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Instructions

- (1) Please read the instruction carefully.
- (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. (12 points) Economic model of Crime.

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 *avgsen*. Based on Model (1.1), test whether the average sentence served from prior convictions has an impact on the number of arrests in the current year (1986). Show your work. (Use $\alpha = 0.05$)

1.b) What is the overall significance of the regression from Model (1.1) and Model (1.2)? What test do you use? (Use $\alpha = 0.01$)

1.c) If we are interested in testing whether “ethnic background and legal income” has an impact on the number of arrests in the current year (1986), what kind of null/alternative hypothesis would we be testing? Perform the test and discuss your finding. (Use $\alpha = 0.05$)

Estimate the model (1.1) reports in the Table 1.1

$$narr86_i = \beta_1 + \beta_2 pcnv_i + \beta_3 avgsen_i + \beta_4 tottime_i + \beta_5 ptime86_i + \beta_6 qemp86_i + u_i \quad (1.1)$$

Table 1.1

Source	SS	df	MS	Number of obs	=	2,725
Model	85.9532425	5	17.1906485	F(5, 2719)	=	24.29
Residual	1924.39391	2,719	.707757967	Prob > F	=	0.0000
				R-squared	=	0.0428
				Adj R-squared	=	0.0410
Total	2010.34716	2,724	.738012906	Root MSE	=	.84128

narr86	Coefficient	Std. err.	t	P> t	[95% conf. interval]
pcnv	-.1512246	.040855			
avgsen	-.0070487	.0124122			
tottime	.0120953	.0095768			
ptime86	-.0392585	.0089166			
qemp86	-.1030909	.0103972			
_cons	.7060607	.0331524			

Omitted for the purpose of this exam

Estimate the model (1.2) reports in the Table 1.2

$$narr86_i = \beta_1 + \beta_2 pcnv_i + \beta_3 avgsen_i + \beta_4 tottime_i + \beta_5 ptime86_i + \beta_6 qemp86_i + \beta_4 inc86_i + \beta_5 black_i + \beta_6 hispan_i + u_i \quad (1.2)$$

where

$narr86_i$	= the number of arrests in the current year (1986)
$pcnv_i$	= the proportion of prior arrests that led to a conviction
$avgsen_i$	= the average sentence served from prior convictions (in months)
$tottime_i$	= months spent in prison since age 18 prior to 1986
$ptime86_i$	= months spent in prison in 1986
$qemp86_i$	= the number of quarters that the man was legally employed in 1986
$inc86_i$	= legal income, 1986, (hundred dollars)
$black_i$	= 1 if black ethnic background
$hispan_i$	= 1 if Hispanic ethnic background

Table 1.2

Source	SS	df	MS	Number of obs	=	2,725
Model	145.390104	8	18.173763	F(8, 2716)	=	26.47
Residual	1864.95705	2,716	.686655763	Prob > F	=	0.0000
				R-squared	=	0.0723
				Adj R-squared	=	0.0696
Total	2010.34716	2,724	.738012906	Root MSE	=	.82865

narr86	Coefficient	Std. err.	t	P> t	[95% conf. interval]
pcnv	-.1332344	.0403502			
avgsen	-.0113177	.0122401			
tottime	.0120224	.0094352			
ptime86	-.0408417	.008812			
qemp86	-.0505398	.0144397			
inc86	-.0014887	.0003406			
black	.3265035	.0454156			
hispan	.1939144	.0397113			
_cons	.5686855	.0360461			

Omitted for the purpose of this exam

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 *avg*sen. Based on Model (1.1), test whether the average sentence served from prior convictions has an impact on the number of arrests in the current year (1986). Show your work. (Use $\alpha = 0.05$)

$$\widehat{nar86_i} = 0.71 - 0.15pcrv_i - 0.007avg\text{sen}_i + 0.01tot\text{time}_i - 0.04times86_i - 0.1qemp86_i$$

When a month of prior average sentenced served from prior convictions increase, the number of assets in 1986 decrease by 0.007 case.

$$t_{cal}(\beta_3) = \frac{\hat{\beta}_3 - \beta_3}{se(\hat{\beta}_3)} = \frac{0.007 - 0}{0.012} = -0.58$$

$\alpha = 0.05$, degree of freedom = $2725 - 6 = 2716$, critical value = ± 1.96

$\therefore$ We cannot reject the null hypothesis as t_{cal} doesn't exceed the critical value
We cannot sure that the parameter is different from zero.

1.b) What is the overall significance of the regression from Model (1.1) and Model (1.2)?
What test do you use? (Use $\alpha = 0.01$)

Overall significance can be test by F-test using R^2

H_0 : all β_k are 0 H_a : otherwise

$$\text{Model 1.1 : } F_{cal} = \frac{R^2 / k - 1}{1 - R^2 / (n - k)} = \frac{0.0428 / 5}{(1 - 0.0428) / (2725 - 6)} = 24.32$$

$$\text{Model 1.2 : } F_{cal} = \frac{R^2 / k - 1}{1 - R^2 / (n - k)} = \frac{0.0723 / 8}{(1 - 0.0723) / (2725 - 9)} = 26.48$$

$\alpha = 0.01$ Model 1.1 : critical value ($F_{6, 2719}$) = 2.64

Model 1.2 : " ($F_{9, 2716}$) = 2.41

$\therefore$ We can reject null hypothesis as F_{cal} exceed critical value

1.c) If we are interested in testing whether "ethnic background and legal income" has an impact on the number of arrests in the current year (1986), what kind of null/alternative hypothesis would we be testing? Perform the test and discuss your finding. (Use $\alpha = 0.05$)

We can use marginal contribution test to compare between Model 1.1 and 1.2

H_0 : Ethnic background and legal income have no marginal contribution to model

H_a : otherwise

$$F_{cal} = \frac{(R_{1,2}^2 - R_{1,1}^2) / k \text{ of new regressor}}{1 - R_{1,2}^2 / (n - k_{1,2})} = \frac{(0.0723 - 0.0428) / 3}{(1 - 0.0723) / (2925 - 9)} = 28.79$$

$$\alpha = 0.05, \text{ critical value } (F_{3, 2916}) = 2.6$$

$\therefore$ We can reject null hypothesis as F_{cal} exceeds the critical value.

The ethnic background and legal income have marginal contribution to model.

Assigned on Apr 9th, 2022. Due date Saturday, May 7th, 2022 before midnight.

Question 2. (12 points) Dummy variables and interaction terms.

Using the Thailand labor force survey (LFS) in quarter 2 of 2019 and 2020, employees log of wage is modeled as follows. (Number of observations is 97,878 in total)

$$\ln wage_i = \beta_1 + \beta_2 civil_i + \beta_3 year_i + \beta_4 civil_i \cdot year_i + u_i$$

where $\ln wage_i$ = natural logarithmic scale of monthly wage

$civil_i$ = 1; civil servant and state employee

$$= 0; \text{ otherwise}$$
$$year_i = 1; \text{ year 2020}$$
$$= 0; \text{ otherwise (2019)}$$

This model is also known as Difference-in-Differences (DiD) and its intention is to capture the effect of COVID-19 since March of 2020 on different types of employment. During the pandemic, we assume that civil servant and state employee's wage is not reduced (control group) while others', namely employees in private firms or freelance, etc., is suspected to be reduced (treatment group). The estimation result is shown below with standard errors in parentheses. Answer the following questions.

$$\ln \widehat{wage}_i = 9.1748 + 0.587 \text{ civil}_i - 0.0336 \text{ year}_i + 0.0444 \text{ civil}_i \cdot \text{year}_i + u_i$$

(0.0035) (0.0072) (0.005) (0.0102)

2.a) Test all the parameters individually if each of them is significantly different from zero or not.

2.b) How much on average does a civil servant and state employee earns more or less than the others disregarding the year?

2.c) How much on average does the pandemic affect wage overall?

2.d) Are the control group and the treatment group better-off or worse-off during the pandemic. Discuss each group separately, show your work and explain with economic reasons according to the intention of this model.

2.a) Test all the parameters individually if each of them is significantly different from zero or not.

$$H_0: \beta_k = 0 \quad H_1: \beta_k \neq 0$$

$$t_{cal}(\beta_1) = \frac{\hat{\beta}_1 - \beta_1}{se(\hat{\beta}_1)} = \frac{9.1748 - 0}{0.0035} = 2,621.37$$

$$t_{cal}(\beta_2) = \frac{\hat{\beta}_2 - \beta_2}{se(\hat{\beta}_2)} = \frac{0.587 - 0}{0.0072} = 81.53$$

$$t_{cal}(\beta_3) = \frac{\hat{\beta}_3 - \beta_3}{se(\hat{\beta}_3)} = \frac{-0.0336 - 0}{0.005} = -6.72$$

$$t_{cal}(\beta_4) = \frac{\hat{\beta}_4 - \beta_4}{se(\hat{\beta}_4)} = \frac{0.0444 - 0}{0.0102} = 4.35$$

$$\alpha = 0.05, \text{ degree of freedom: } 97,878 - 4 = 97,874, \text{ critical value } = \pm 1.96$$

$\therefore$ All t_{cal} exceeds the critical value. We can reject all hypothesis of β_k and all parameter are different from zero.

2.b) How much on average does a civil servant and state employee earn more or less than the others disregarding the year?

We can consider β_2 which is coefficient represent difference between civil servant and other groups. On average, civil servants earn more than other groups by $100 \times (e^{\hat{\beta}_2} - 1) = 79.86\%$.

2.c) How much on average does the pandemic affect wage overall?

From the second quarter of 2019 and 2020, the pandemic effect is realized in the second quarter of 2020 and β_3 is the represent of effect. It is a negative coefficient. Overall wage drop by $100 \times (e^{\hat{\beta}_3} - 1) = 3.30\%$ for all group.

2.d) Are the control group and the treatment group better-off or worse-off during the pandemic. Discuss each group separately, show your work and explain with economic reasons according to the intention of this model.

When the civil servant variable is interacted with year 2020, there is a positive effect and different from zero

The civil servant group overall wage in 2020 :

In $\widehat{wage}_i = 9.1748 + 0.587(1) - 0.0336(1) + 0.0444(1) \cdot 1$, other group :

In $\widehat{wage}_i = 9.1748 + 0.587(0) - 0.0336(1) + 0.0444(0) \cdot 1$

The interaction term do not add to other group. Even the civil servant went down 0.0336 in 2020, the interaction term bounce back 0.0444

The civil servant group is $100 \times (e^{\hat{\beta}_3 + \hat{\beta}_4} - 1) \approx 1.09\%$ increase of overall wage in this group. Other group is $100 \times (e^{\hat{\beta}_3} - 1) \approx 3.30\%$ decrease of overall wage.

This make economic sense because the civil servant wage do not drop during pandemic, but the rest work less due to the lower hours.

Question 3. (8 points) Multicollinearity.

As cheese ages, several chemical processes take place that determine the taste of the final product. The data given pertain to concentrations of various chemicals in a sample of 30 mature cheddar cheeses and subjective measure of taste for each sample.

Estimate the model (3.1) reports in the Table 3.1

$$Taste = \beta_0 + \beta_1 acetic + \beta_2 h2s + \beta_3 lactic + u \quad (3.1)$$

Where *Taste* = Measures of taste for each sample

acetic = The natural logarithm of concentration of acetic

h2s = The natural logarithm of concentration of hydrogen sulfide

lactic = Lactic

Table 3.1

Source	SS	df	MS	Number of obs	=	30
Model	5020.64468	3	1673.54823	F(3, 26)	=	16.47
Residual	2642.24237	26	101.624706	Prob > F	=	0.0000
				R-squared	=	0.6552
				Adj R-squared	=	0.6154
Total	7662.88705	29	264.237485	Root MSE	=	10.081

taste	Coefficient	Std. err.	t	P> t	[95% conf. interval]
acetic	1.538645	3.000501			
h2s	3.915242	1.153106			
lactic	18.80235	8.342614			
_cons	-34.13491	15.67628			

Omitted for the purpose of this exam

	acetic	h2s	lactic	Variable	VIF	1/VIF
acetic	1.0000			lactic	1.83	0.546648
h2s	0.2700	1.0000		h2s	1.72	0.582609
lactic	0.3607	0.6448	1.0000	acetic	1.15	0.867477
				Mean VIF	1.57	

3.a) Is there evidence of multicollinearity in the data? How do you know? Explain your answers in detail and state the critical value for hypothesis testing to receive full points.

$$H_0: \beta_k = 0 \quad H_1: \beta_k \neq 0$$

$$t_{\text{cal}}(\beta_1) = \frac{\hat{\beta}_1 - \beta_1}{\text{se}(\hat{\beta}_1)} = \frac{-34.1349 - 0}{15.6713} = -2.18$$

$$t_{\text{cal}}(\beta_2) = \frac{\hat{\beta}_2 - \beta_2}{\text{se}(\hat{\beta}_2)} = \frac{1.5386 - 0}{3.0005} = 0.51$$

$$t_{\text{cal}}(\beta_3) = \frac{\hat{\beta}_3 - \beta_3}{\text{se}(\hat{\beta}_3)} = \frac{3.9152 - 0}{1.1531} = 3.4$$

$$t_{\text{cal}}(\beta_4) = \frac{\hat{\beta}_4 - \beta_4}{\text{se}(\hat{\beta}_4)} = \frac{18.8023 - 0}{8.3426} = 2.25$$

$\alpha = 0.05$, degree of Freedom: $30 - 4 = 26$, critical value = ± 2.056

We can reject the null hypothesis for all parameter except β_2 . We can see that R^2 and almost all parameter are different from zero. The conflicting test and multicollinearity is not in the model.

3.b) What is the property of BLUE? If there is the multicollinearity problem, is the OLS estimators still retain the property of BLUE? If not, which properties are violated?

BLUE stand for Best Linear Unbiased Estimator, which mean the estimator have lowest variance possible. When there are more samples, probability limit of the estimators tend toward true parameter. Multicollinearity does not affected BLUE, but it caused misleading conclusion on hypothesis testing.

3.a) Is there evidence of multicollinearity in the data? How do you know? Explain your answers in detail and state the critical value for hypothesis testing to receive full points.

3.b) What is the property of BLUE? If there is the multicollinearity problem, is the OLS estimators still retain the property of BLUE? If not, which properties are violated?

Question 4. (8 points) Heteroscedasticity.

The data on U.S. inflation rates (%) and unemployment rates (%), 1948-2006

Estimate the model (4.1) reports in the Table 4.1

$$Inf_t = \beta_1 + \beta_2 unem_t + u_t \quad (4.1)$$

where Inf_t = inflation rates (%)

$unem_t$ = unemployment rates (%)

Table 4.1

Source	SS	df	MS	Number of obs	=	59
Model	32.3284496	1	32.3284496	F(1, 57)	=	3.85
Residual	478.096987	57	8.38766644	Prob > F	=	0.0545
				R-squared	=	0.0633
				Adj R-squared	=	0.0469
Total	510.425437	58	8.80043856	Root MSE	=	2.8961

inf	Coefficient	Std. err.	t	P> t	[95% conf. interval]
unem	.5054734	.2574699			
_cons	1.010847	1.491583			

Omitted for the purpose of this exam

White's general test statistic: 1.0266 Chi-sq (2)

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity

$$\chi^2(1) = 1.12$$

Answer the following questions.

4.a) Interpret the intercept and slope coefficients.

4.b) According to the test statistics given after Table 4.1 below, is there any sufficient evidence to conclude that there is heteroscedasticity problem? Show your work on the hypothesis testing. (Use $\alpha = 0.05$)

4.c) Given your test results in a), do the OLS estimators still retain the property of BLUE? If not, which properties are violated?

4.a) Interpret the intercept and slope coefficients.

$\hat{\beta}_1$ have the intercept of 1.01. When unemployment rate is 0, inflation rate is 1.01 on average

$\hat{\beta}_2$ have the slope of 0.5. When unemployment rate increase by 1%, inflation rate increase by 0.5% on average.

4.b) According to the test statistics given after Table 4.1 below, is there any sufficient evidence to conclude that there is heteroscedasticity problem? Show your work on the hypothesis testing. (Use $\alpha = 0.05$)

- As using White's test, we have LM_{cal} for X_{k-1}^2 is 1.0266

- When X_1^2 and $\alpha = 0.05$, critical value is 3.84146

We cannot reject null hypothesis of homoscedasticity as $LM_{cal} < X_1^2$

4.c) Given your test results in a), do the OLS estimators still retain the property of BLUE? If not, which properties are violated?

As we cannot reject the null hypothesis, BLUE property is not violated