U.S. Monthly Wind Power Production Report and Forecasting

(a)Description of the data: This dataset, provided by the U.S. Energy Information Administration (EIA) in the Electric Power Monthly report, contains monthly data on wind energy production and other renewables in the United States from January 2001 to February 2023. Frequency of this data is Monthly(12) with total 266 observations. Other information:

- "wind_state_name" : wind power production for the current state
- "other_state_name" : production for all other renewables sources for the current state

My motivation to choose this data is Conducting time series analysis to forecast wind energy production and capacity factors. This forecast might help Modeling wind energy production and capacity factors for forecasting and planning purposes as well Evaluate the impact of policy changes on wind energy production in the United States.

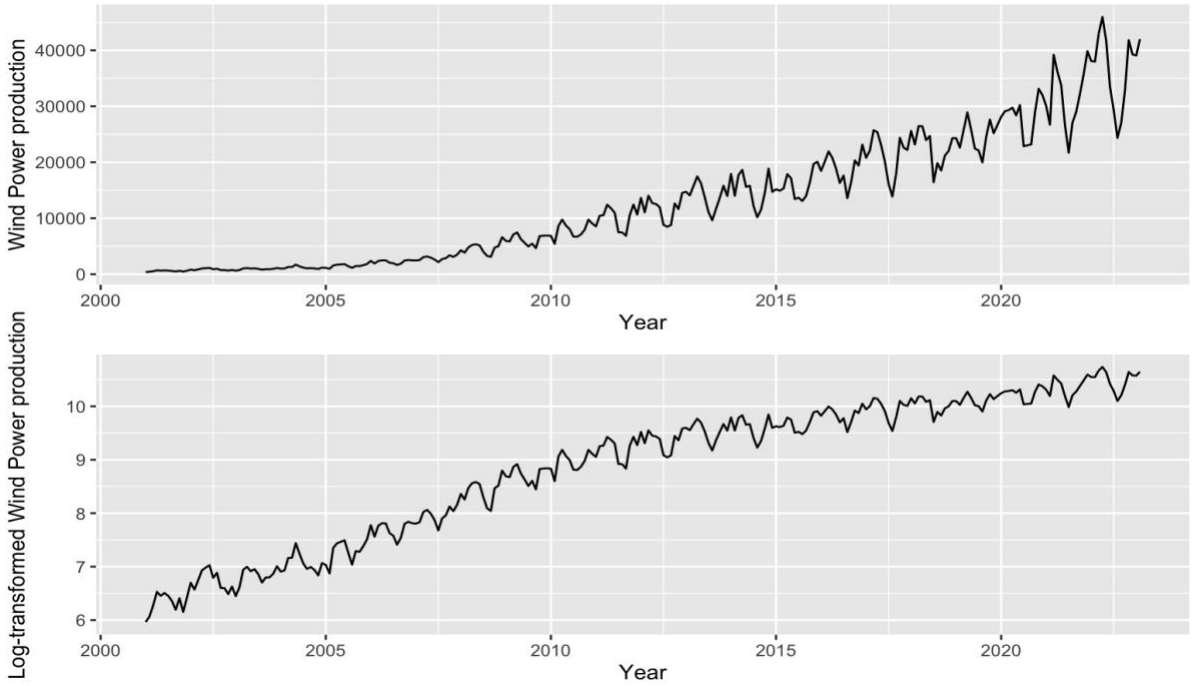

Fig: 1 Time Series plot of wind power production with Log-transformed wind power production

An additive model is usually suitable, if the variation in the observations does not increase with the overall level of the time series. Moreover, (economic) theory should not suggest an exponential increase in the data (and neither should such an increase be observable in the observations). On the other hand, a multiplicative model is often considered for data with an increasing variation for an increasing overall level. Furthermore, it is suitable, when we observe an exponential increase in the data (or if theory suggests such an increase).

As stated in the given time series admits an increasing variation for an increasing overall level of the series. Thus, a multiplicative model might be a good choice in this example. Thus, we will continue and consider the multiplicative model by applying a log-transformation.

(b). The estimated bandwidth is 0.1197724. The estimated bandwidth represents the range of data points used for local smoothing around each point in the time series.

(c) The fitted local linear trend illustrated appears to be quite suitable, as it reflects upward trend and the overall change in the level of the series well, even at boundary points.

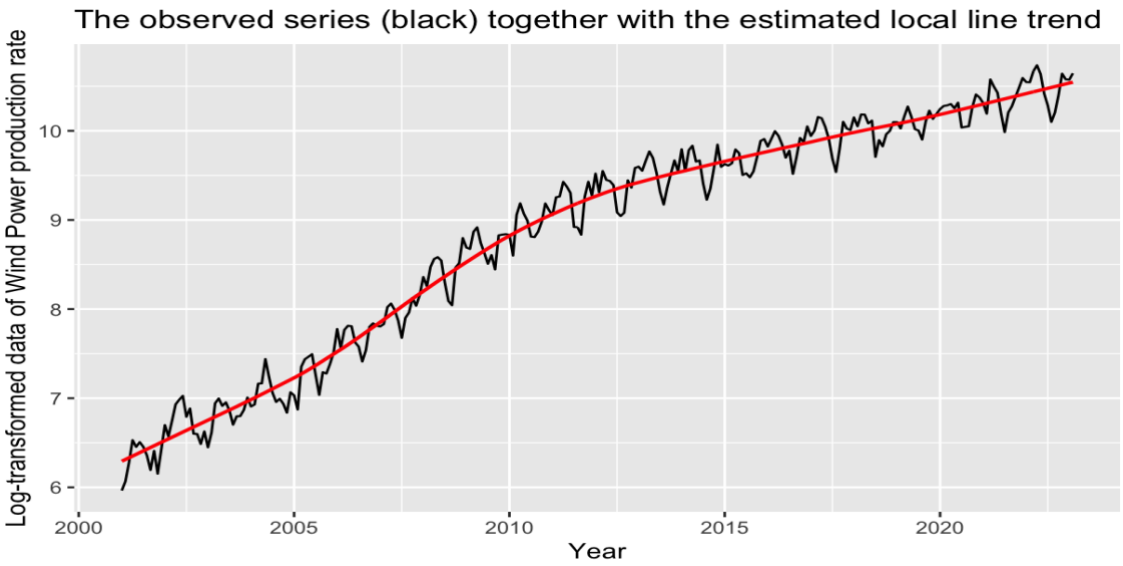

Fig: 2 Estimated Local Trend

In the ACF plot, Figure indicates (clearly more than 5% of the vertical lines that reflect the sample autocorrelations are outside of the confidence interval with the blue bounds), there appears to be a significant autocorrelation in the residual series

There is a significant positive autocorrelation at lag 1, indicating that the series values are positively correlated with their immediately preceding values. The significant positive autocorrelation at lag 1 suggests that if the series had a positive value, it is likely to be followed by another positive value. The presence of significant autocorrelations at multiple lags indicates that the series may have a periodic component, where values repeat or show similar patterns at regular intervals.

Several other lags (e.g., 3, 10, 20, 24) show significant autocorrelations, suggesting periodic or cyclical patterns in the data. There are significant negative autocorrelations at certain lags (e.g., 4, 5, 6, 7, 8, 11, 12, 13), indicating that the series values are negatively correlated with their values at these lags. Negative autocorrelations at specific lags suggest an alternating pattern, where high values tend to be followed by low values and vice versa.

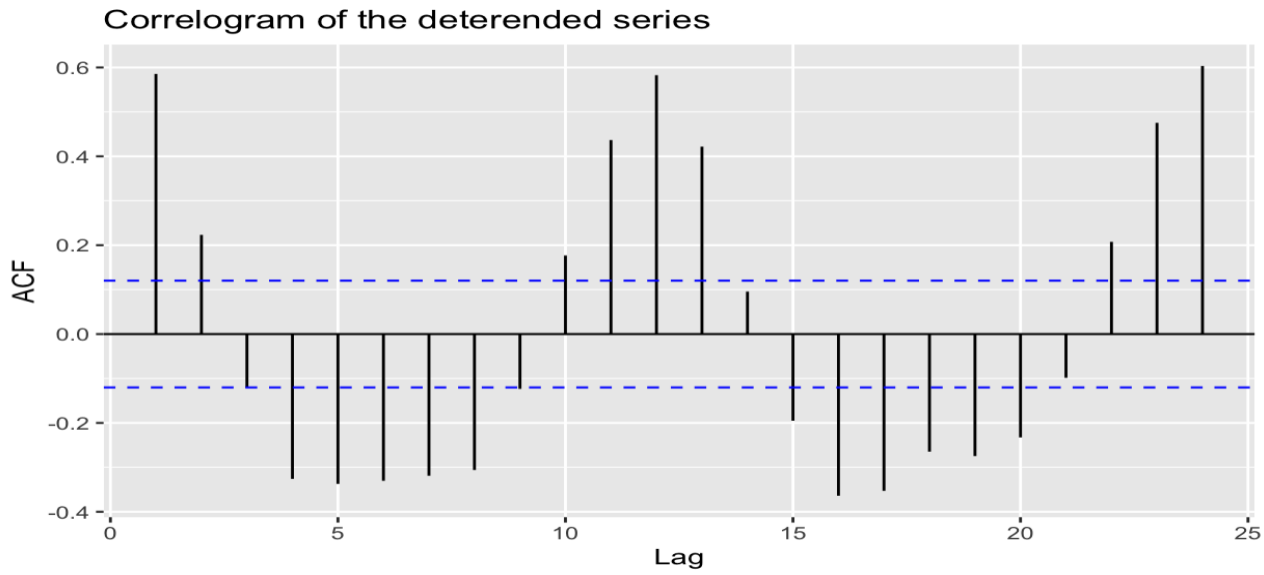

Fig: 3 ACF plot

(d) The best ARMA model for ARMA (p, q), p = 0, 1, 2 and q = 0, 1, 2, the detrended values according to the smallest BIC of this time series is**:**

$\hat{Z}_t = 1.4202\, Z_{t-1} - 0.6571\, \hat{Z}_{t-2} - 0.7905\, \epsilon_{t-1} + \epsilon_t,$

(e) This data shows a clear upward trend with some fluctuations. The blue line indicates the forecasted values from last observation to the 95%-forecasting intervals for the next 30 future time points. The forecast continues the upward trend observed in the historical data. The forecast predicts continued growth in wind power production. This is consistent with the historical trend, suggesting confidence in the ongoing expansion of wind power capacity and utilization in the USA.

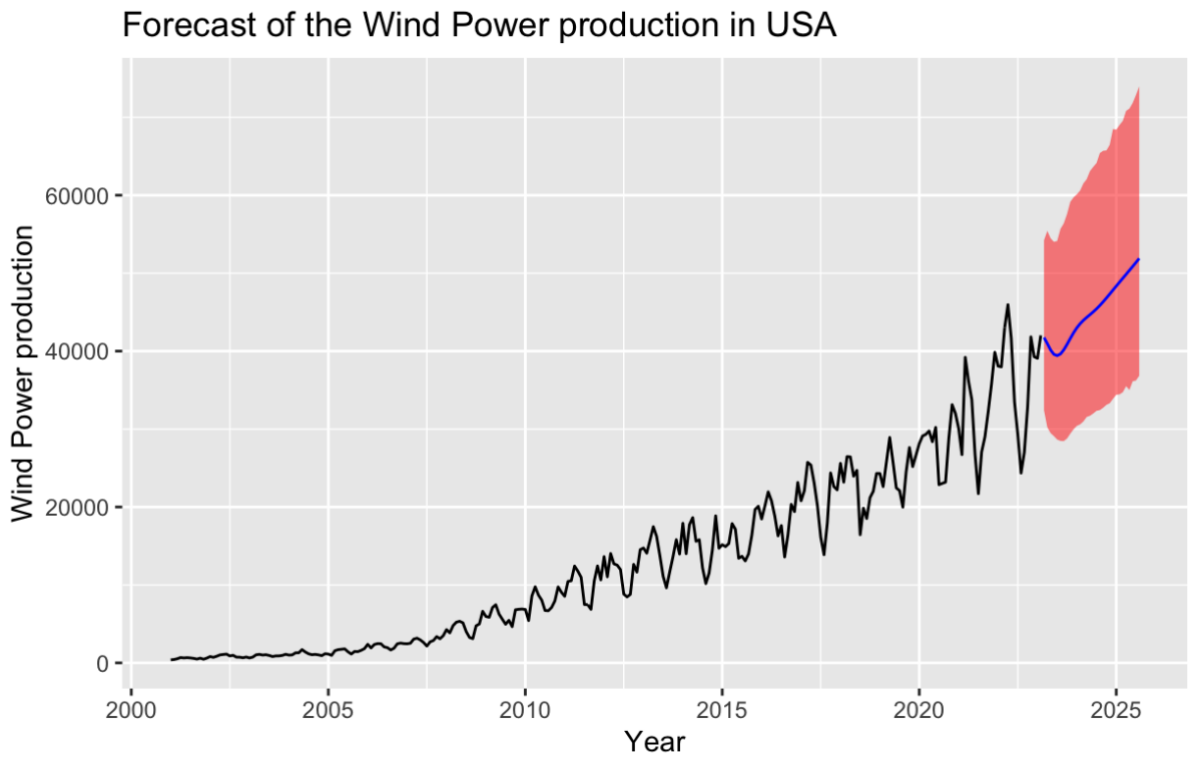

Fig: 4 The 95%-forecasting intervals for the next 30 future time points.

The red shaded area indicates increasing uncertainty over time. The further out the forecast, the wider the prediction interval. 73033.39 , This is typical in time series forecasting due to the cumulative effect of errors and unknown future events. While the forecast shows a general upward trend, the prediction intervals suggest that wind power production could experience significant variability. This might be due to factors such as policy changes, technological advancements, market conditions, or natural variability in wind resources.

Reference: https://www.kaggle.com/datasets/henriupton/wind-power-production-us-2001-2023