

**Instructions**

- (1) Please read the instruction carefully. Also take this habit with you into the exam room.
- (2) Please read each question carefully and answer the questions straightforwardly. Always provide economic reasons at least a paragraph for your analysis, or a graph when necessary, even when the question does not indicate so.
- (3) Handing and submitting assignments are only available via BE Moodle.

**Answering the questions and preparing answer sheets**

- (1) Answers are to be handwritten, in either digital or analog form, in a blank canvas or any clean paper. Make sure that your handwriting is clearly visible and readable.
- (2) There is no need to rewrite the question. Just indicate the question number clearly for each of the answer, such as 1.a).
- (3) Default decimal point is 4.
- (4) Choose precise wordings, especially when you want to interpret the meaning of a test, confidence interval, or coefficients.
- (5) When done, for the digital case, collage all the pages into a single PDF file. For those who write on sheets of paper, take photo of all pages then convert all of them into a single PDF file as well.
- (6) Name your PDF file as StudentID\_YourNickname, such as 640123456\_Bo.

**Submitting your answers**

- (1) Make sure your file does not exceed 10MB. This is the maximum file size for BE Moodle upload.
- (2) Login to BE Moodle, head into the course, then the assignment topic.
- (3) Choose your file to submit. Done. There will be timestamp for your upload date and time, so please make sure to not submit later than that.

**Question 1.****Effects of Physical Attractiveness on Wage**

Hamermesh and Biddle (1994) used measures of physical attractiveness in a wage equation. Each person in the sample was ranked by an interviewer for physical attractiveness using five categories (homely, quite plain, average, good looking, and strikingly beautiful or handsome). Because there are so few people at the two extremes, the authors put people into one of three groups for the regression analysis: “average”, “below average”, and “above average”, where **the base or reference group is “average”**. Using data from the 1977 Quality of Employment Survey, after controlling for the usual productivity characteristics, the following two regressions were estimated using data on  $n = 1,260$ :

**Estimate the model (1.1) reports in the Table 1.1**

$$\log(\text{wage}_i) = \beta_1 + \beta_2 \text{educ}_i + \beta_3 \text{exper}_i + \beta_4 \text{expersq}_i + \beta_5 \text{union}_i + \beta_6 \text{female}_i + u_i \quad (1.1)$$

**Table 1.1**

Source	SS	df	MS	Number of obs	=	1,260
Model	166.011417	5	33.2022834	F(5, 1254)	=	149.25
Residual	278.96855	1,254	.222462959	Prob > F	=	0.0000
				R-squared	=	0.3731
				Adj R-squared	=	0.3706
Total	444.979967	1,259	.353439211	Root MSE	=	.47166

lwage	Coefficient	Std. err.	t	P> t	[95% conf. interval]
educ	.0708503	.0052325			Omitted for the purpose of this exam
exper	.0389808	.0043524			
expersq	-.0005986	.0000975			
union	.1924593	.0301994			
female	-.4421609	.0289766			
_cons	.443611	.078859			

**Estimate the model (1.2) reports in the Table 1.2**

$$\log(\text{wage}_i) = \beta_1 + \beta_2 \text{educ}_i + \beta_3 \text{exper}_i + \beta_4 \text{expersq}_i + \beta_5 \text{union}_i + \beta_6 \text{female}_i + \beta_7 \text{belavg}_i + \beta_8 \text{abvavg}_i + u_i \quad (1.2)$$

where  $\log(\text{wage}_i)$  or  $lwage$  = logarithm of hourly wage (in USD)

- $\text{educ}_i$  = years of schooling
- $\text{exper}_i$  = years of workforce experience
- $\text{expersq}_i$  = years of workforce experience squared
- $\text{union}_i$  = 1 if union member
- $\text{female}_i$  = 1 if female
- $\text{belavg}_i$  = 1 if in below average physical attractiveness
- $\text{abvavg}_i$  = 1 if in above average physical attractiveness

## Assignment 2

Assigned on Nov 9<sup>th</sup>, 2021. Due date Nov 25<sup>th</sup>, 2021 before midnight.

Table 1.2

Source	SS	df	MS	Number of obs	=	1,260
Model	168.697151	7	24.099593	F(7, 1252)	=	109.21
Residual	276.282816	1,252	.220673176	Prob > F	=	0.0000
				R-squared	=	0.3791
				Adj R-squared	=	0.3756
Total	444.979967	1,259	.353439211	Root MSE	=	.46976

lwage	Coefficient	Std. err.	t	P> t	[95% conf. interval]
educ	.0691306	.00525			Omitted for the purpose of this exam
exper	.0395785	.0043428			
expersq	-.0006081	.0000971			
union	.1884632	.0301843			
female	-.4388235	.028877			
belavg	-.1388291	.0417749			
abvavg	.0070104	.0302809			
_cons	.4737302	.0795614			

Answer the following questions.

- 1.a) Based on the regression results provided, write out the estimated coefficients in the form of regression equation (1.1). Interpret the estimated coefficients associated with  $educ_i$ . Based on Model (1.1), test whether education has an impact on logarithm of hourly wage. Show your work. (Use  $\alpha = 0.05$ )
- 1.b) What is the overall significance of the regression from Model (1.2)? What test do you use? (Use  $\alpha = 0.05$ )
- 1.c) If we are interested in testing whether “physical attractiveness” has an impact on logarithm of hourly wage at all, what kind of null/alternative hypothesis would we be testing? Perform the test and discuss your finding. (Use  $\alpha = 0.05$ )
- 1.d) Is there convincing evidence that women with above average looks earn more than women with average looks? Explain.

1.a) Based on the regression results provided, write out the estimated coefficients in the form of regression equation (1.1). Interpret the estimated coefficients associated with  $educ_i$ . Based on Model (1.1), test whether education has an impact on logarithm of hourly wage. Show your work. (Use  $\alpha = 0.05$ )

$$\log(wage_i) = \beta_1 + \beta_2 educ_i + \beta_3 exper_i + \beta_4 expersq_i + \beta_5 union_i + \beta_6 female_i + u_i$$

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Source	SS	df	MS	Number of obs	=	1,260
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exper	.0389808	.0043524			
expersq	-.0005986	.0000975			
union	.1924593	.0301994			
female	-.4421609	.0289766			
$\beta_1$ _cons	.443611	.078859			

①  $\log(wage) = 0.44 + 0.07 edu + 0.04 exper - 0.0005 expersq + 1.9 union - 0.44 female$

equation is log-linear

$\beta = 0.07$  if education increase by 1 year, wage will increase by  $0.07 \times 100 = 7\%$

$$\log(wage_i) = \beta_1 + \beta_2 educ_i + \beta_3 exper_i + \beta_4 expersq_i + \beta_5 union_i + \beta_6 female_i + u_i \quad (1.1)$$

Table 1.1

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Step 1 : set hypothesis

$$\begin{array}{l} H_0 : \beta_{\text{edu}} = 0 \\ H_a : \beta_{\text{edu}} \neq 0 \end{array} \left. \begin{array}{l} \text{two tails } [=, \neq] \\ \leftarrow \neq 0 \text{ unváránvna} \end{array} \right\}$$

Step 2 : Significant level = 0.05

$$\frac{0.05}{2} = 0.025$$

Step 3 :

$$t = \frac{\hat{\beta} - \beta}{SE(\hat{\beta})} = \frac{0.07 - 0}{0.00523} = 13.38 \quad \#$$

Step 4 :

$$n = 1260$$

$$k = 6$$

$$df = 1254$$

$$\alpha = 0.05 \quad \frac{\alpha}{2} = 0.02$$



Reject  $H_0$ , Accept  $H_a$   $\beta_{\text{edu}} \neq 0$

$\therefore$  Edu affect wage at 0.05 significant level

1.b) What is the overall significance of the regression from Model (1.2)? What test do you use?

(Use  $\alpha = 0.05$ )

Table 1.2

Source	SS	df	MS	Number of obs	=	1,260
Model	168.697151	7	24.099593	F(7, 1252)	=	109.21
Residual	276.282816	1,252	.220673176	Prob > F	=	0.0000
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Total	444.979967	1,259	.353439211	Root MSE	=	.46976

lwage	Coefficient	Std. err.	t	P> t	[95% conf. interval]
educ	.0691306	.00525			
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Omitted for the purpose of this exam

2) Overall significant : • F-test

1) Check overall significant [5 steps]

Step 1 : Set hypothesis

$$H_0 : \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = \beta_7 = \beta_8 = 0$$

$$H_a : \text{at least 1 } \beta \neq 0$$

Significant level = 0.05

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F-test

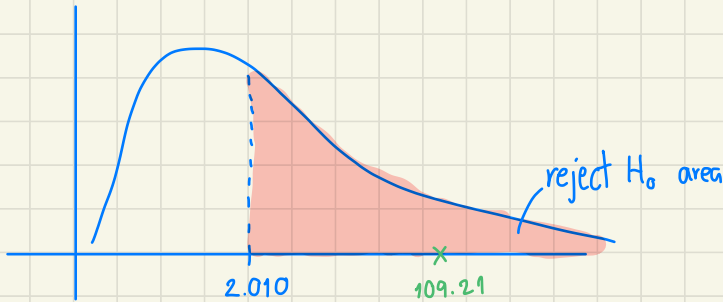
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F-test = 109.21

P-value = 0.000

$F(7, 1252)$   
 $\downarrow$        $\downarrow$   
 $df_1$     $df_2$

F table = 2.010



Reject  $H_0$

Accept  $H_1$  = have at least 2 variable impact wage

1.c) If we are interested in testing whether “physical attractiveness” has an impact on logarithm of hourly wage at all, what kind of null/alternative hypothesis would we be testing? Perform the test and discuss your finding. (Use  $\alpha = 0.05$ )

$$\log(\text{wage}_i) = \beta_1 + \beta_2 \text{educ}_i + \beta_3 \text{exper}_i + \beta_4 \text{expersq}_i + \beta_5 \text{union}_i + \beta_6 \text{female}_i + u_i \quad (1.1)$$

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F test

①  $H_0 : \beta_{be} = \beta_{ab} = 0$   
 $H_a : \text{otherwise}$

②  $F = \frac{[R^2_{UR} - R^2_R] / q}{(1 - R^2_{UR}) / [n - k - 1]}$

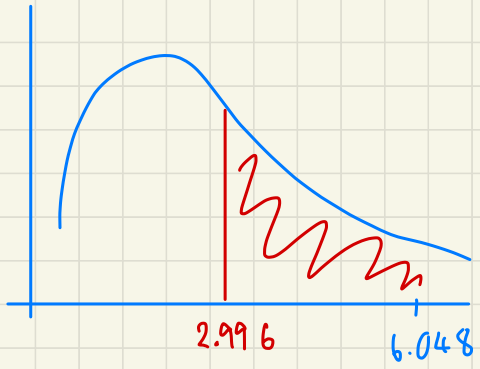
$F = \frac{[0.3791 - 0.3731] / 2}{[1 - 0.3791] / [1260 - 8 - 1]}$   
 $= 6.048$

③  $\alpha = 0.05 \quad df = 1251$

$F_{upper} = 2.996$

$\therefore$  Reject  $H_0$

Physical attractiveness affect to wage at  $\alpha = 0.05$



1.d) Is there convincing evidence that women with above average looks earn more than women with average looks? Explain.

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Omitted for the purpose of this exam

from 1.C table 1.2 is the better one

$$\beta_{\text{female}} = -0.43$$

$$\text{male} = 0.43 \times 100 = 43\%$$

$$\textcircled{3} \alpha = 0.05 \quad df = 1252$$

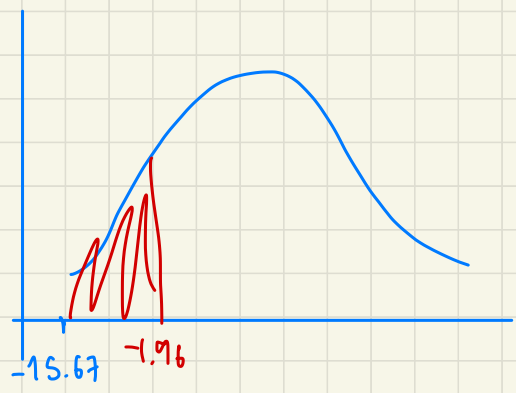
$$t = -1.96$$

$$\textcircled{1} H_0: \beta_{\text{female}} \geq 0$$

$$H_1: \beta_{\text{female}} < 0$$

$$\textcircled{2} t = \frac{-0.4388 - 0}{0.028}$$

$$= -15.67$$



∴ wage of female is less than male at  $\alpha = 0.05$

**Question 2.**

A household expenditure model is given by

$$hhexp_i = \beta_1 + \beta_2 area_i + \beta_3 child_i + u_i$$

where  $hhexp_i$  = household expenditure per month  
 $area_i$  = a dummy variable for household location:  
 (0 if in a municipal area and 1 if otherwise)  
 $child_i$  = number of children in household  $i$ , aged under 15

Using socio-economic dataset collected in 2018 with 14,908 households, the result is given below with **t value in parentheses**. Answer the following questions.

$$\widehat{hhexp}_i = 9,736 - 2,835area_i + 881child_i + \hat{u}_i$$

(43.83) (-15.8) (6.82)

- 2.a)** Do all the signs for each coefficient make economic sense? Explain.
- 2.b)** Test each parameter separately if they are significantly different from zero or not. (Use  $\alpha = 0.01$ )
- 2.c)** Find the expected value of a household expenditure not living in a municipal area with 3 children aged under 15.
- 2.d)** When an interaction term is included in this model, the result becomes with **t value in parentheses**.

$$\widehat{hhexp}_i = 9,693 - 2,742area_i + 910child_i - 64(area_i * child_i) + \hat{u}_i$$

(34.38) (-6.55) (5.17) (-0.25)

Draw a diagram for this model displaying sampled regression functions (SRF) with expected value of household expenditure on the vertical axis and number of children on the horizontal axis, taking **only significant parameter(s)** into account. Indicate the intercept and slope for each SRF where applicable. Testing of significance can be shortened.

2.a) Do all the signs for each coefficient make economic sense? Explain.

$$\widehat{h\text{exp}}_i = 9,736 - 2,835\text{area}_i + 881\text{child}_i + \hat{u}_i$$

(43.83)    (-15.8)            (6.82)

$\beta_{\text{area}}$  is negative value, which means not living in municipality have 2,835 less expense. It is make economic sense because people who live in the place where the cost of living is lower are more likely to have less expense

$\beta_{\text{child}}$  is positive, which means the more children the family have, the more expense. It make sense that more people means more food, more electricity, more cost of living.

2.b) Test each parameter separately if they are significantly different from zero or not. (Use  $\alpha = 0.01$ )

$H_0: \beta_2 = 0$  - null hypothesis

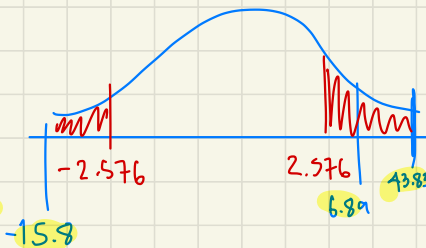
$H_1: \beta_2 \neq 0$

$t_{\text{cal}} \beta_2 = 43.83 \therefore$  we can reject  $H_0$

$\alpha = 0.01 \quad \frac{\alpha}{2} = 0.005$

$t_{\text{crit}} = 2.576$

$df = 14905$



$t_{\text{cal}}(\beta_2) = -15.8$

$\therefore$  we can reject  $H_0$

$\alpha = 0.01 \quad \frac{\alpha}{2} = 0.005$

$t_{\text{crit}} = 2.576 \quad t_{\text{cal}}(\beta_2) = 6.89$

$df = 14905$

$\therefore$  we can reject  $H_0$

2.c) Find the expected value of a household expenditure not living in a municipal area with 3 children aged under 15.

$$\widehat{hhexp} = 9736 - 2835(1) + 881(3)$$

$$= 9544$$

∴ The expected value of household expenditure is 9544

2.d) When an interaction term is included in this model, the result becomes with **t value in parentheses**.

$$H_0 : \hat{\beta}_2 = 0$$

$$H_a : \hat{\beta}_2 \neq 0$$

$$t_{cal} = -6.55$$

$$t_{cri} = 2.576$$

$$\alpha = 0.01$$

$$\frac{\alpha}{2} = 0.005$$

can reject  
 $H_0$

$$H_0 : \beta_3 = 0$$

$$H_a : \beta_3 \neq 0$$

$$t_{cal} = 5.17$$

$$t_{cri} = 2.576$$

can reject  $H_0$

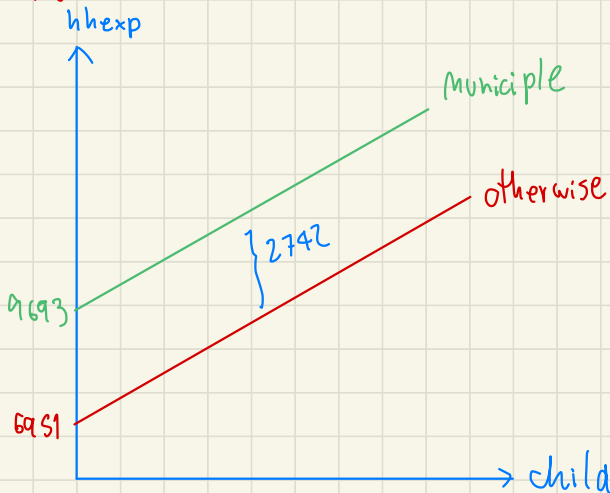
$$H_0 : \beta_4 = 0$$

$$H_a : \beta_4 \neq 0$$

$$t_{cal} = -0.25$$

$$t_{cri} = 2.576$$

cannot reject  $H_0$



**Question 3.**

Assume a multiple linear regression model as

$$hours_i = \beta_1 + \beta_2 sex_i + \beta_3 age_i + \beta_4 agesq_i + \beta_5 weekot_i + u_i$$

where  $hours_i$  is hours worked in a week  
 $sex_i$  is a dummy variable: 0 = male and 1 = otherwise  
 $age_i$  is age of observation  $i$   
 $agesq_i$  is age square observation  $i$   
 $weekot_i$  is nominal overtime paid per week

Answer the following questions.

**3.a)** A VIF and tolerance table (postestimation) is given below

Variable	VIF	1/VIF
2.sex	1.02	0.979129
age	50.61	0.019759
agesq	50.68	0.019731
weekot	1.01	0.985618
Mean VIF	25.83	

Given that you are exploring multicollinearity assumption, which pair of variables that you suspect they might be linearly correlated? Provide clear explanation what criteria (ion) that you rely on making that judgement.

**3.b)** From **(3.a)**, do you consider removing one of the variables from the model? Why or why not and which one that you choose to remove, if that is the case?

**3.c)** The graph provided below is a scatter plot between  $\hat{u}_i^2$  (vertical axis) and  $weekot_i$  (horizontal axis). Using the graphical method, do you conclude that heteroscedasticity is present in this model or not. Explain clearly to support your answer.

**3.a)** A VIF and tolerance table (postestimation) is given below

Variable	VIF	1/VIF
2.sex	1.02	0.979129
age	50.61	0.019759
agesq	50.68	0.019731
weekot	1.01	0.985618
Mean VIF	25.83	

$$VIF = \frac{1}{1 + r^2_{x_i x_j}} \quad VIF > 10 \quad \text{Multicollinearity}$$

From the table VIF of age and age sq  $> 10$

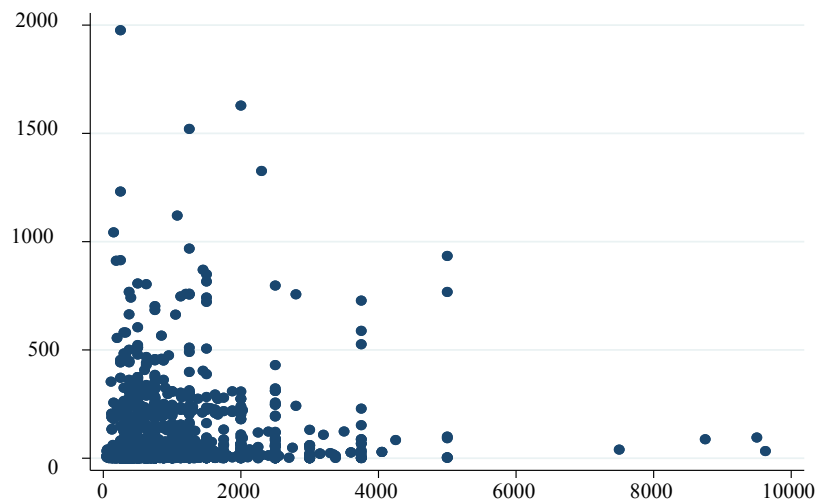
So it must be multicollinearity

**3.b)** From (3.a), do you consider removing one of the variables from the model? Why or why not and which one that you choose to remove, if that is the case?

No, we don't have other data to confirm that variable should be removed.

Assignment 2

Assigned on Nov 9<sup>th</sup>, 2021. Due date Nov 25<sup>th</sup>, 2021 before midnight.



3.d) An auxiliary model here is estimated and the result is given in the table below.

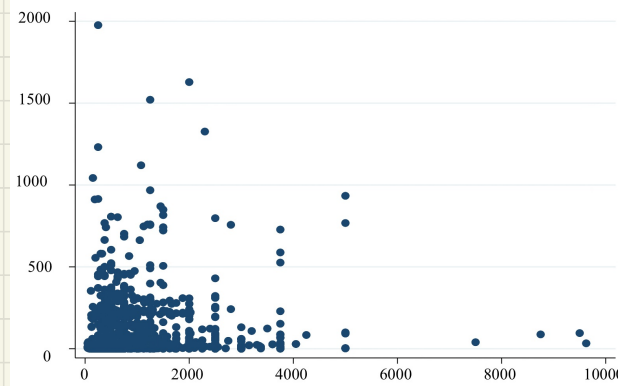
$$\hat{u}_i^2 = \beta_1 + \beta_2 \text{sex}_i + \beta_3 \text{age}_i + \beta_4 \text{agesq}_i + \beta_5 \text{weekot}_i + v_i$$

Source	SS	df	MS	Number of obs	=	2,032
Model	829063.863	4	207265.966	F(4, 2027)	=	9.52
Residual	44148135	2,027	21780.037	Prob > F	=	0.0000
Total	44977198.8	2,031	22145.3465	R-squared	=	0.0184
				Adj R-squared	=	0.0165
				Root MSE	=	147.58
uhat2	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
2.sex	-5.648899	6.630832	-0.85	0.394	-18.65286	7.355058
age	-2.490434	2.37094	-1.05	0.294	-7.140168	2.1593
age2	.044175	.0301279	1.47	0.143	-.0149098	.1032599
weekot	.0229916	.0043502	5.29	0.000	.0144603	.0315229
_cons	83.8484	44.4418	1.89	0.059	-3.307973	171.0048

From the table, setup the hypotheses and perform the Breusch-Pagan test to check that heteroscedasticity is present in the original model or not.

\*\*\*\*\*

3.c) The graph provided below is a scatter plot between  $\hat{u}_i^2$  (vertical axis) and  $weekot_i$  (horizontal axis). Using the graphical method, do you conclude that heteroscedasticity is present in this model or not. Explain clearly to support your answer.



Yes, heteroscedasticity is present in the model because weekot income also increase in  $\hat{u}_i^2$

3.d) An auxiliary model here is estimated and the result is given in the table below.

$$\hat{u}_i^2 = \beta_1 + \beta_2 sex_i + \beta_3 age_i + \beta_4 agesq_i + \beta_5 weekot_i + v_i$$

Source	SS	df	MS	Number of obs	=	2,032
Model	829063.863	4	207265.966	F(4, 2027)	=	9.52
Residual	44148135	2,027	21780.037	Prob > F	=	0.0000
				R-squared	=	0.0184
				Adj R-squared	=	0.0165
				Root MSE	=	147.58

uhat2	Coeff.	Std. Err.	t	P> t	[95% Conf. Interval]
2.sex	-5.648899	6.630832	-0.85	0.394	-18.65286 7.355058
age	-2.490434	2.37094	-1.05	0.294	-7.140168 2.1593
age2	.044175	.0301279	1.47	0.143	-.0149098 .1032599
weekot	.0229916	.0043502	5.29	0.000	-.0144603 .0315229
_cons	83.8484	44.4418	1.89	0.059	-3.307973 171.0048

From the table, setup the hypotheses and perform the Breusch-Pagan test to check that heteroscedasticity is present in the original model or not.

$H_0$ : the model is heteroscedasticity  
 $H_a$ : otherwise

$$F_{cal} = \frac{[R_{ur}^2 - R_R^2] / q}{(1 - R_{ur}^2) / [n - k - 1]}$$

$$= \frac{0.00368}{0.00048} = 7.6667$$

$$\therefore F_{cal} > F_{cri}$$

We can reject  $H_0$ , which means that 95 times of observation, Heteroscedasticity is present.

$$F_{cri}(5, 2026) = 2.2141$$

$\alpha = 0.05$