Problem 1

Slaughter of Victorian bulls, bullocks and steers

Fig 1 and 2 show the number of bulls, bullocks, and steers in Victoria. We used Guerrero's method for Box-Cox lambda selection. According to the transformation, the lambda coefficient is $\lambda \approx -0.72$. The process did not affect seasonality. However, there are small changes in amplitudes.

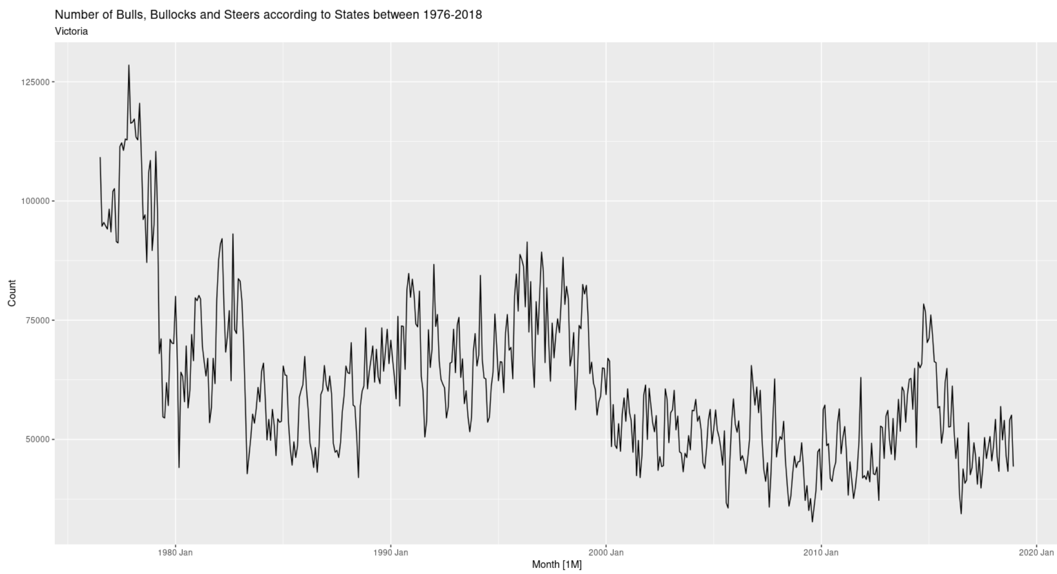

Figure 1: Number of bulls, bullocks and steers between 1976-2018 in Victoria, Australia.

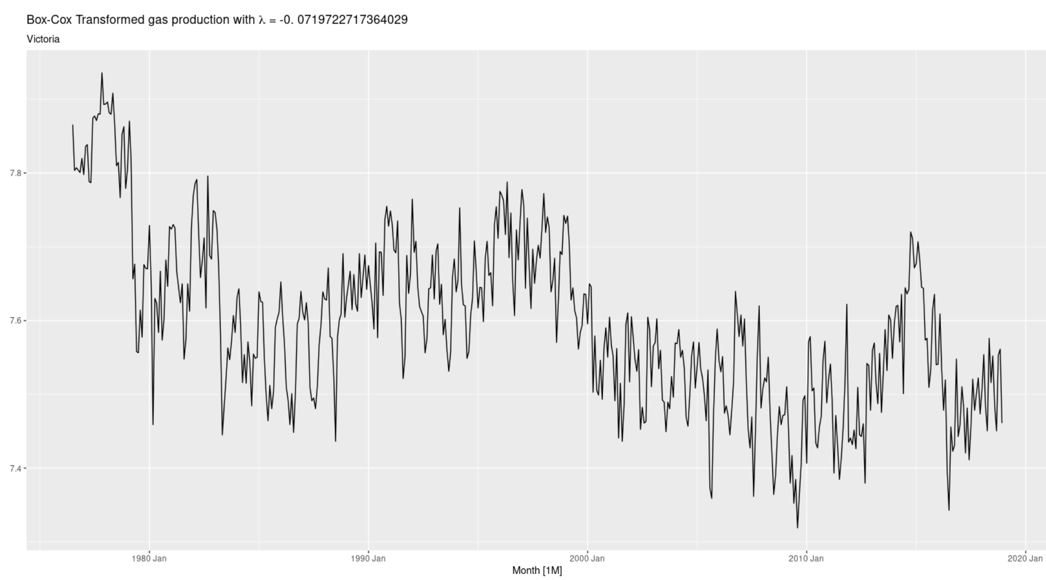

Figure 2: Box-Cox transformation for the time series of the same data.

Victoria electricity demand

Fig 3 and 4 show electricity demand in Victoria, Australia. We used Guerrero's method for Box-Cox lambda selection. According to the transformation, the lambda coefficient is $\lambda \approx 1$. Box-Cox transformation seems not to affect time series other than small amplitude changes.

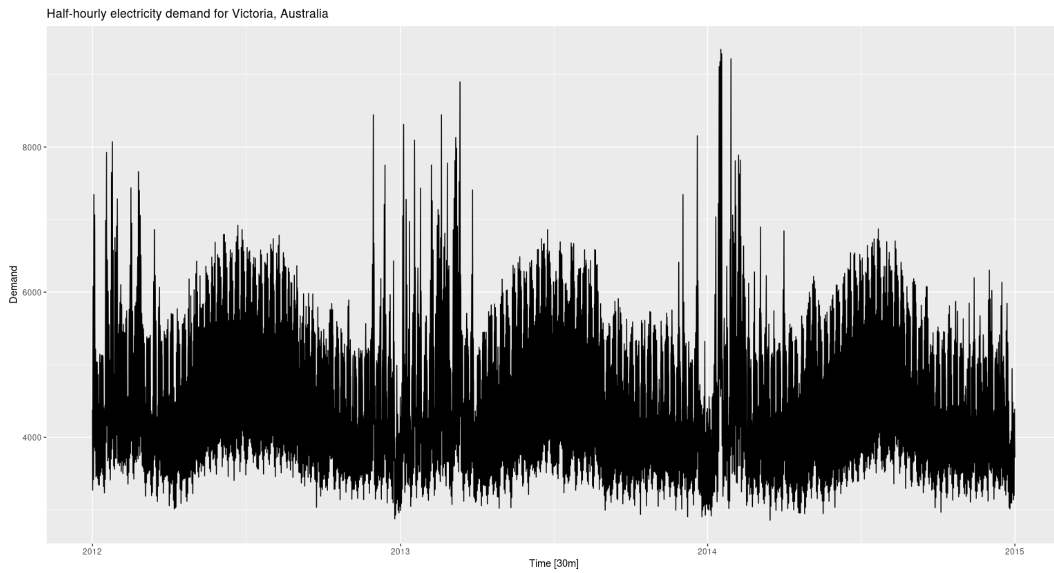

Figure 3: Half-hourly electricity demand between 2012-2015 in Victoria, Australia

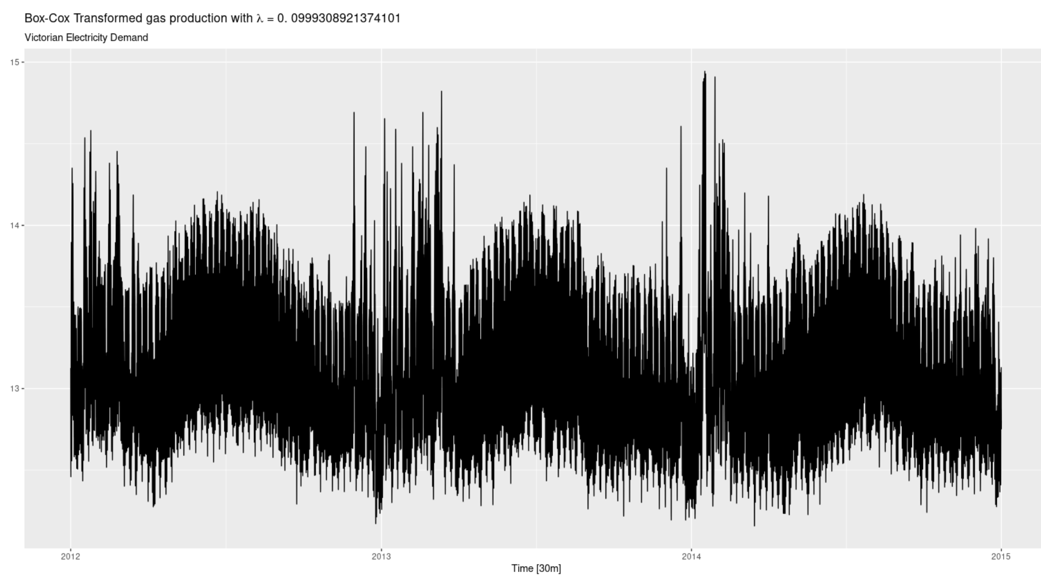

Figure 4: Box-Cox transformation of the electricity demand in Victoria, Australia.

Gas Production in Australia

Fig 5 and 6 represent the gas production in Australia. We again used Guerrero's method for Box-Cox lambda selection. According to the transformation, lambda coefficient is $\lambda \approx 0.12$. Unlike the first two cases, we can see a noticeable change in the time series. The trend of data is changed dramatically around 1970 and gets stiffer. We also note that the amplitudes of seasonal behaviors seem to normalize after transformation. That would allow us to interpret the data more accurately.

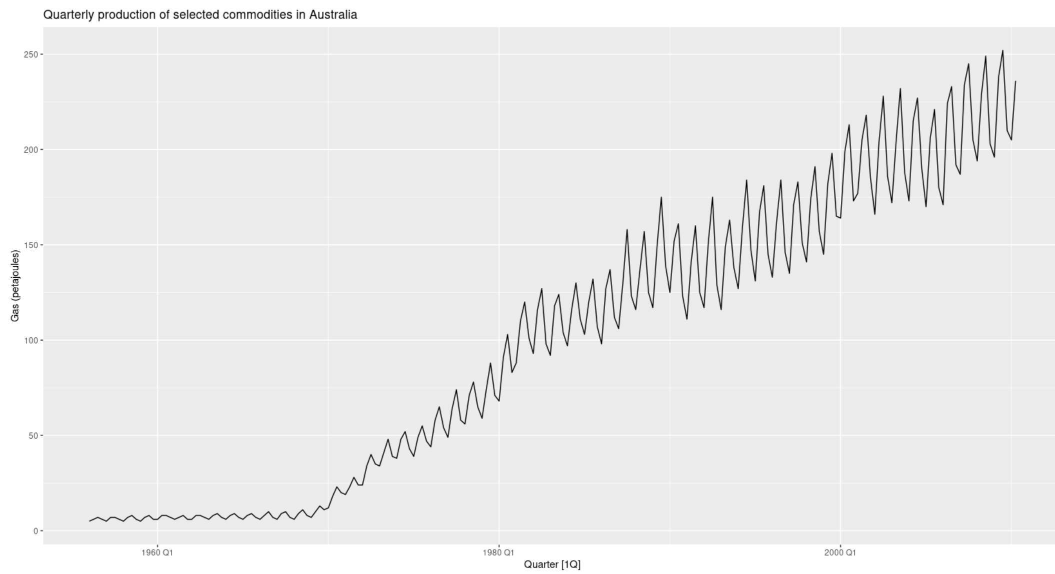

Figure 5: Quarterly gas production estimates in Australia

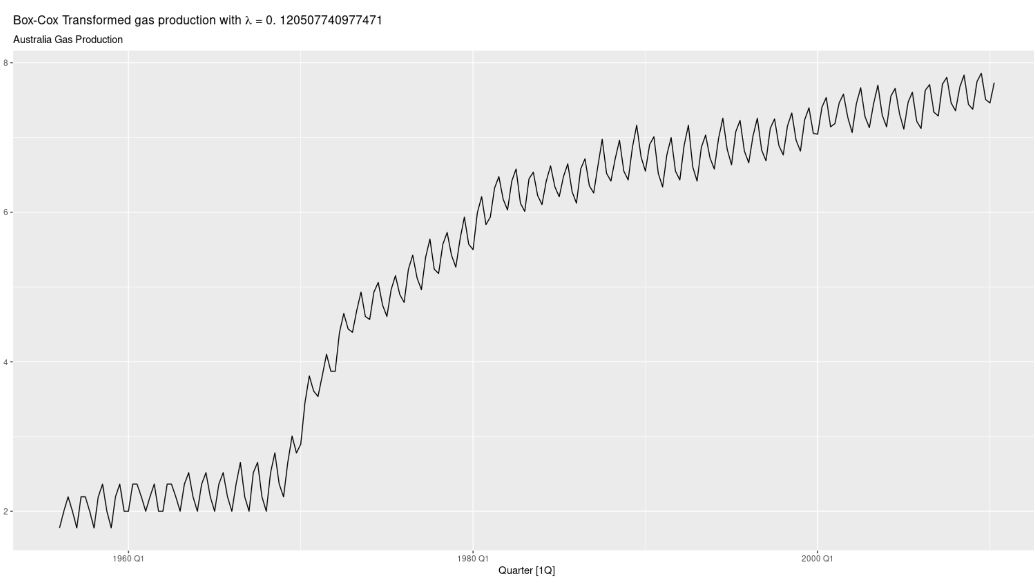

Figure 6: Box-Cox transformation for the quarterly gas production estimates in Australia

Problem 2

$$\tilde{T}_t = \frac{1}{3}\left[\frac{1}{5}(y_{t-3} + y_{t-2} + y_{t-1} + y_t + y_{t+1}) + \frac{1}{5}(y_{t-2} + y_{t-1} + y_t + y_{t+1} + y_{t+2}) + \frac{1}{5}(y_{t-1} + y_t + y_{t+1} + y_{t+2} + y_{t+3})\right]$$

$$\tilde{T}_t = \frac{1}{15}\left[y_{t-3} + 2y_{t-2} + 3y_{t-1} + 3y_t + 3y_{t+1} + 2y_{t+2} + y_{t+3})\right]$$

$$\tilde{T}_t = \frac{1}{15}y_{t-3} + \frac{2}{15}y_{t-2} + \frac{3}{15}y_{t-1} + \frac{3}{15}y_t + \frac{3}{15}y_{t+1} + \frac{2}{15}y_{t+2} + \frac{1}{15}y_{t+3}$$

$$\tilde{T}_t = 0.067y_{t-3} + 0.133y_{t-2} + 0.200y_{t-1} + 0.200y_t + 0.200y_{t+1} + 0.133y_{t+2} + 0.067y_{t+3}$$

Problem 3

Part b

In Fig 7 and 8, we see quarterly gas production in Australia produced by autoplot and classical multiplicative decomposition. Fig 7 demonstrates a clear seasonal behavior (yearly period) and a trend even without a decomposition plot. In Fig 8 there is yearly periodic behavior in the third panel in which seasonal behavior can be seen clearly. There is also an upward trend in the second panel, an increasing movement through the years.

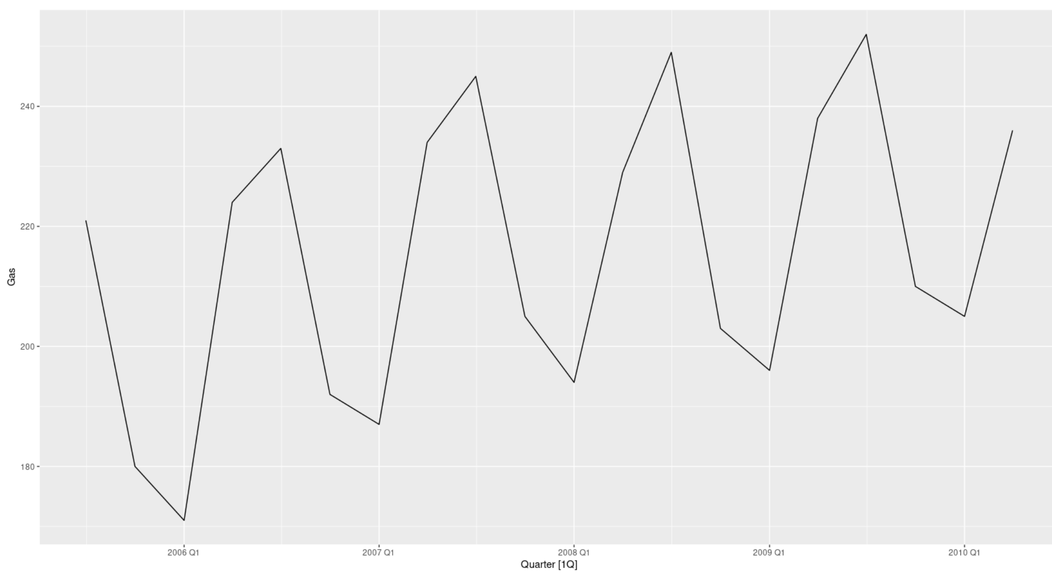

Figure 7: Plot of quarterly gas production in Australia.

Part c

In Fig 8 we see explicit evidence of seasonal and trend components in which supports our first inquiry about the data in Fig 7. However, it might be hard to see in Fig 7 that a plateau in trend between the second half of 2007 and the first half of 2008.

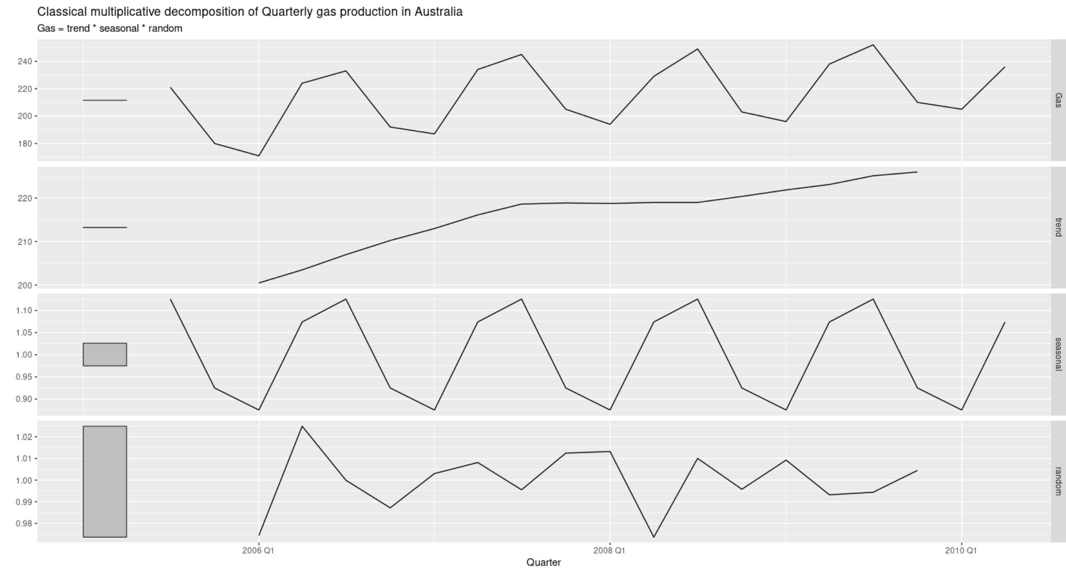

Figure 8: Classical multiplicative decomposition (Gas = Trend*Seasonal*Random) for the quarterly gas production in Australia.

Part e

In Fig 9, we see a seasonally adjusted time series for quarterly gas production in Australia. The outlier has been applied to three different dates in the data. First, the outlier has placed at the beginning, the first quarter of 2005, which created a sudden decrease and fluctuation around 2008 (Fig 10). When we put outlier to the middle, the first quarter of 2008, it has shown by Fig 11 that fluctuations became more visible and seasonally adjusted line tends to follow the original data more rigidly. The outlier is at the end of the data, the effect of the outlier is the least compared to the previous cases. The seasonally adjusted line is closer to the original shape even though some features (little up and downtrends around the second quarters of 2006 and 2008) have changed. There is also a second dip around the second quarter of 2009 which does not appear in the first place.

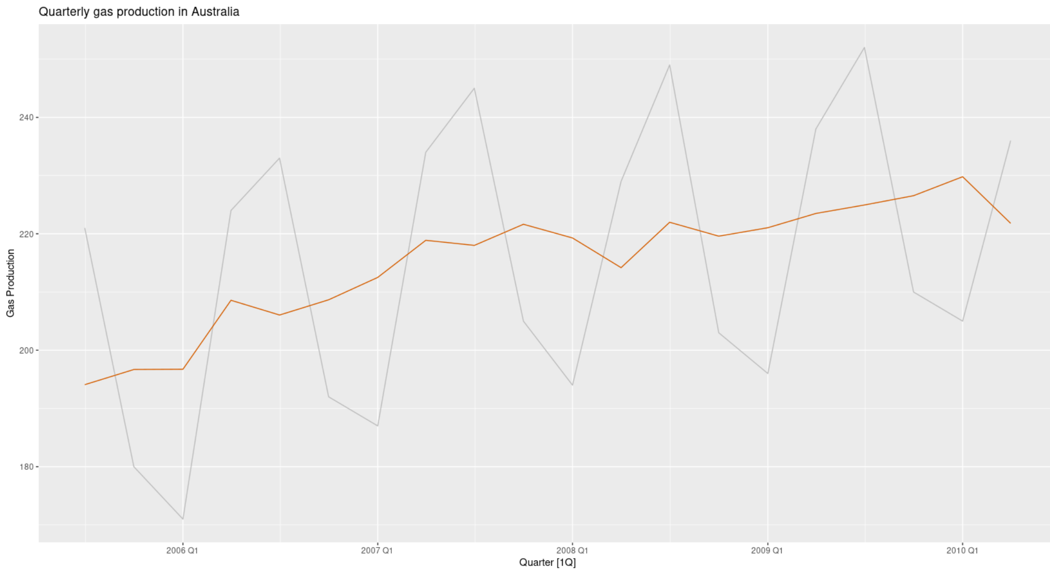

Figure 9: Seasonally adjusted quarterly gas production time series in Australia.

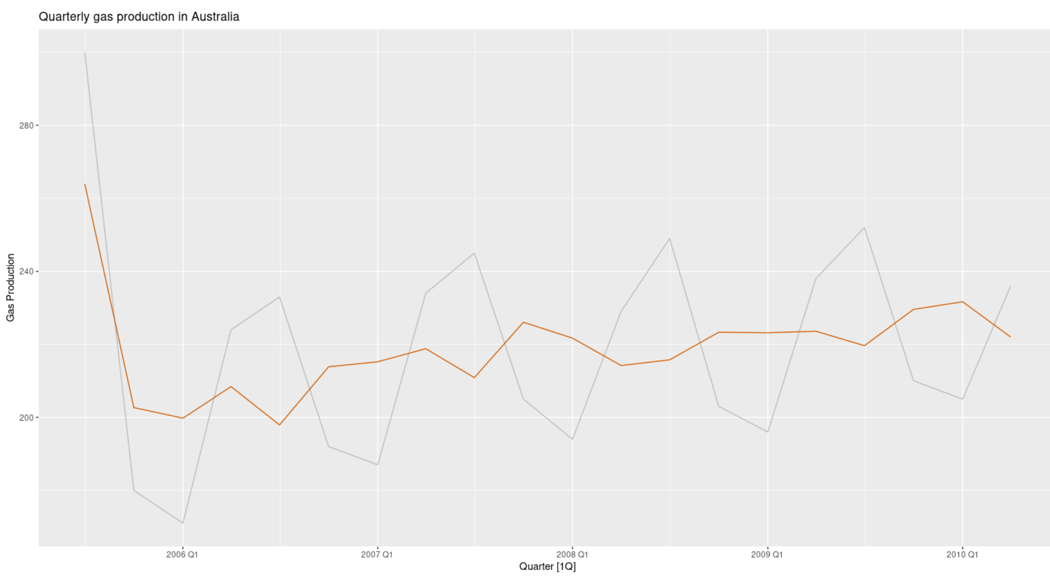

Figure 10: Seasonally adjusted quarterly gas production time series in Australia. The value of first quarter in 2005 (first row) is replaced with 300.

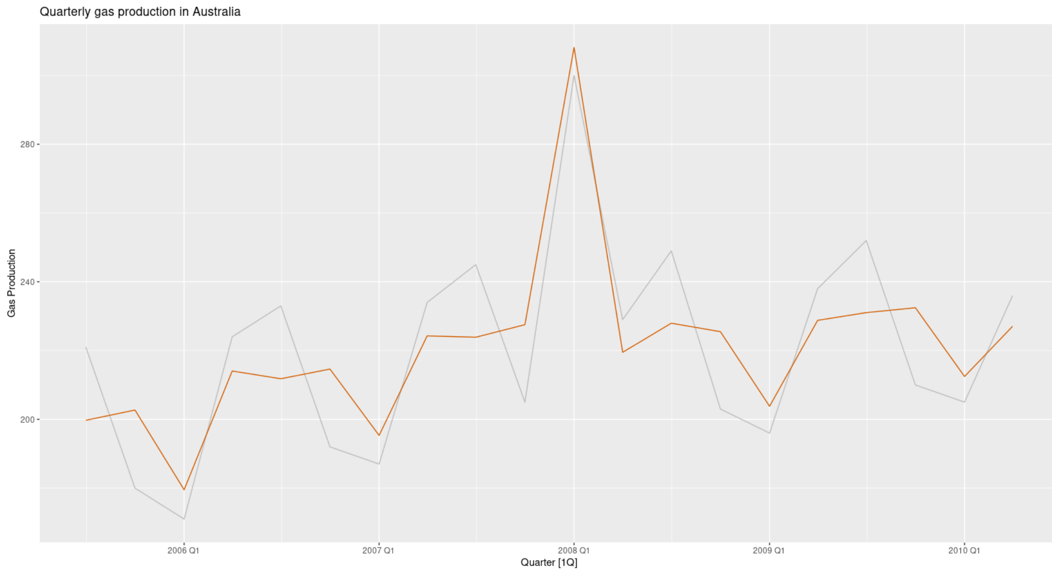

Figure 11: Seasonally adjusted quarterly gas production time series in Australia. The value of first quarter in 2008 (middle row) is replaced with 300.

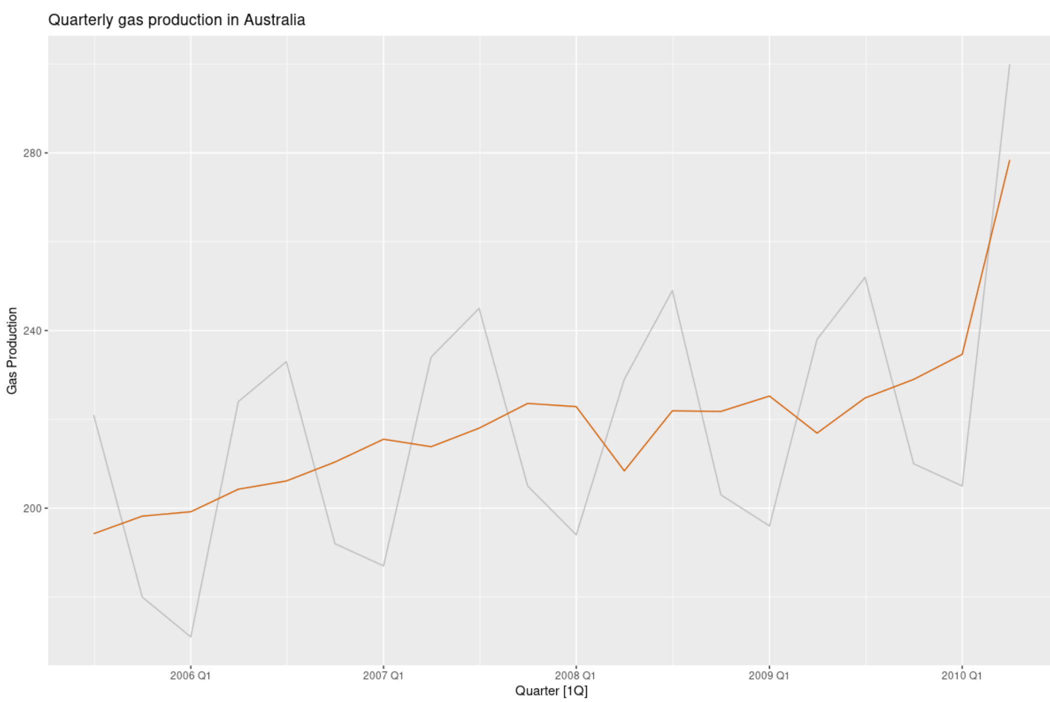

Figure 12: Seasonally adjusted quarterly gas production time series in Australia. The value of second quarter in 2010 (last row) is replaced with 300.

Part f

Change in the behavior of the data heavily depends on the position of the outlier. The effect has felt least if the outlier is at the end of the data. On the other hand, the outlier in the middle affected the behavior most. The outlier at the beginning has a moderate effect on the data.

Problem 4

Part a

In Fig 13,14, 15 and last panel (irregular) in the bottom plot of Fig 16 we can see an unusual event between 1980-1990. A brief research of Canadian gas production in that era shows that demand for gas grew while suppliers increased their capacity. which caused more production than market needs. Eventually, they had to reduce the gas prices and continued until the late 1990s. Along with low gas prices, crude oil prices dropped during the 1980s created extra stress on the industry. As a result, competition in the market was so high, dealers were unable to make money due to the low gas prices.

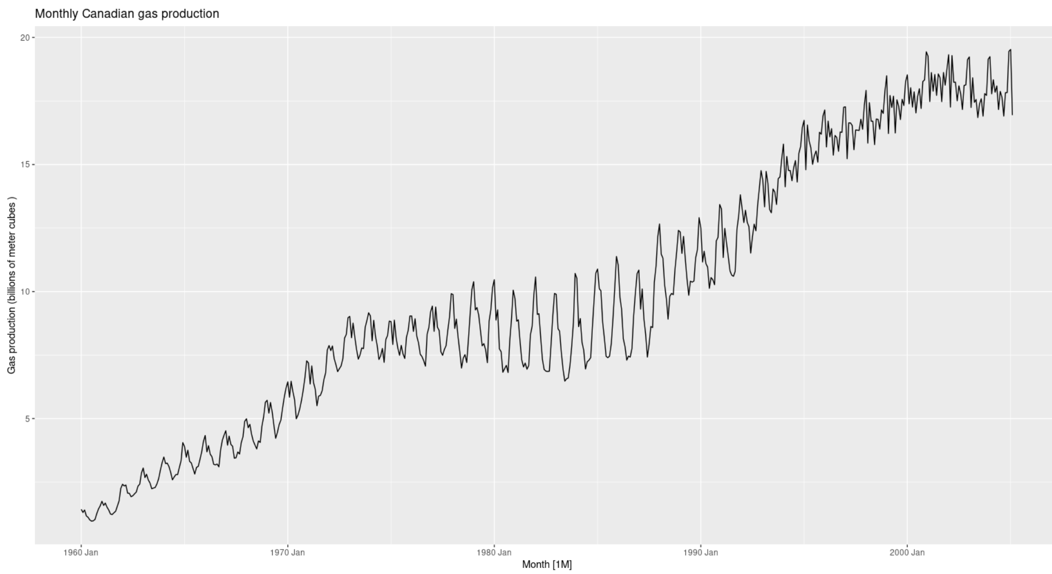

Figure 13: Monthly Canadian gas production, billions of cubic metres, from January 1960 to February 2005.

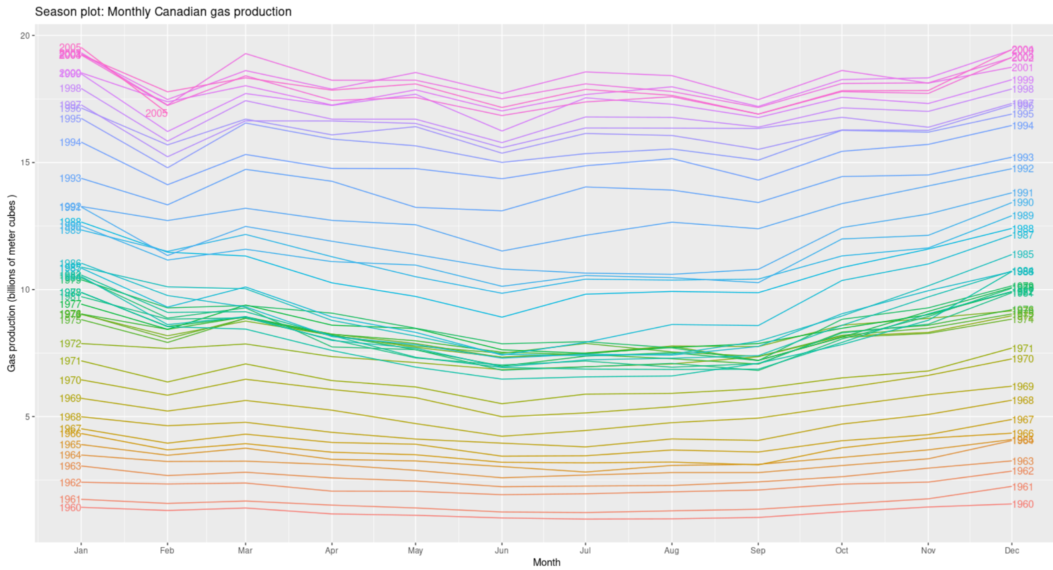

Figure 14: Seasonal plot for monthly gas production in Canada.

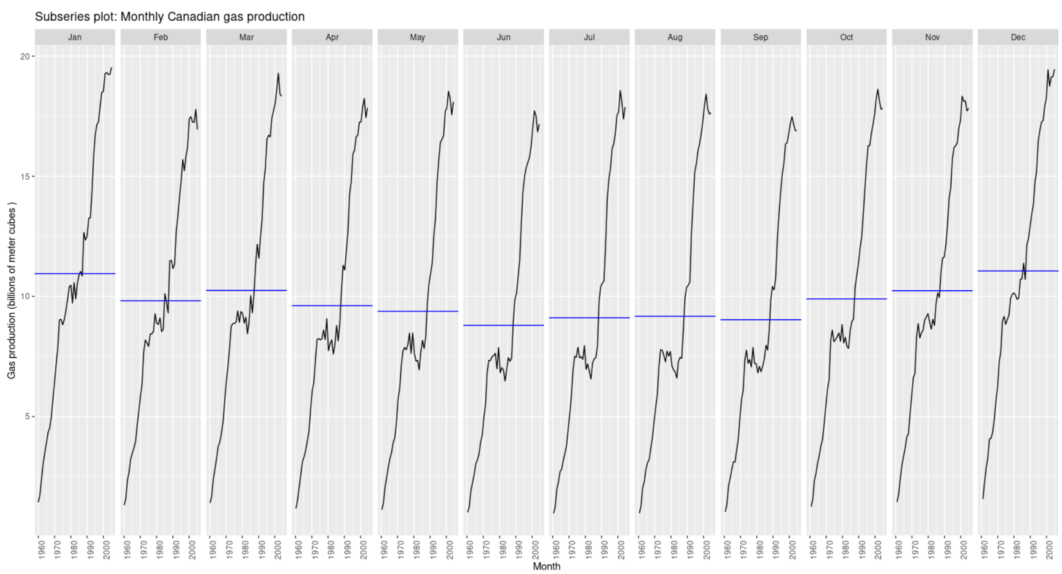

Figure 15: Subseries plot for monthly gas production in Canada.

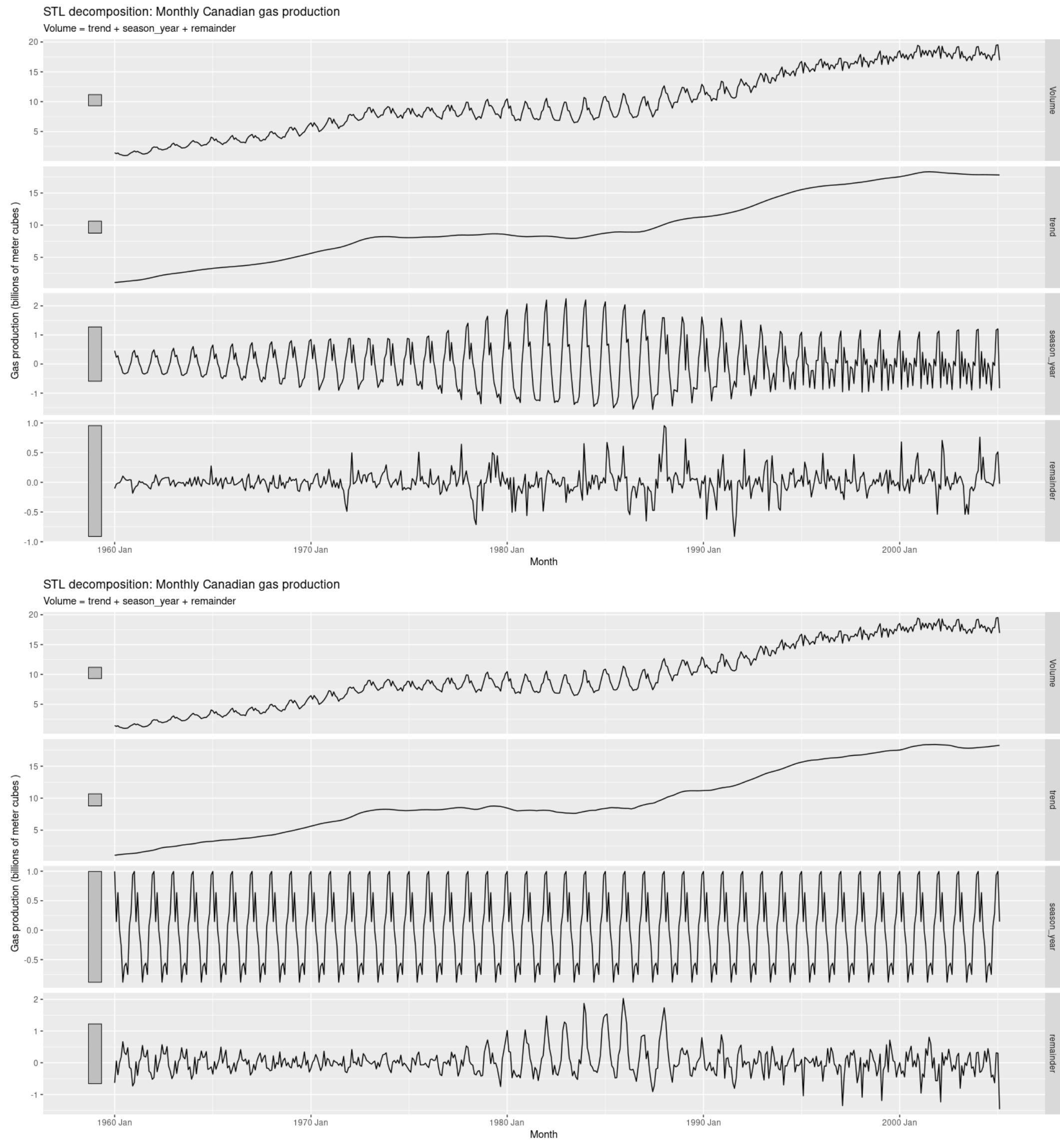

Figure 16: STL decomposition plot for monthly gas production in Canada. The upper plot show STL decomposition when window equals to 9, and the bottom one equals to periodic.

Part c

In Fig 18, during pre-1980s, there is a predictable seasonal behavior. Throughout the next two decades, we see fluctuations due to the reasons mentioned in [Part a]. After the 1908s, there was a new seasonal behavior that changed monthly. For example, gas production decreases between January and February increases between February and March. Thereupon the trend has a turning point around mid-summer where production starts to increase with two-monthly fluctuating behavior. This behavior repeats itself through the time interval, decreasing in the first half and increasing in the second half of the year.

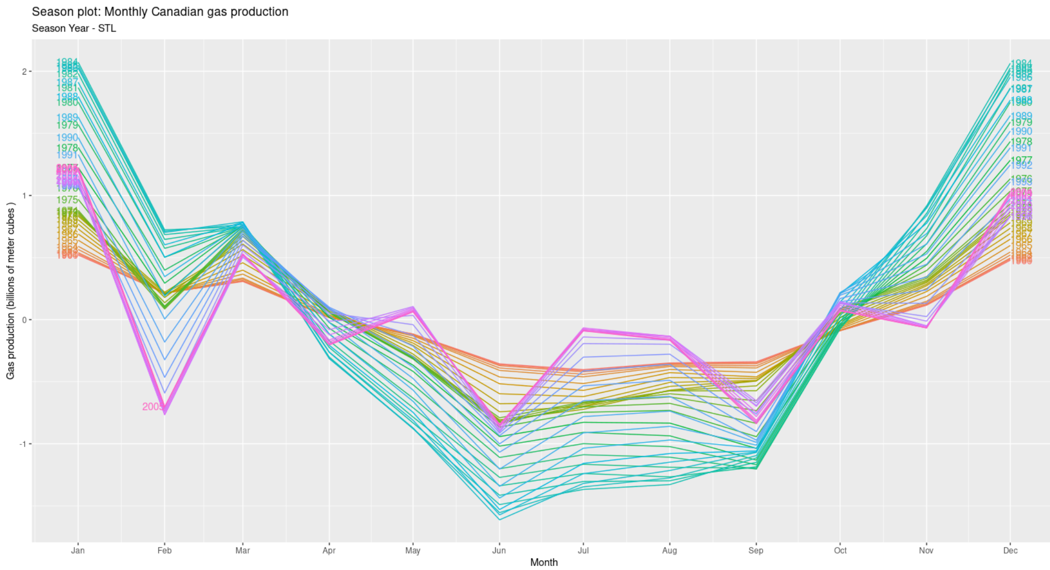

Figure 17: Plot for seasonal component (season year) of monthly gas production in Canada.

Part d

Seasonally adjusted line shows a plateau between 1975-1987. That might indicates a different nature of gas production over the period.

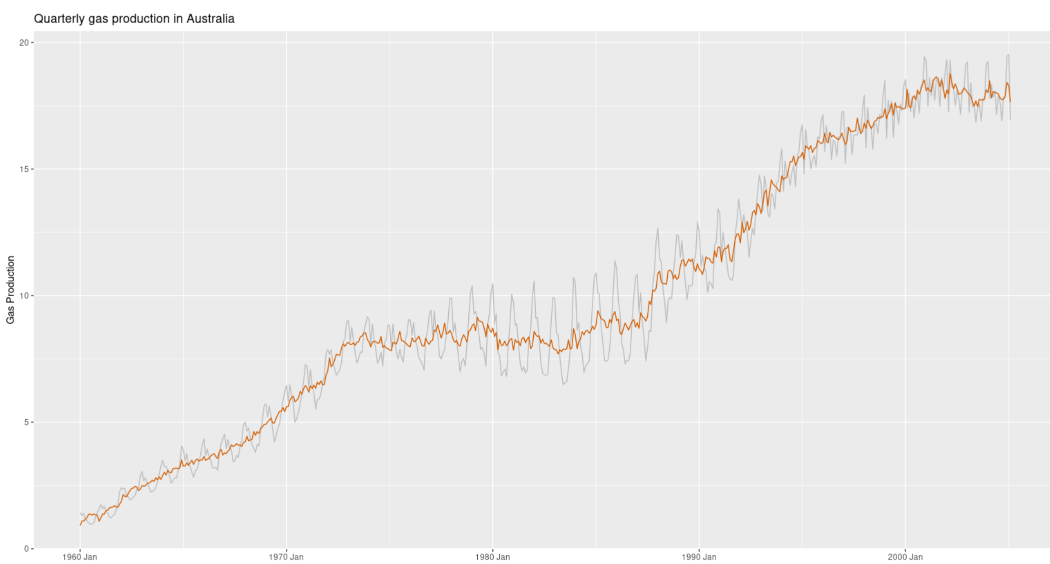

Figure 18: Plot for seasonally adjusted monthly gas production in Canada.

Part e

The bottom plot on the Fig 16 shows periodic STL decomposition (top plot was put to show variation between differently chosen windows) and Fig 19, 20 are represent X-11 and SEATS decompositions, respectively. The last two put forward similar time series characteristics except for irregularity. The biggest difference between STL and X-11 / SEATS is in seasonality. Their resemblance with a poorly chosen window in STL decomposition in seasonality is noticeable. The trend for all three looks identical. Moreover, irregular part in STL decomposition precisely expresses unusual behavior during a specific interval. Lastly, there seems like more irregularity in the SEATS decomposition respect to X-11.

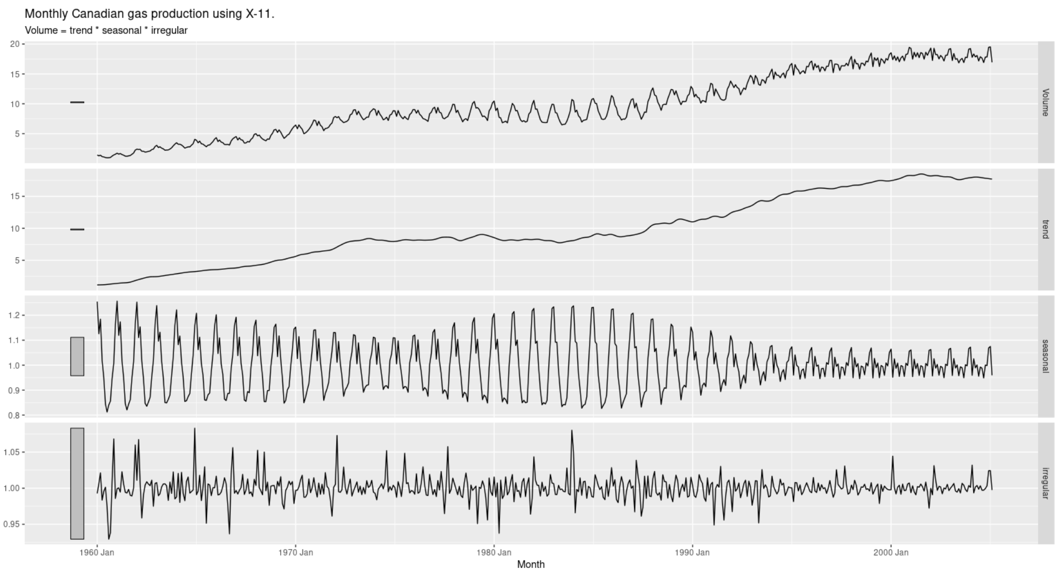

Figure 19: X-11 decomposition plot for monthly gas production in Canada.

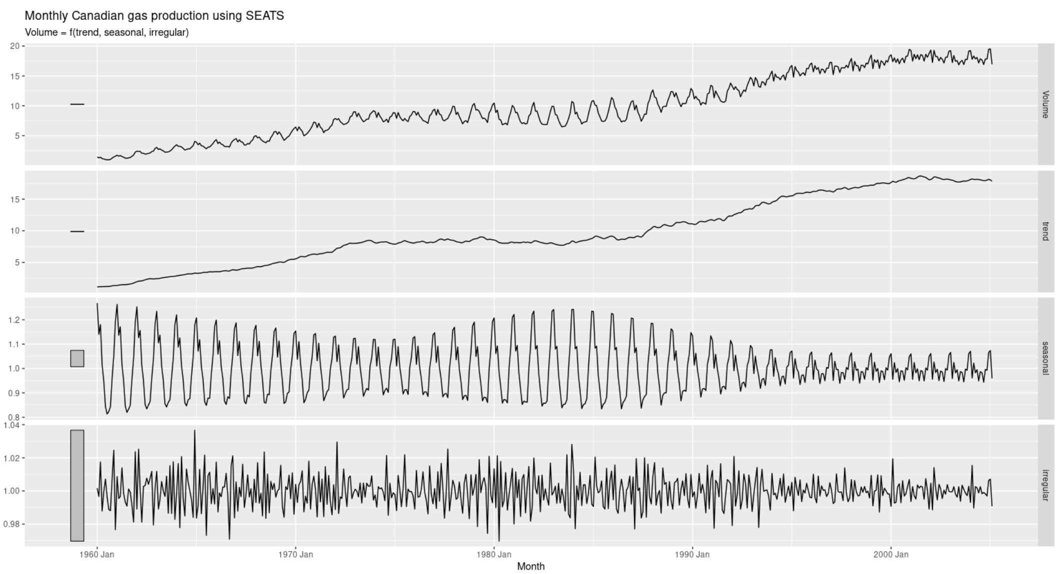

Figure 20: SEATS decomposition plot for monthly gas production in Canada.