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Chapter 4: Multiple Regression Analysis: Inference Problems
Book Title: Introductory Econometrics
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Chapter Review

Problems

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.
   Because it violates the assumption of homoscedasticity.

   ii. A sample correlation coefficient of .95 between two independent variables that are in the model.
   × because it only require the coefficient not to be 1

   ✓ iii. Omitting an important explanatory variable.
   Because it violates the 4 assumption $E(u|x) = 0$

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.
   $H_0: \beta_3 = 0$
   $H_1: \beta_3 > 0$

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

$$\begin{aligned} \widehat{\log(salary)} &= \underset{(.32)}{4.32} + \underset{(.035)}{.280} \log(sales) + \underset{(.0041)}{.0174}\, roe + \underset{(.00054)}{.00024}\, ros \\ n &= 209, R^2 = .283. \end{aligned}$$

   By what percentage is *salary* predicted to increase if *ros* increases by 50 points? Does *ros* have a practically large effect on *salary*?
   The proportionate effect on log(salary) is $0.00024(50) = 0.012$
   >> 1.2%

   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.
   df = ∞ $t_{df,n-2} = 1.282$ $t = \dfrac{(\hat{\beta}_3 - 0)}{se(\hat{\beta}_3)} = 0.44$ | $0.44 < 1.282$
   ∴ fail to reject the null hypothesis

iv. Would you include *ros* in a final model explaining CEO compensation in terms of firm performance? Explain. other explanatory variables are still very significant even with ros included in regression.

3. The variable *rdintens* is expenditures on research and development (R&D) as a percentage of sales. Sales are measured in millions of dollars. The variable *profmarg* is profits as a percentage of sales.

   Using the data in RDCHEM for 32 firms in the chemical industry, the following equation is estimated:

$$\widehat{rdintens} = \underset{(1.369)}{.472} + \underset{(.216)}{.321}\log(sales) + \underset{(.046)}{.050}\,profmarg$$
$$n = 32, R^2 = .099.$$

   i. Interpret the coefficient on $\log(sales)$. In particular, if *sales* increases by 10%, what is the estimated percentage point change in *rdintens*? Is this an economically large effect?

   ii. Test the hypothesis that R&D intensity does not change with *sales* against the alternative that it does increase with sales. Do the test at the 5% and 10% levels.

   iii. Interpret the coefficient on *profmarg*. Is it economically large?

   iv. Does *profmarg* have a statistically significant effect on *rdintens*?

4. Are rent rates influenced by the student population in a college town? Let *rent* be the average monthly rent paid on rental units in a college town in the United States. Let *pop* denote the total city population, *avginc* the average city income, and *pctstu* the student population as a percentage of the total population. One model to test for a relationship is

$$\log(rent) = \beta_0 + \beta_1 \log(pop) + \beta_2 \log(avginc) + \beta_3 pctstu + u.$$

   i. State the null hypothesis that size of the student body relative to the population has no ceteris paribus effect on monthly rents. State the alternative that there is an effect.

   ii. What signs do you expect for β_1 and β_2 ?

   iii. The equation estimated using 1990 data from RENTAL for 64 college towns is

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Chapter Review

Computer Exercises

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 ? the elasticity of candidate A's expense 1% of change of expense A is associated with β_1 % of VoteA

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.

H_0 $\beta_1 = -\beta_2$

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.)

$H_0: \beta_1 = -\beta_2 \rightarrow H_0: \beta_1 + \beta_2 = 0$
Let $H_0: \alpha = 0$ | $\alpha = \beta_1 + \beta_2 \rightarrow \beta_1 = \alpha - \beta_2$
H_a $\alpha \neq 0$

$voteA = \beta_0 + \alpha \log(expendA) + \beta_2 [\log(expendB) - \log(expendA)] + \beta_1 prtystrA + u_i$

```
. reg voteA lexpendA lexpendB prtystrA

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

…3, state and test the … ceteris paribus effect

…nely, *LSAT* and *GPA* …ary? (Be sure to

1. must find the covariance between β_1 and β_2
2. increased in A's expenditure is associated with 6.083316 %.

```
. gen exp =  lexpendb -  lexpenda

. * generate a new variable exp that equals to lexpendb subtract lexpenda
. reg  votea  lexpenda exp prtystra

      Source |       SS       df       MS              Number of obs =     173
-------------+------------------------------           F(  3,   169) =  215.23
       Model |  38405.1089     3  12801.703            Prob > F      =  0.0000
    Residual |  10052.1397   169  59.4801165           R-squared     =  0.7926
-------------+------------------------------           Adj R-squared =  0.7889
       Total |  48457.2486   172  281.728189           Root MSE      =  7.7123

------------------------------------------------------------------------------
       votea |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    lexpenda |   -.532101   .5330858    -1.00   0.320    -1.584466     .520264
         exp |  -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
```