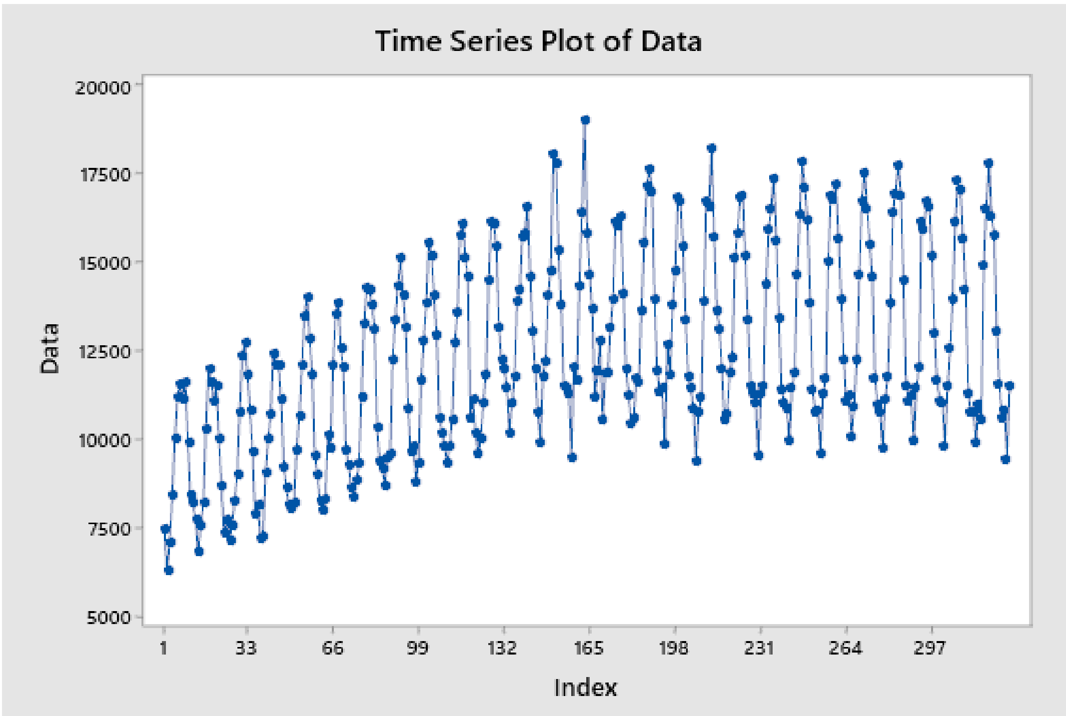
Seasonal ARIMA Modeling

A) Do you need a pre-differencing transformation to stabilize the variance? If yes, what is the transformation that you choose? Please explain briefly.

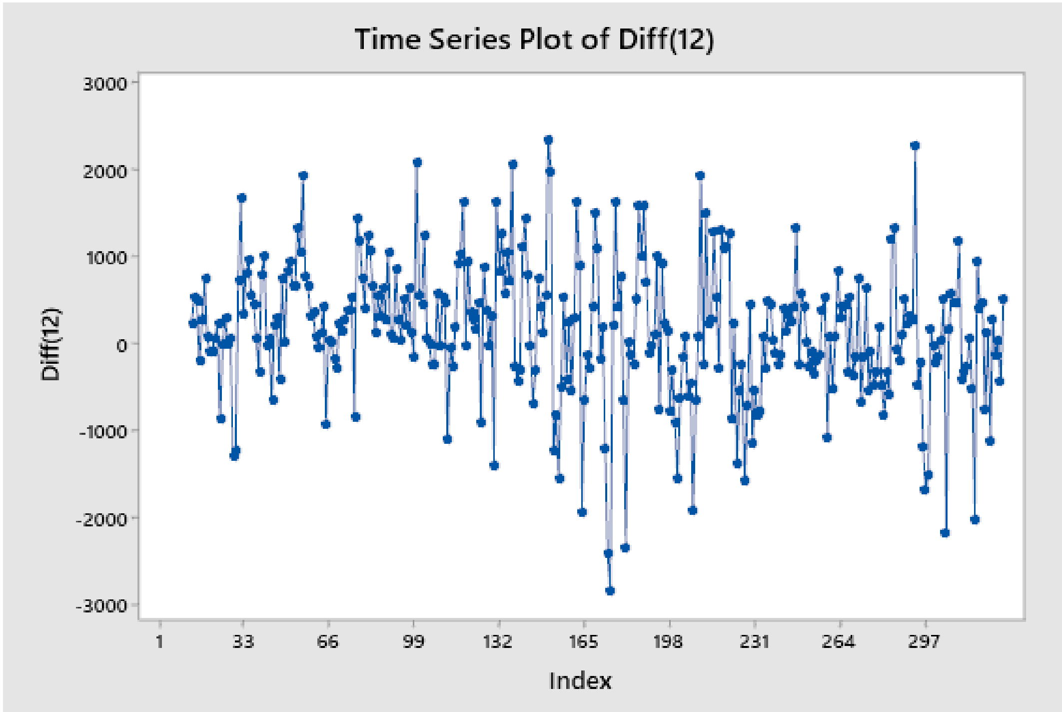


Yes, the original data shows seasonal patterns - electricity consumption peaks at the summer and bottoms at the winter. There also seems to be an increasing trend of electricity consumption through the years.

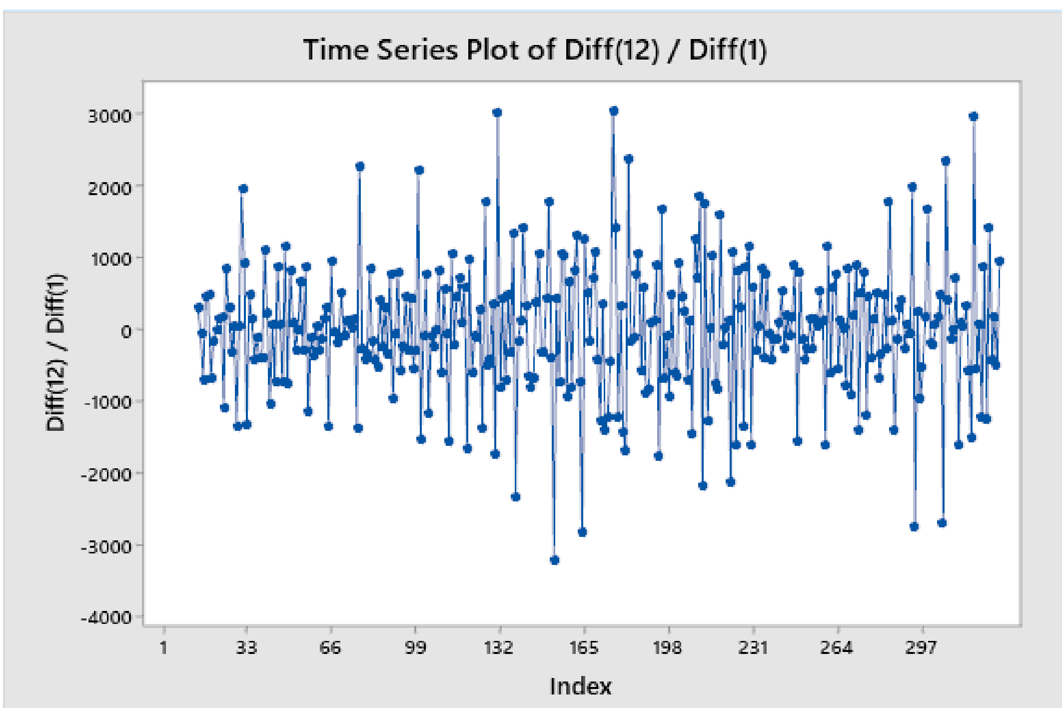
The transformation used will be seasonal and regular differencing. The seasonal differencing is aimed at removing the seasonal effect, while the regular differencing is aimed at removing the trend effect.

B) Do you need to use regular difference and/or seasonal difference to produce a stationary series after step (A)? If yes, what is the appropriate difference(s)? Please explain briefly.

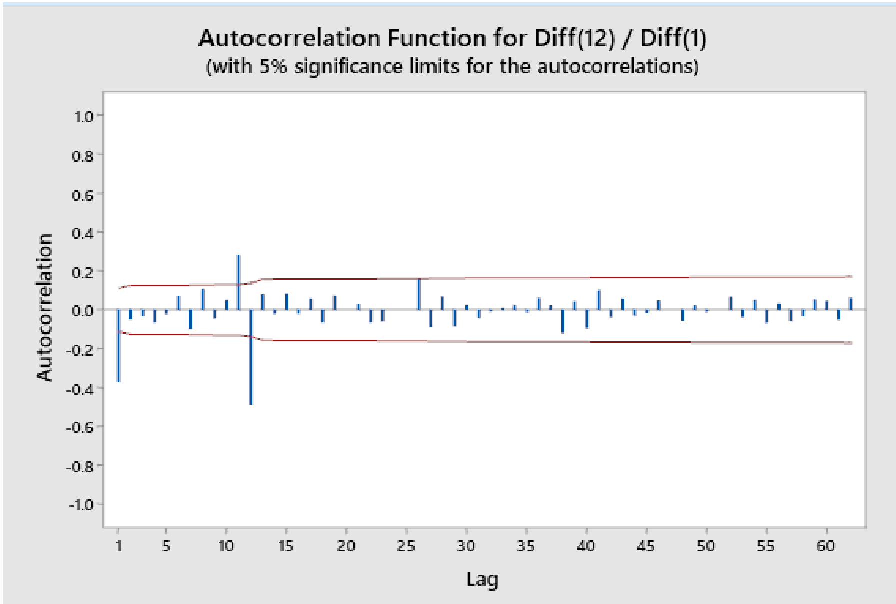
Seasonal Difference: deal with year-on-year seasonal variations, e.g. January in Year 1 vs January in Year 2. A period of 12 will be used. The difference of lag = 12 will be done on the original time series.



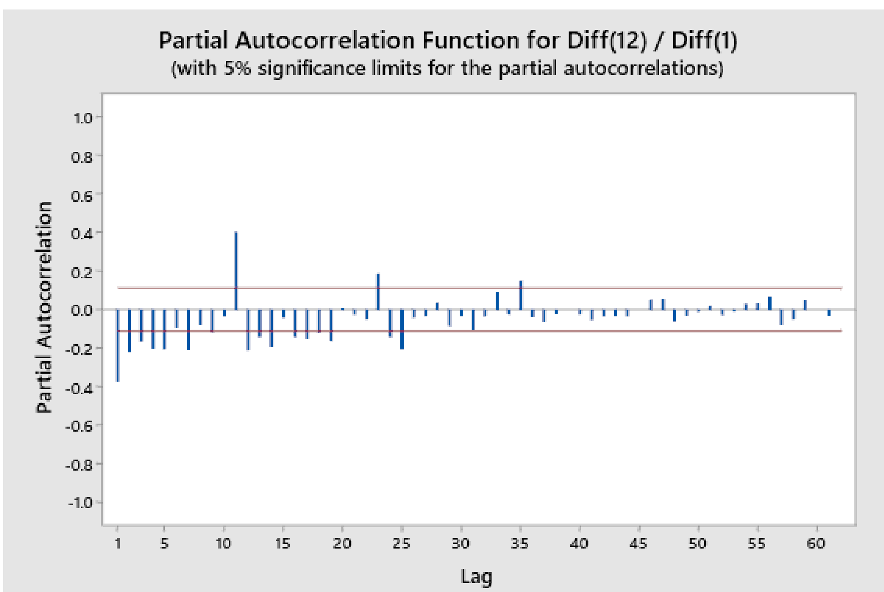
Regular Difference: deal with month-on-month trend variations, e.g. January vs February. The difference of lag = 1 will be done on the above time series.



C) Examine graphical statistics such as SAC or SPAC to tentatively identify a model for the series obtained from (B). Please explain the model of your choice.



Sample Autocorrelation Function

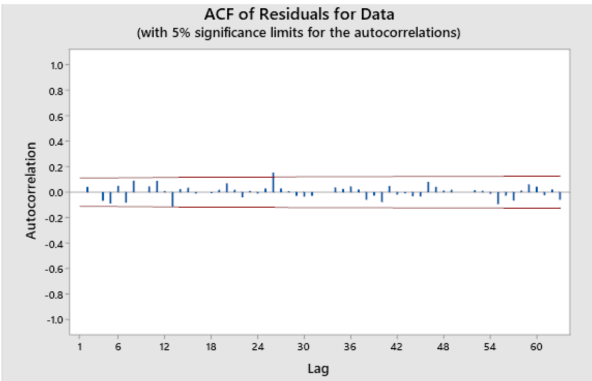


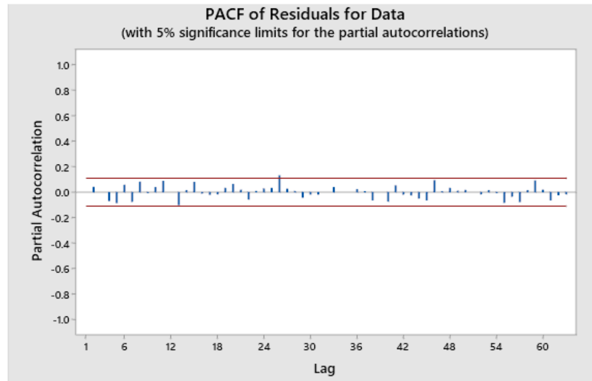
Sample Partial Autocorrelation Function

There seems to be prominent spikes at lag 1, 11, and 12 for both SAC, while the prominent spikes are at 1 and 11 for SPAC. The chosen model is ARIMA(1,1,1)x(1,1,1)12. The first part of the ARIMA model (1,1,1) is targeted at the non-seasonal part of the time series, which is determined by both the SAC and SPAC graphs by the spike in lag 1. The second part of the

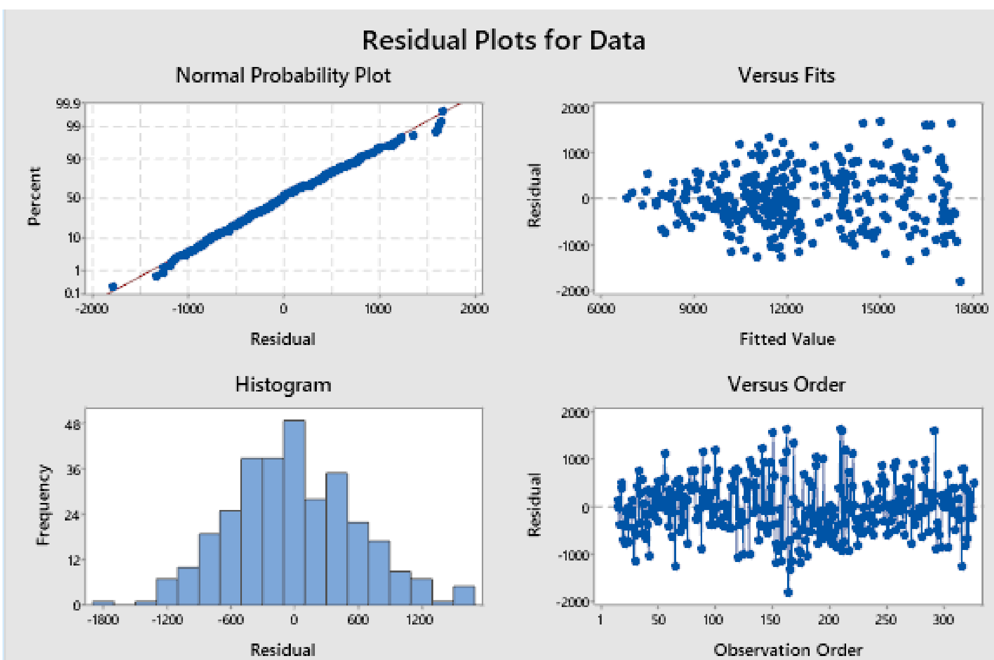
ARIMA model (1,1,1)12 is targeted at the seasonal part of the time series, which is determined by both the SAC and SPAC and the recurrent spikes every year (11 / 12 months).

D) Carry out a diagnostic checking on the model you identified in (C). Is the model adequate? Do you need to modify it? Are there other competing models?





Based on the SAC and SPAC graphs, it seems like the residuals are not significant and there is not a drastic spike, which is expected behavior.



Normal Probability Plot - shows that the model fits the data points pretty well, except the last few points, which may be due to outliers.
Versus Fits - shows that the distribution is random and that there is no clear pattern.
Histogram - shows normally behaving normal distribution.

Versus Order - shows that the data points are stationary and reverts back to a mean.

The model is quite adequate.

E) Please recommend your final model for Hong Kong total electricity consumption. Explain your recommendation and use the model to forecast the electricity consumption from April, 2021 – March, 2022.

The final model for Hong Kong total electricity consumption is ARIMA(1,1,1)x(1,1,1)12. It has a lower MSE than other models tested - most notably ARIMA(0,0,0)x(1,1,1)x12 (with no non-seasonal ARIMA part).

ARIMA(1,1,1)x(1,1,1)12			*ARIMA(0,0,0)x(1,1,1)x12*		
Residual Sums of Squares			Residual Sums of Squares		
DF	SS	MS	DF	SS	MS
309	112256168	363289	312	159287908	510538
Back forecasts excluded			*Back forecasts excluded*		

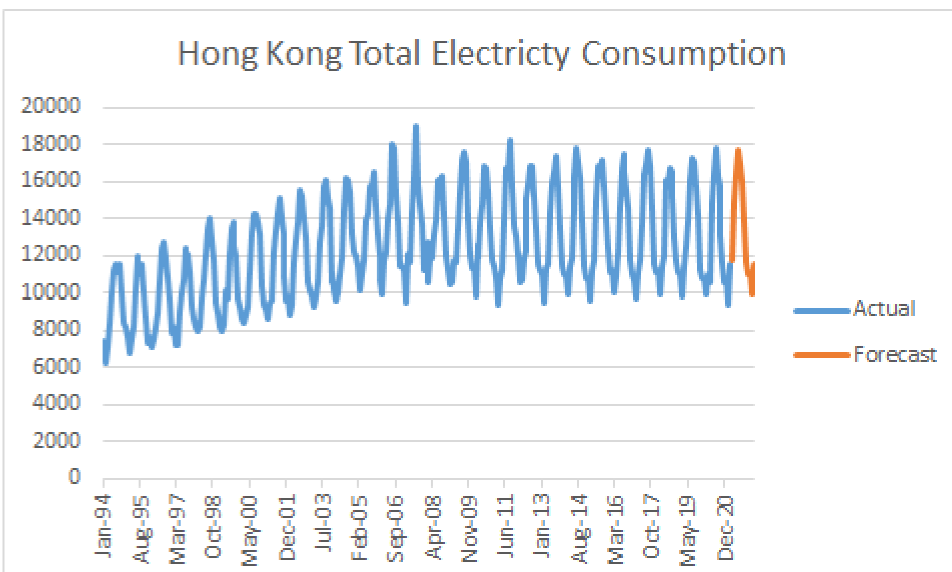
The current model accounts for both the seasonal and trend variations, which is prevalent in the original time series.

Forecast

Below is the forecast for the next 12 periods using the ARIMA(1,1,1)x(1,1,1)12 model.

Forecasts from period 327

		95% Limits		
Period	Forecast	Lower	Upper	Actual
328	11767.8	10367.0	13168.5	
329	14879.9	13479.1	16280.6	
330	16582.3	15181.6	17983.1	
331	17761.8	16361.0	19162.5	
332	16914.1	15513.3	18314.8	
333	15961.0	14560.2	17361.7	
334	13816.5	12415.8	15217.3	
335	11722.0	10321.2	13122.7	
336	10993.2	9592.5	12394.0	
337	11086.9	9686.2	12487.7	
338	9930.3	8529.6	11331.1	
339	11564.4	10163.7	12965.2	



F) Discuss what you learn about Hong Kong electricity consumption from the preceding analysis and comment on its long term implications.

Hong Kong electricity consumption has been steadily increasing from 1994 to 2007; however, since 2007, the consumption is fluctuating at the same level with a constant mean. The change in trend could be explained by the changes in policy of the Hong Kong Government. In 2007, the

Chief Executive emphasized on a policy that aims to reduce greenhouse gas emission, which is following APEC's goal. Consequently, the government has been pushing forward policies that reduce energy consumption of society and hence we see a flattening trend of electricity consumption from 2007.

There is also strong seasonality in Hong Kong electricity consumption, with a peak in the months of June to August. The high electricity consumption during the summer time can be caused by the high usage of air conditioning and other home electronic appliances since people prefer to stay indoors during the time.

Electricity consumption is often closely related to the factory production sector and the advancement of society. The long term implications is that there may be no more new factories operating in Hong Kong; therefore the electricity consumption is maintained at a steady level. Lastly, many offices and buildings could have already adapted to the ‘green’ policies and do not consume additional energy despite new offices and buildings constantly being built.