10.24 Consider the data file *mroz* on working wives. Use the 428 observations on married women who participate in the labor force. In this exercise, we examine the effectiveness of alternative standard errors for the IV estimator. Estimate the model in Example 10.5 using IV/2SLS using both *MOTHEREDUC* and *FATHEREDUC* as IV. These will serve as our baseline results.

a. Calculate the IV/2SLS residuals, $\hat{e}_{IV}$. Plot them versus *EXPER*. Do the residuals exhibit a pattern consistent with homoskedasticity?

b. Regress $\hat{e}_{IV}^2$ against a constant and *EXPER*. Apply the NR^2 test from Chapter 8 to test for the presence of heteroskedasticity.

c. Obtain the IV/2SLS estimates with the software option for Heteroskedasticity Robust Standard Errors. Are the robust standard errors larger or smaller than those for the baseline model? Compute the 95% interval estimate for the coefficient of *EDUC* using the robust standard error.

d. Obtain the IV/2SLS estimates with the software option for Bootstrap standard errors, using $B = 200$ bootstrap replications. Are the bootstrap standard errors larger or smaller than those for the baseline model? How do they compare to the heteroskedasticity robust standard errors in (c)? Compute the 95% interval estimate for the coefficient of *EDUC* using the bootstrap standard error.

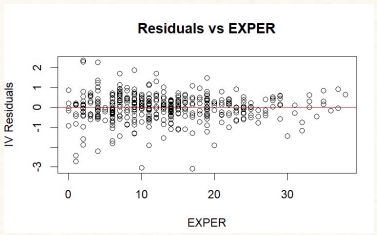
(a)

```
Call:
ivreg(formula = LWAGE ~ EXPER + EXPERSQ + EDUC | EXPER + EXPERSQ +
    MOTHEREDUC + FATHEREDUC, data = mroz_lfp)

Residuals:
     Min       1Q   Median       3Q      Max
-3.0986 -0.3196  0.0551  0.3689  2.3493

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  0.0481003  0.4003281   0.120  0.90442
EXPER        0.0441704  0.0134325   3.288  0.00109 **
EXPERSQ     -0.0008990  0.0004017  -2.238  0.02574 *
EDUC         0.0613966  0.0314367   1.953  0.05147 .
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.6747 on 424 degrees of freedom
Multiple R-Squared: 0.1357,     Adjusted R-squared: 0.1296
Wald test: 8.141 on 3 and 424 DF,  p-value: 2.787e-05
```



(b)

```
> summary(bp_model)

Call:
lm(formula = resid_sq ~ EXPER, data = mroz_lfp)

Residuals:
    Min      1Q  Median      3Q     Max
-0.6707 -0.4309 -0.2707 -0.0228  9.1549

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  0.672812   0.096560   6.968 1.23e-11 ***
EXPER       -0.017466   0.006303  -2.771  0.00583 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 1.049 on 426 degrees of freedom
Multiple R-squared:  0.01771,   Adjusted R-squared:  0.0154
F-statistic:  7.68 on 1 and 426 DF,  p-value: 0.005829
```

$NR^2 \sim \chi^2(k-1)$

```
> cat("NR^2 test statistic:",
NR^2 test statistic: 7.579075
P-value: 0.005904975
```

$< \alpha \rightarrow$ reject H_0 (同變異)

(c)

```
> print(se_comparison)
             Estimate Baseline_SE Robust_SE Increased_SE
(Intercept)  0.04810     0.40033   0.42980          Yes
EXPER        0.04417     0.01343   0.01555          Yes
EXPERSQ     -0.00090     0.00040   0.00043          Yes
EDUC         0.06140     0.03144   0.03334          Yes
> cat('Conclusion:\nAs shown in the table, all robust standard errors are larger than t
heir baseline counterparts. This is consistent with the presence of heteroskedasticity,
which inflates the variability of the estimators when not properly accounted for.')
Conclusion:
As shown in the table, all robust standard errors are larger than their baseline counte
rparts. This is consistent with the presence of heteroskedasticity, which inflates the
variability of the estimators when not properly accounted for.> cat("95% Robust CI for
EDUC: [", round(ci_lower, 4), ",", round(ci_upper, 4), "]\n")
95% Robust CI for EDUC: [ -0.0039 , 0.1267 ]
```

(d)

```
                Coef Baseline_SE Robust_SE Bootstrap_SE Larger_than_Baseline_SE
(Intercept) (Intercept)     0.40033   0.42980      0.43792                     Yes
EXPER             EXPER     0.01343   0.01555      0.01577                     Yes
EXPERSQ         EXPERSQ     0.00040   0.00043      0.00043                     Yes
EDUC               EDUC     0.03144   0.03334      0.03235                     Yes
           Larger_than_Robust_SE
(Intercept)                   Yes
EXPER                         Yes
EXPERSQ                       Yes
EDUC                           No
> (boot_ci_educ <- boot.ci(boot_result, type = "norm", index = 4))
BOOTSTRAP CONFIDENCE INTERVAL CALCULATIONS
Based on 200 bootstrap replicates

CALL :
boot.ci(boot.out = boot_result, type = "norm", index = 4)

Intervals :
Level      Normal
95%   (-0.0047,  0.1221 )
Calculations and Intervals on Original Scale
```