	=	0.0000
Total	48457.2486	172	281.728189	R-squared	=	0.7926
				Adj R-squared	=	0.7889
				Root MSE	=	7.7123

voteA	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lexpendA	-.532101	.5330858	-1.00	0.320	-1.584466	.5202638
new	-6.615417	.3788203	-17.46	0.000	-7.363246	-5.867588
prtystrA	.1519574	.0620181	2.45	0.015	.0295274	.2743873
_cons	45.07893	3.926305	11.48	0.000	37.32801	52.82985

$$t = \frac{\hat{\theta}_1 - 0}{s.e.\,\hat{\theta}_1} = \frac{-0.532}{0.533} = 1$$

Therefore, H_0 cannot be rejected at 5% level