Homework Assignment 10

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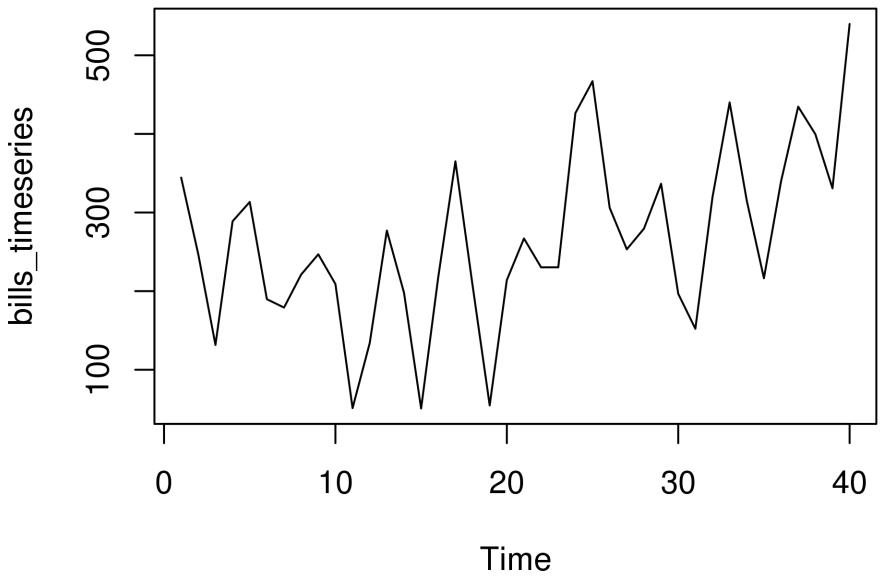
Problem 1. Plot the energy bills versus time. What kind of trend appears to exist? What type of seasonal variation appears to exist? Is a transformation needed to obtain a series that displays constant variation?

Solution. See below for a plot of the bills time series data:



It is clear from the plot that there is a trend that appears to move upwards as time increases and a seasonal variation with period 4 lags present in the data so a transformation is needed to obtain residuals that represent a stationary time series. □

Problem 2. Write algebraically a time series model with trend and seasonal component with definitions of the dummy variable.

Solution. Note that it appears that this time series has a quadratic trend. Additionally, we are interested in capturing the seasonal quarter data of the time series. Therefore, a time series model for the data with trend and seasonal components is given by

$$X_t = a_0 + a_1 t + a_2 t^2 + a_3 Q_1 + a_4 Q_2 + a_5 Q_3 + a_6 Q_4,$$

where we define Q_i as 1 if $t \equiv i \mod 4$ and 0 otherwise and a_j is constant. □

Problem 3. Are all the variables in the model statistically significant? Justify your answer.

Solution. The following `R` code performs a linear regression on our data set using the above equation:

```
quarter_variable <- function(ts, position){
    vector <- rep(0, 4)
    vector[position] <- 1

    variable <- rep(vector, length(ts) / 4)

    return(variable)
}

bills <- scan("bills.csv", skip=1)
bills.ts <- ts(bills)

bills.ts.Q1 <- quarter_variable(bills.ts, 1)
bills.ts.Q2 <- quarter_variable(bills.ts, 2)
bills.ts.Q3 <- quarter_variable(bills.ts, 3)
bills.ts.Q4 <- quarter_variable(bills.ts, 4)

bills.ts.regression_equation <- bills.ts ~ 0 + time(bills.ts) +
    I(time(bills.ts)^2) + bills.ts.Q1 + bills.ts.Q2 + bills.ts.Q3 +
    bills.ts.Q4
bills.ts.regression <- lm(bills.ts.regression_equation)

# The following tells us that all variables are significant
# using a significance level of alpha = 0.05.
summary(bills.ts.regression)
```

The code above outputs the following table displaying the significance of the variables in the regression equation:

```
Coefficients:
                    Estimate Std. Error t value Pr(>|t|)
time(bills.ts)       -7.4582     3.3960  -2.196 0.034999 *
I(time(bills.ts)^2)   0.3012     0.0803   3.751 0.000657 ***
```

```
bills.ts.Q1         342.4070    33.8113  10.127 8.44e-12 ***
bills.ts.Q2         238.7662    34.3165   6.958 5.06e-08 ***
bills.ts.Q3         149.0250    34.7278   4.291 0.000139 ***
bills.ts.Q4         276.6363    35.0485   7.893 3.43e-09 ***
---
Signif. codes:  0 *** 0.001 ** 0.01 * 0.05 . 0.1   1
```

From this table we see that all of our of our variables are statistically significant using a significance level of $\alpha = 0.05$. □