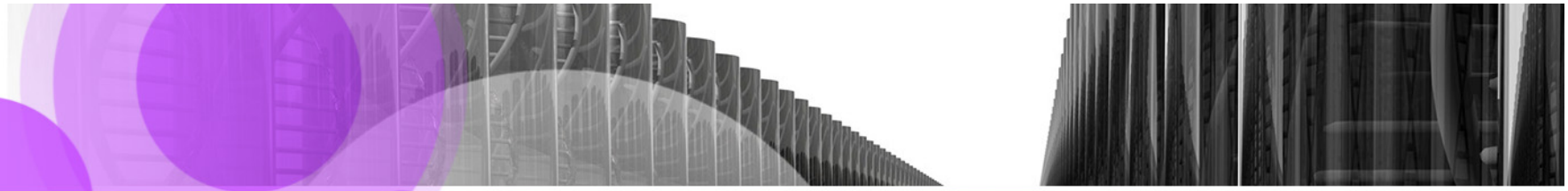

Time Series Analysis

# What is Time Series

- Time series is a sequence of data where a metric is recorded over regular time interval.

- Depending on frequency, a time series can be yearly (budget), quarterly (expenses), monthly (air traffic), weekly (sales), daily (weather), hourly (stock price), minute (in bound calls in call center), and even seconds (web traffic).
- Occurs in many areas: economics, finance, environment, and medicine.
- To describe and summarize time series data, fit models, and make forecasts.



# Why studying Time Series

- **Understanding** of the mechanism generating the series.
- **Control** of the process producing the series.
- **Prediction** of the future based on the historical data
- **Description** of the salient features of the data series.
- **Analyze** major patterns such as trends, seasonality, global trend, and irregularity.

# Time Series Components

Time series can split into:

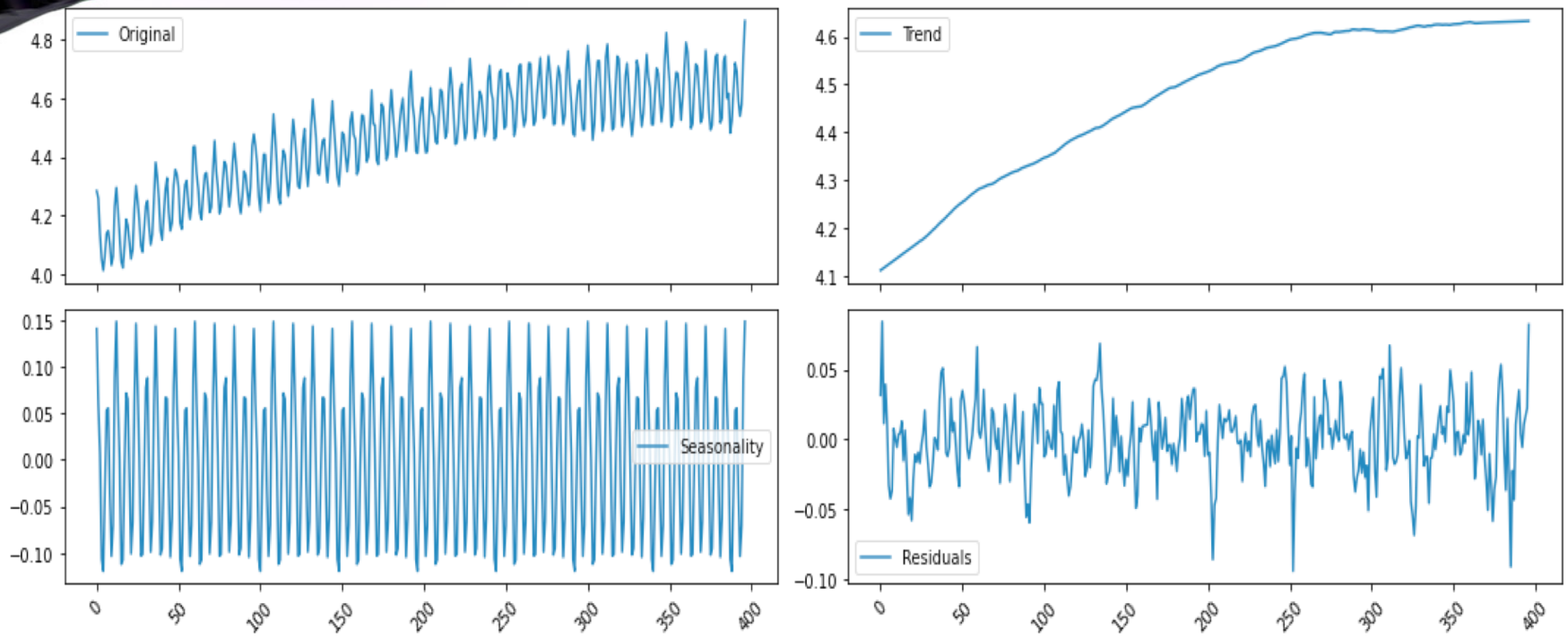
- Base Level + Trend + Seasonality + Error

**Trend** is observed when there is increasing or decreasing slope pattern observed in the time series data.

**Seasonality** is a repeated pattern observed in regular intervals due to seasonal factors.

**Irregular fluctuations**: after trend and seasonality have been removed from a time series, which may or may not be completely random.

# Decomposition of Time Series



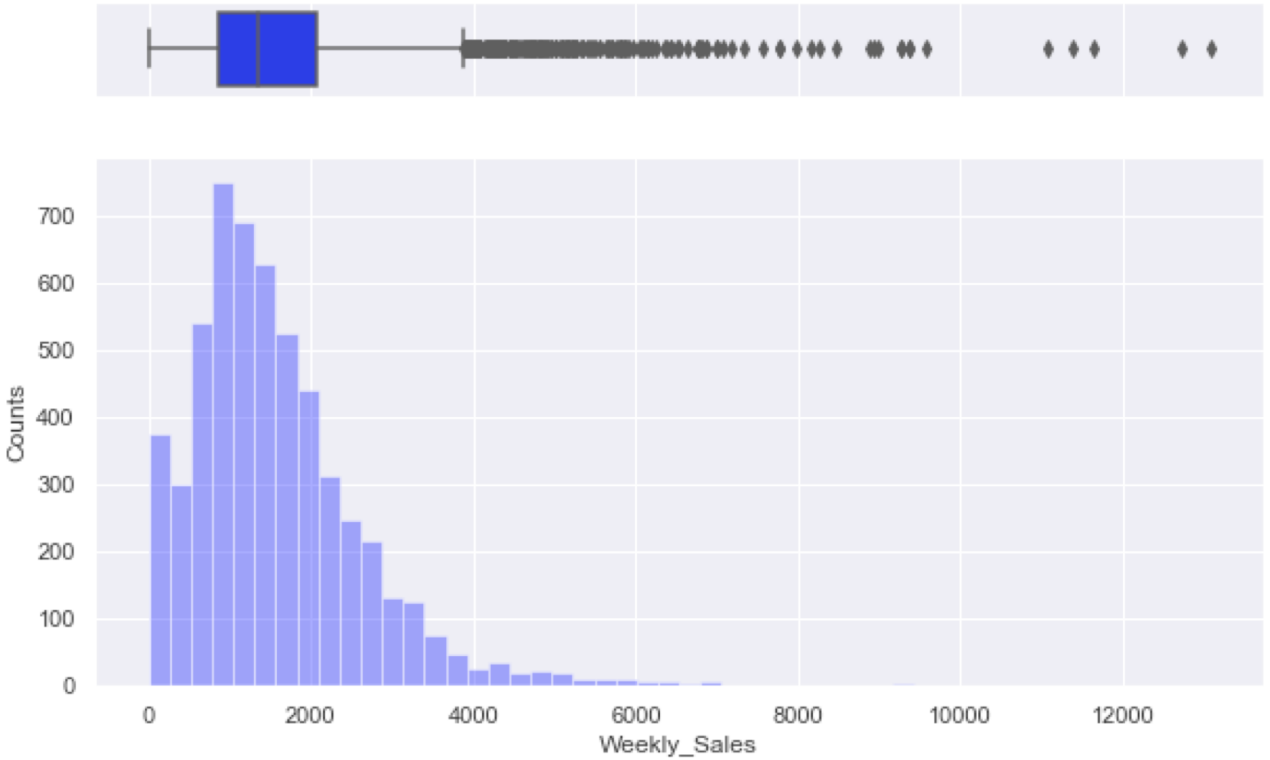
# Stationary Properties

- ✓ Stationarity is a property of time series
- ✓ A stationary series is one where the values of the series is not a function of time.
- ✓ A stationary time series without seasonal effects as well.
- ✓ The statistical properties of the series like mean, variance, and auto correlation are constant over time.
- ✓ Stationary Data: Self correlated, no global trend, no periodicity, and no seasonality.

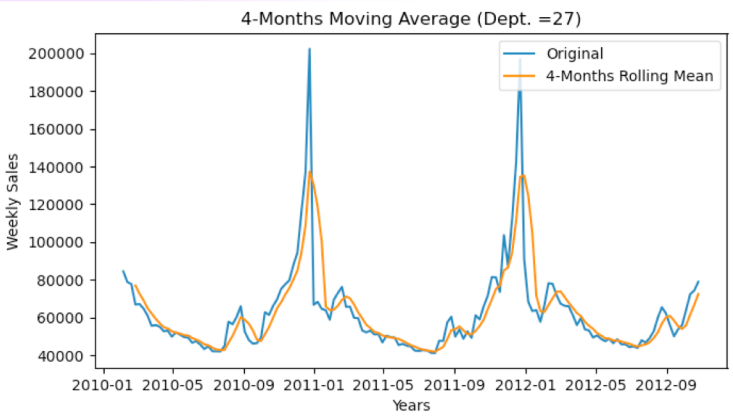
# How to make time series stationary?

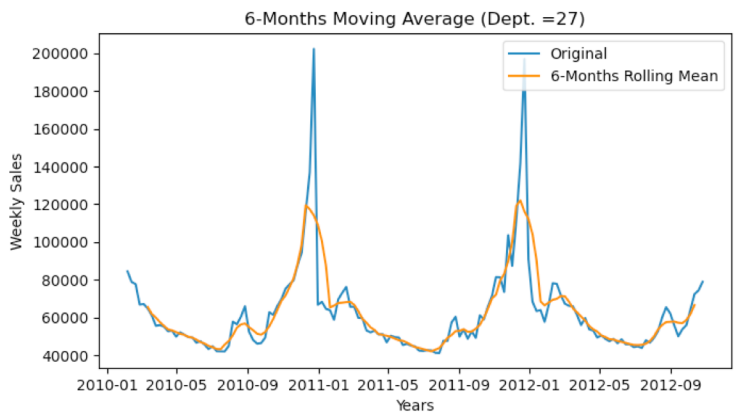
- Differencing the time series (once or more)
- Take log of the series
- Take $n^{th}$ root of the series.
- Combination of the above

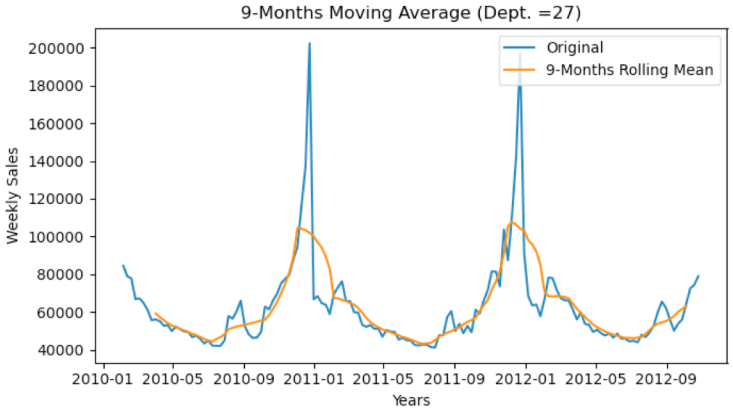
# Weekly sales variation

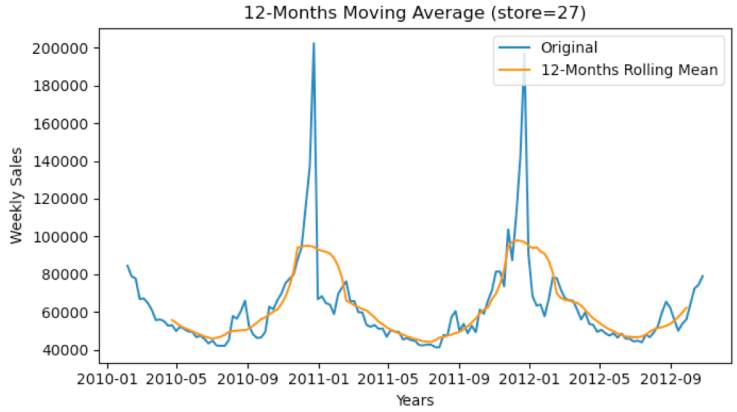


# Time series: Rolling mean



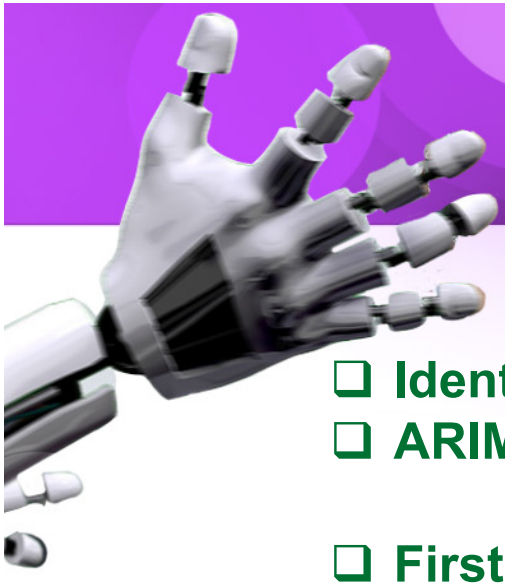



# ARIMA Model

- Auto Regressive Integrated Moving Average (ARIMA) is forecasting algorithm.
- Using past historical values to predict the future values.
- ARIMA characterized by 3 terms: p, d, q
- Where “p” is the order of Auto Regressive (AR) term.
- Where “q” is the order of Moving Average (MA) term.
- Where “d” is the differencing required to make the time series stationary.
- Auto Regressive (AR) process: series current values depend on its own previous values.
- Moving Average (MA) process: The current deviation from mean depends on previous deviations.



# Identification of orders p and q

- Identification starts with d
- ARIMA (p, d, q)

- First we need to make time series stationary

- The right order differencing is the minimum differencing required.

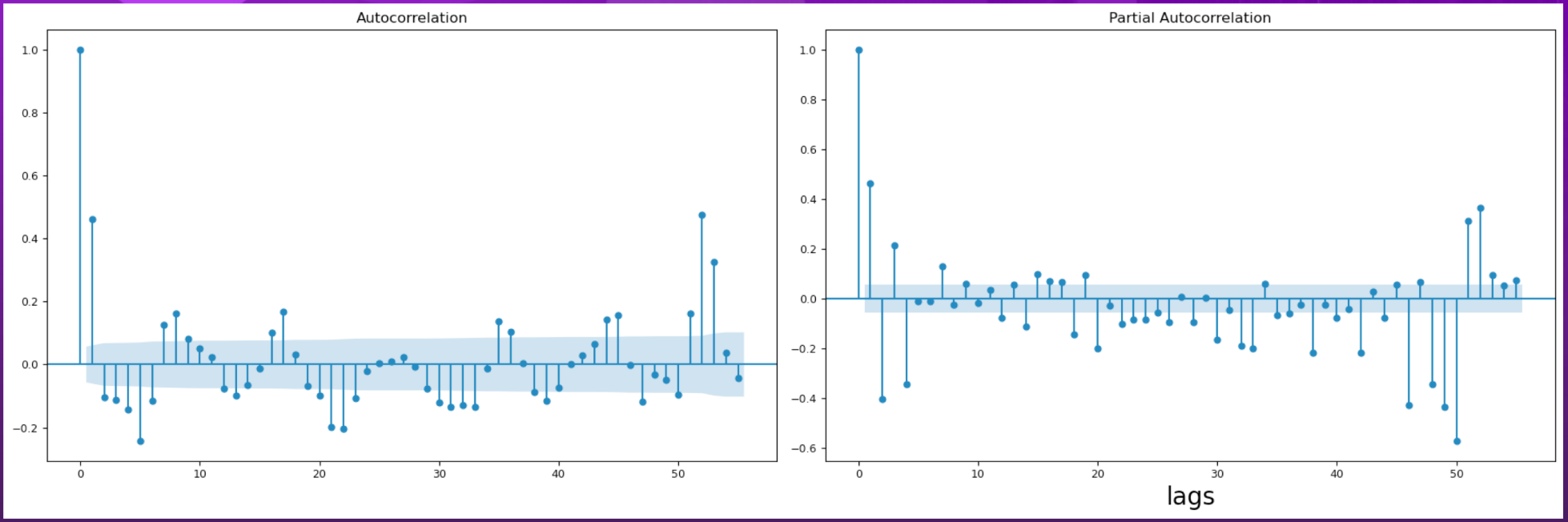
- We need to learn about Auto Correlation Function (ACF) and Partial Auto Correlation Function (PACF) to identify p, q.

- Once we are working with a stationary time series, we can examine the ACF and PACF to help identify the proper number of lagged y (AR) and $\in$ (MA) terms.

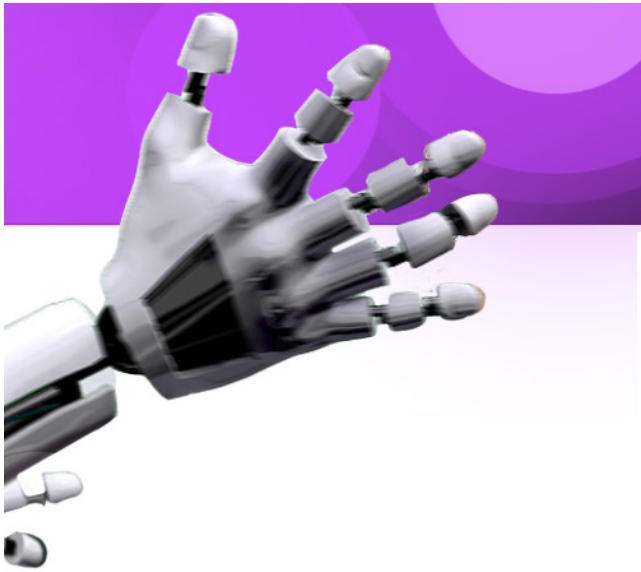
# Auto Correlation Function (ACF)

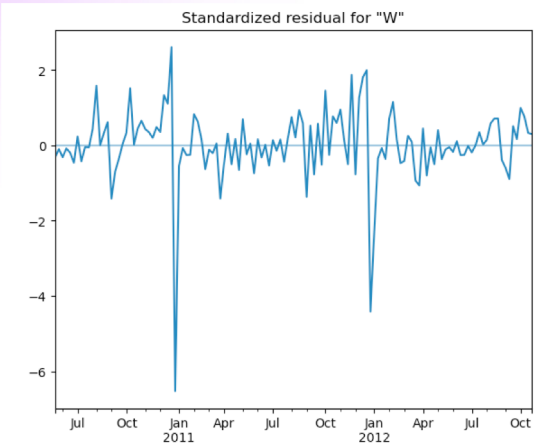
- Coefficients of correlation between a time series and lags of itself.
- It helps to determine the value of (p) or AR term in ARIMA model.
- If the correlations are positive for many number of lags (10 or more), the series needs for further differencing.
- On the other hand, if the lag1 auto correlation it self is too negative then the series is probably over differenced.
- The auto correlation function (ACF) plot reaches to zero, no further differencing the series.

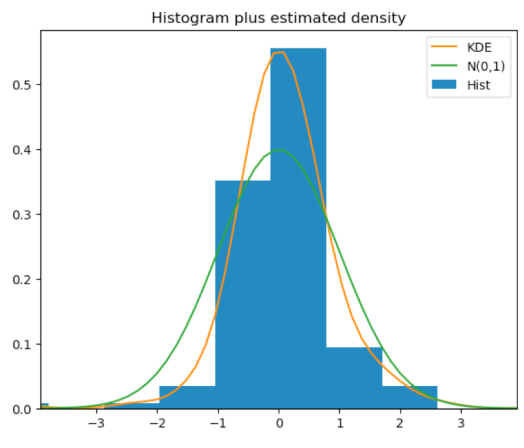
# ACF and PACF Plots

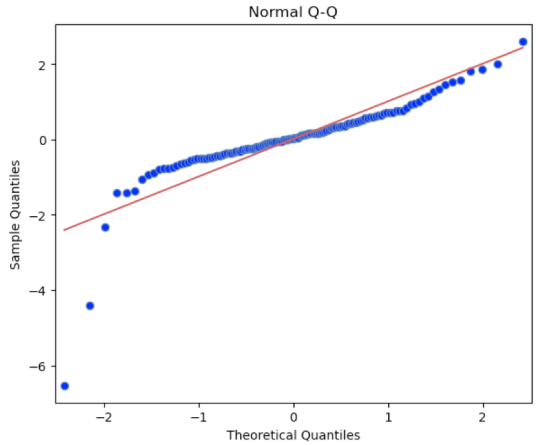


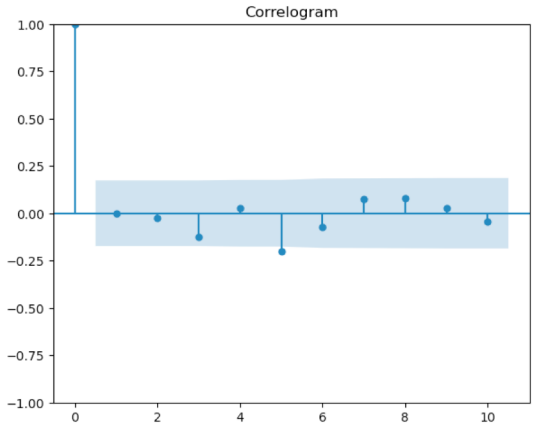
# Residual plot



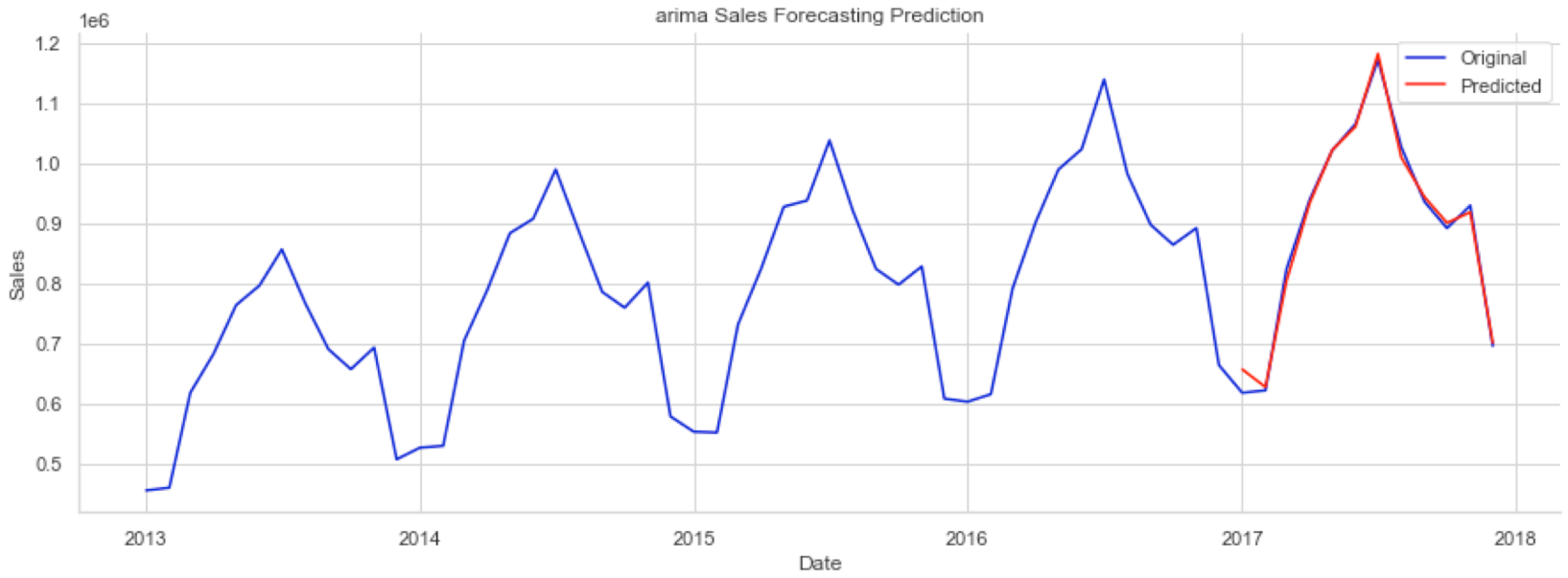


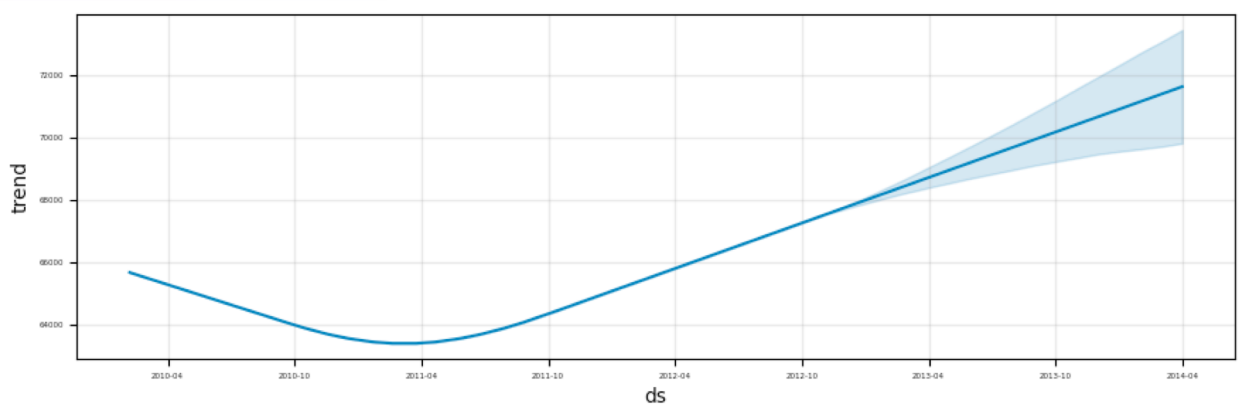



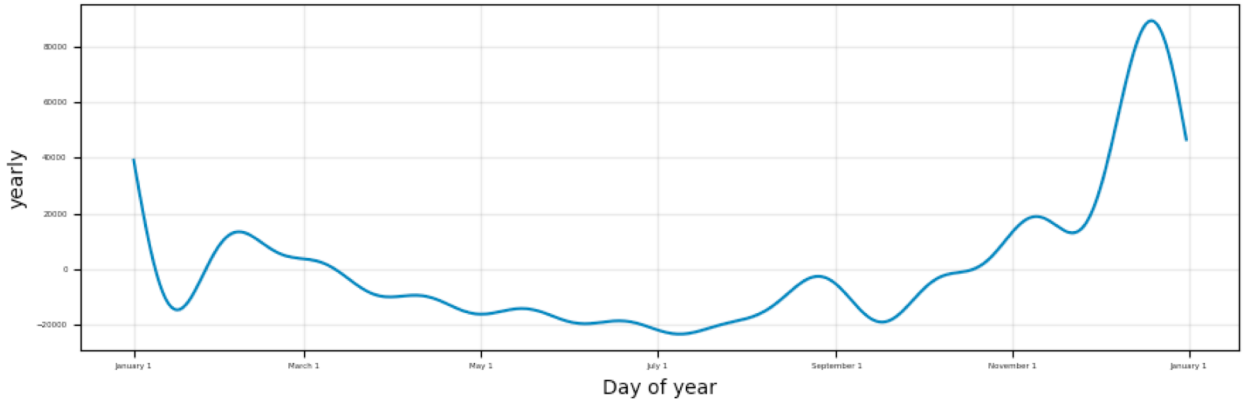



# ARIMA model predictions

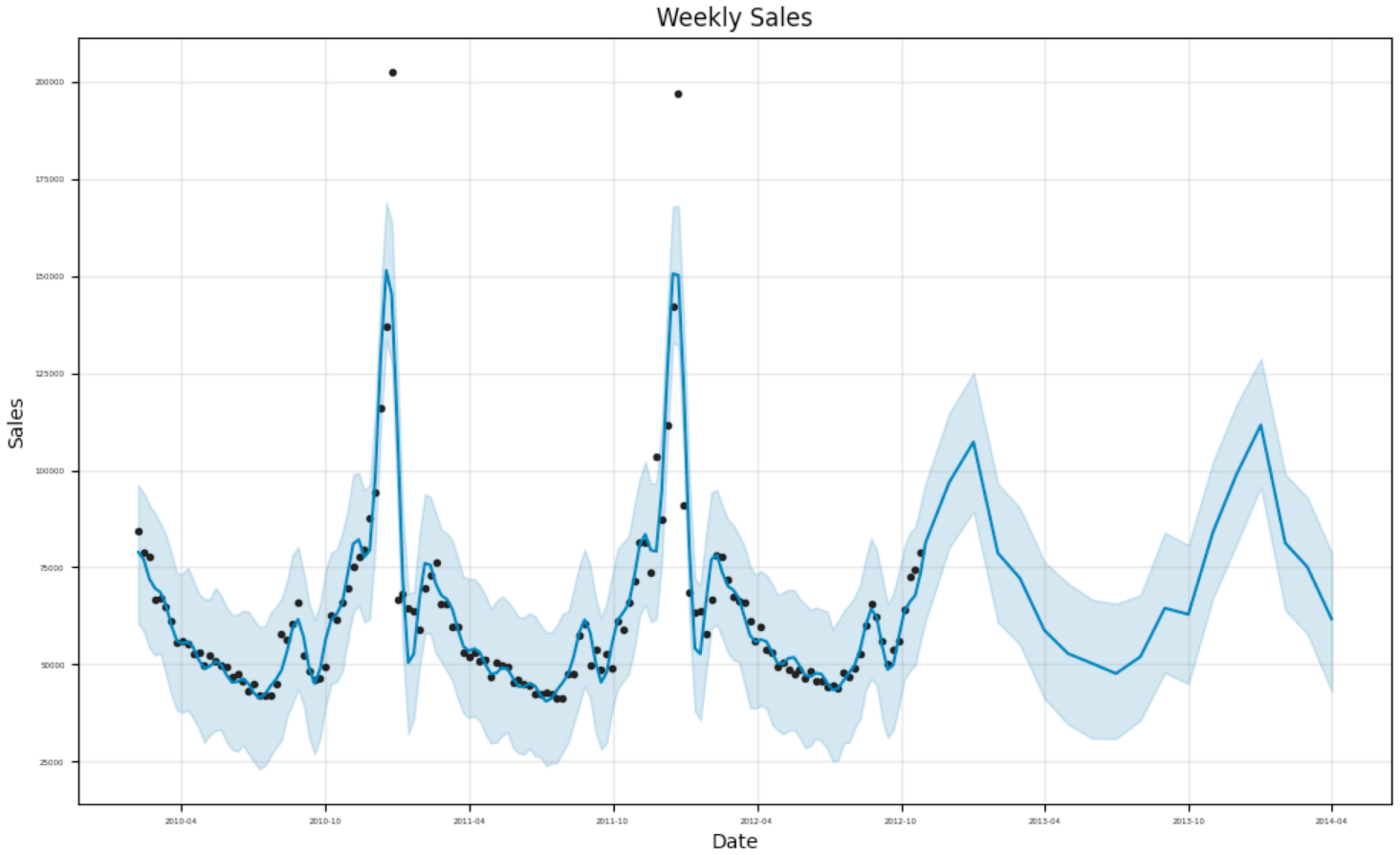


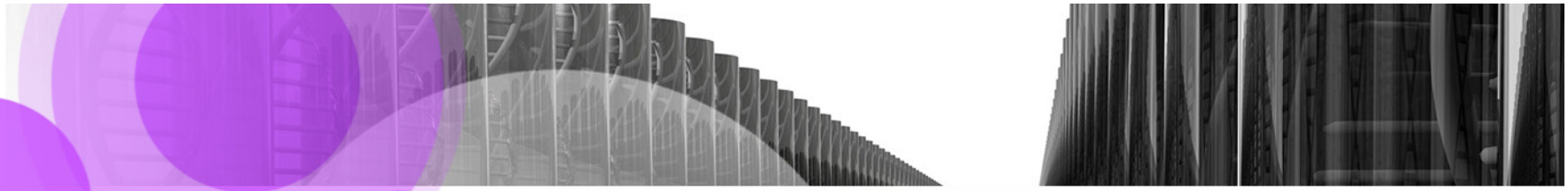
# Trend and patterns in Time Series



# Weekly sales predictions





Thank you