1a) $- \widehat{narr86_i} = 0.71 - 0.15\,pcnv_i - 0.007\,avgsen_i + 0.01\,tottime_i - 0.04\,ptime86_i - 0.1\,qemp86_i$

t cal for avgsen : $t_{cal}(\beta_3) = \dfrac{\hat{\beta}_3 - \beta_3}{se(\hat{\beta}_3)} = \dfrac{-0.007 - 0}{0.012} = -0.58$

$\alpha = 0.05$; Critical value for d.f (n-k) $2{,}725 - 6 = 2{,}719$ ± 1.96

$\therefore$ we cannot reject the null hypothesis because the value does not exceed the critical value in the negative zone.
Means that, we cannot make sure that the parameter is different from zero.

2b) - Use an F-test by R^2

H_0: β_k are 0 simultaneously

H_a: otherwise for both test

Model 1.1 : $F_{cal} = \dfrac{R^2/k-1}{1-R^2/(n-k)} = \dfrac{0.0429/5}{(1-0.0429)/(2725-6)} = 24.32$

Model 1.2 : $F_{cal} = \dfrac{R^2/k-1}{1-R^2/(n-k)} = \dfrac{0.0723/8}{(1-0.0723)/(2{,}725-9)} = 26.48$

- When $\alpha = 0.01$
  Critical value of $\underbrace{\text{Model 1.1 is 2.64}}_{[F_{6,2716}]}$ and $\underbrace{\text{Model 1.2 is 2.41}}_{[F_{9,2716}]}$
- we can reject null hypothesis for both models (1.1 & 1.2).

1c) - use the marginal contribution test to compare between model 1.1 and 1.2.

H_0: Ethic background and income have no marginal contribution to the model.

H_a: otherwise

F-test : $F_{cal} = \dfrac{0.0723 - 0.0429/3}{(1-0.0723)/(2{,}725-9)} = 28.79$

$\alpha = 0.05$, the critical value of $F_{3,2716}$ is 2.6

$\therefore$ we can reject the null hypothesis and can make sure that ethic background and income have no marginal contribution to the model as F_{cal} exceeds the critical value

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2a) $H_0: \beta_k = 0$ and

$H_a: \beta_k \neq 0$ when $k = 1,2,3,4$

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

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

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

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

When $\alpha = 0.05$, the critical value for d.f (n-k) $97{,}878 - 4 = 97{,}874$ is ± 1.96

$\therefore$ we can reject all the hypothesis of β_k and tell that all the parameters individually are significantly different from zero, as all the t_{cal} exceeds the critical value.

2b)

I look at β_2 as it is the coefficient tells difference between civil servants and other groups.
Moreover, as the coefficient is positive, therefore, on average civil servants earn more than other groups by $100 \times (e^{\hat{\beta}_2} - 1) = 79.86\%$.

2c) Use β_3 to represent the effect of pandemic on wage in the second quarter of 2020.
As the coefficient of β_3 is negative, therefore, in 2020 overall wage decreases by $100 \times (e^{\hat{\beta}_3} - 1) = 3.30\%$ (all graps).

2d)

The civil servant grap overall wage in 2020:

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

The other graps wages:

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

From this, it means that even though in 2020 the civil servant wage went down by the year coefficient (-0.0336), the interaction also shows a bance back for this grap $(+0.0444)$.

In conclusion, during pandemic the civil servant (control grap) is better-off by $100 \times (e^{\hat{\beta}_3 + \hat{\beta}_4} - 1) = 1.09\%$ increase of overall wage of the grap. However, the other graps are worse-off by $100 \times (e^{\hat{\beta}_3} - 1) = 3.30\%$. decrease overall wage. It makes sense for economic reasons because the wage of civil servants did not drop during pandemic while the rest may worked less due to the less hours or limited work placement.

3a) Test all parameters ; $H_0: \beta_k = 0$ and $H_0: \beta_k \neq 0$ when $k = 1,2,3,4$

$$tcal(\beta_1) = \frac{\hat{\beta}_1 - \beta_1}{se(\hat{\beta}_1)} = \frac{-34.1349 - 0}{15.6763} = 2.18$$

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

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

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

$\alpha = 0.05$, The critical value for d.f $(n-k)$ $30 - 4 = 26$ is ± 2.056

$\therefore$ we can reject the null hypothesis for all the parameters but β_2.
Moreover, we can summarize that conflict test is not found and the multicollinearity is not seen as the R^2 is 0.6552 and almost all the parameters are significantly different from zero.

3b) Best Linear Unbiased Estimator (BLUE), It is linear, unbiased, have the least variance among possible and when there are more samples, probability limit of estimators tend towards true parameters.
Best Linear Unbiased Estimator (BLUE) is not affected by multicollinearity. However, multicollinearity causes misleading conclusion of hypothesis testing.

4a) $\hat{\beta}_1$ is the intercept means that when unemployment rate is 0, inflation rate on average is 1.01.

$\hat{\beta}_2$ is the slope means that when unemployment rate increases by 1 percent, inflation rate on average increase by 0.5 %.

4b) The white's test ; LM_{cal} for χ^2_{k-1} is 1.0266.

Therefore, the critical value when χ^2_1 and $\alpha = 0.05$ is 3.8416.

$\therefore$ we cannot reject the null hypothesis as $LM_{cal} < \chi^2_1$.

4c) From 4b), we cannot reject the null hypothesis. As a result, we can make sure that Best Linear Unbiased Estimator (BLUE) property is not violated.