e) By observing the R code output, we find that the value of R-squared is 0.9946 and adjusted R-squared is 0.9938. The R-squared increases from 0.9928 to 0.9946 by comparing the results of part c) and part e). Since the value of adjusted R-squared is 0.9938, this indicates that approximately 99.38% of variation on the log transformation of GDP is accounted for by the variables in the model, including the observed seasonal component, which is Quarter, and linear trend, and quadratic trend. Furthermore, the p-value is smaller than $2.2*10^{(-16)}$, which is smaller than 0.05, so we reject the null hypothesis and conclude that variables in this model, including the observed seasonal component, which is Quarter, and linear trend, and quadratic trend, are significantly related to the log transformation of GDP.

```
# e)
GDP_US$timesquared <- (c(1:40))^2
gdplmsqu <- lm(log(GDP)~Q+time+timesquared,data=GDP_US)
summary(gdplmsqu)
```

```
Call:
lm(formula = log(GDP) ~ Q + time + timesquared, data = GDP_US)

Residuals:
      Min         1Q     Median         3Q        Max
-0.0112731 -0.0027532 -0.0003484  0.0040286  0.0128477

Coefficients:
              Estimate Std. Error  t value Pr(>|t|)
(Intercept) 8.211e+00  3.041e-03 2700.454  < 2e-16 ***
QQ2         2.150e-02  2.433e-03    8.836 2.51e-10 ***
QQ3         2.774e-02  2.437e-03   11.387 3.79e-13 ***
QQ4         4.123e-02  2.442e-03   16.882  < 2e-16 ***
time        4.644e-03  3.054e-04   15.207  < 2e-16 ***
timesquared 2.418e-05  7.221e-06    3.348    0.002 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.005438 on 34 degrees of freedom
Multiple R-squared:  0.9946,     Adjusted R-squared:  0.9938
F-statistic:  1256 on 5 and 34 DF,  p-value: < 2.2e-16
```

f) Based on the R code output from part e), we find that the estimate of QQ2, QQ3, QQ4 are positive. This means that the effect of the first quarter on the log transformation of GDP is smaller than the effect of the other three quarters on the log transformation of GDP. To be specific, the effect of the first quarter(Q1) on the log transformation of GDP is $2.15*10^{(-2)}$ smaller than the effect of the second quarter(Q2) on the log transformation of GDP. Also, the effect of the first quarter(Q1) on the log transformation of GDP is $2.774*10^{(-2)}$ smaller than the effect of the third quarter(Q3) on the log transformation of GDP. Also, the effect of the first quarter(Q1) on the log transformation of GDP is $4.123*10^{(-2)}$ smaller than the effect of the fourth quarter(Q4) on the log transformation of GDP. Thus, the effect of the fourth quarter on the log transformation of GDP is larger than the effect of the other three quarters on the log transformation of GDP. Moreover, since the p-value of QQ2, QQ3, and QQ4 are smaller than 0.05, we should reject null

hypothesis and there exist differences between the effects of these four quarters on the log transformation of GDP and so we should consider all four quarters since there are differences between the effects of these four quarters on the log transformation of GDP.