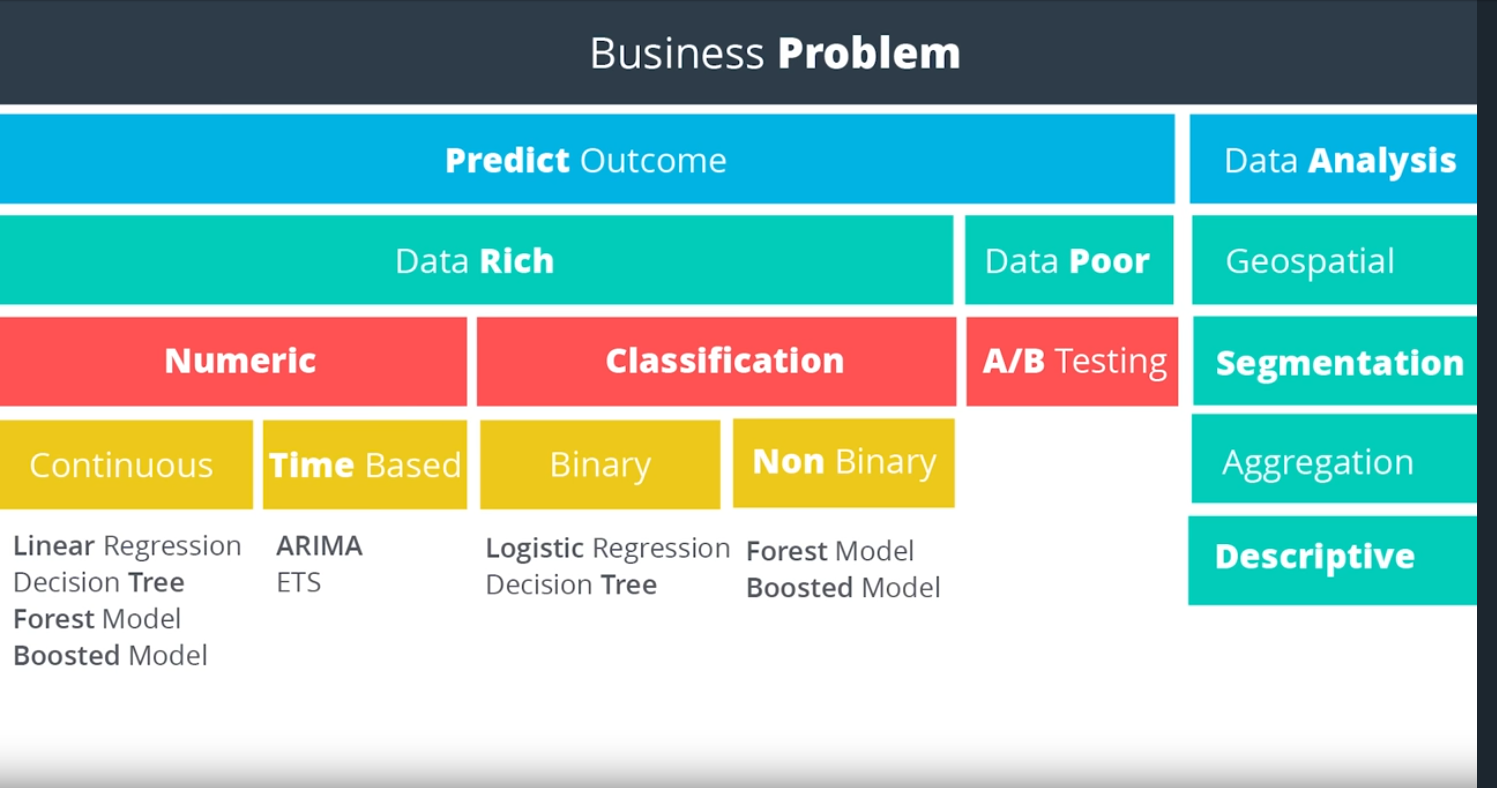
1. Time series forecasting

Time series forecasting is the use of a model to predict future values based on previously observed values.

1. Business Problem



ETS: Exponential Smoothing

ARIMA: Autoregressive Integrated Moving Average

1. Attributes of a Time Series

* It's over a continuous time interval
* There are sequential measurements across that interval
* There is equal spacing between every two consecutive measurements
* Each time unit within the time interval has at most one data point
* Order Matters: There is a dependency on time and changing the order could change the meaning of the data.

1. Simple Exponential Smoothing in Excel

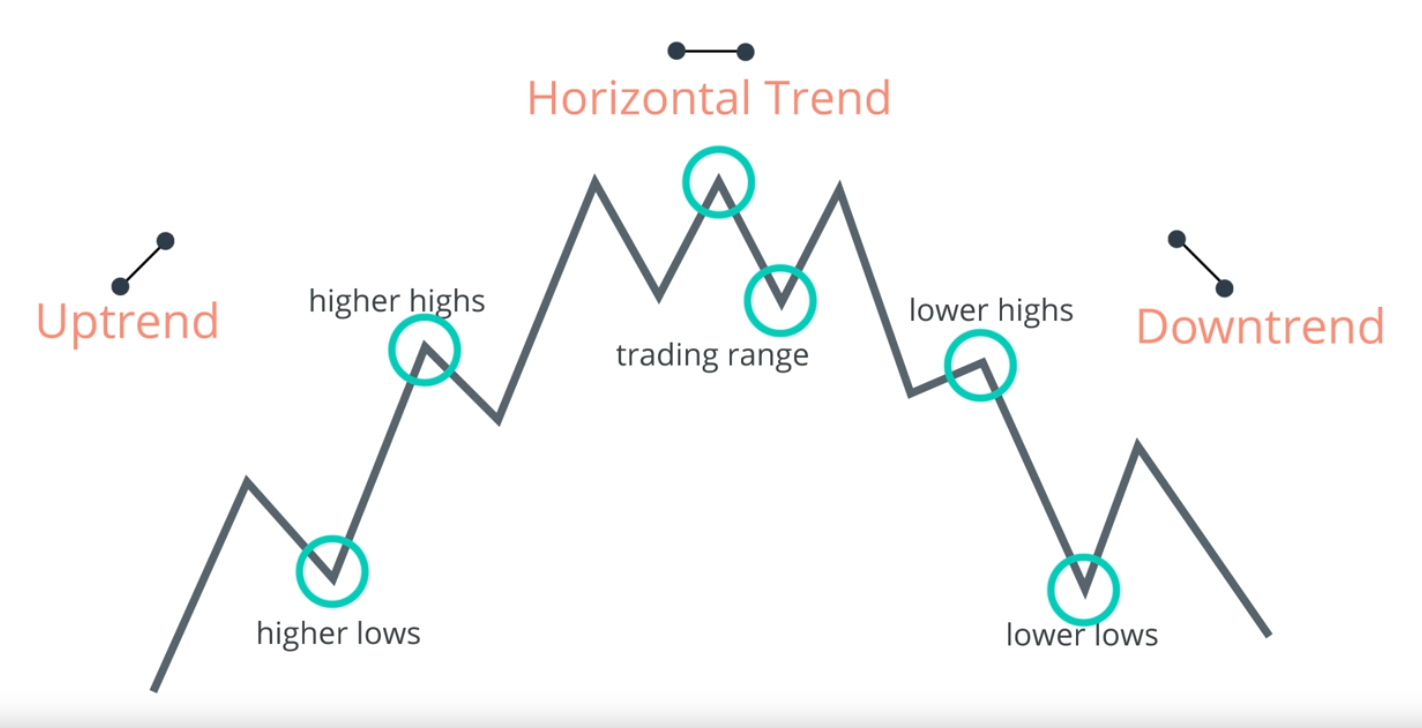
<http://www.excel-easy.com/examples/exponential-smoothing.html>

1. Time Series Components

* Trend (uptrend, downtrend, horizontal trend)
* Seasonal pattern
* Cyclical pattern

Seasonality is always of a fixed and known period. Hence, seasonal time series are sometimes called periodic time series. A **cyclic pattern** exists when data exhibit **rises and falls that are not of fixed period**

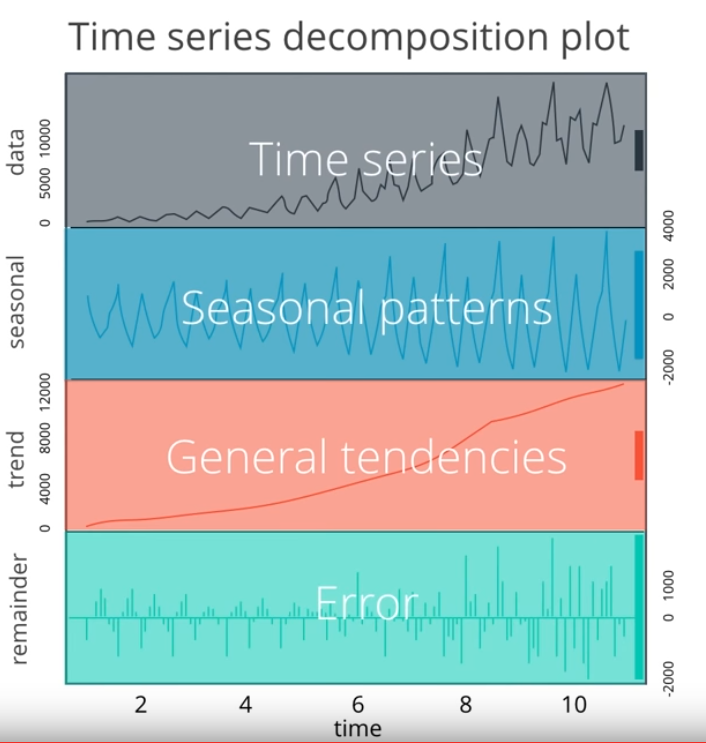
1. Trend



1. ETS (Error ,Trend, Seasonality)🡪**Additive** or **Multiplicative** terms

Exponential Smoothing -More weight on the most recent observations. The weights decreasing exponentially as the observations get older.







### Scenarios

Therefore the scenarios could be:

* No-Trend, No-Seasonal
* No-Trend, Seasonal-Constant
* No-Trend, Seasonal-Increasing
* Trend-Linear,No-Seasonal
* Trend-Linear,Seasonal-Constant
* Trend-Linear,Seasonal-Increasing
* Trend-Exponential,No-Seasonal
* Trend-Exponential,Seasonal-Constant
* Trend-Exponential,Seasonal-Increasing

As you can see there are nine possible scenarios.

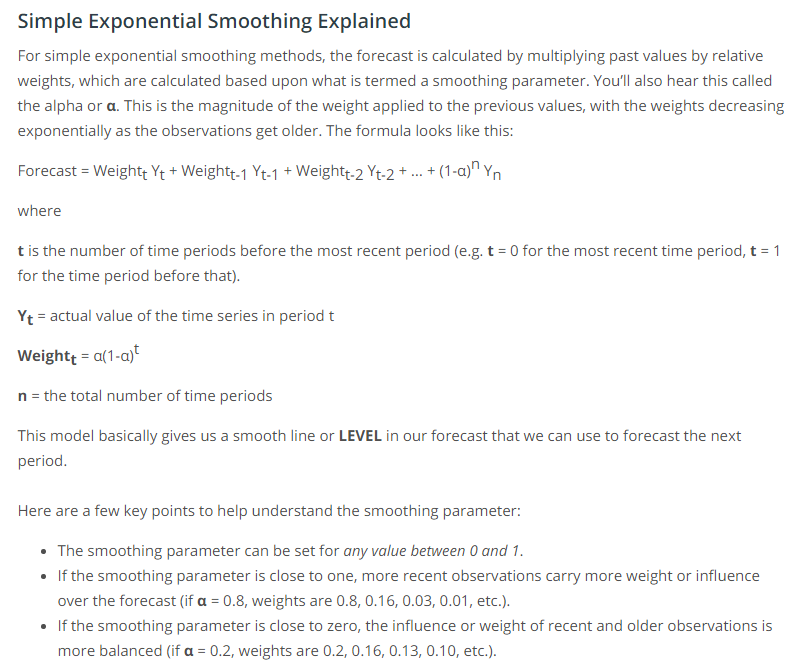
### ETS Models

We are going to explore four ETS models that can help forecast these possible time-series scenarios.

1. Simple Exponential Smoothing Method (suitable only for time series without trend and seasonality)
2. Holt's Linear Trend Method
3. Exponential Trend Method
4. Holt-Winters Seasonal Method
5. Simple Exponential Smoothing Method

The series does not have a trend line and does not have seasonality component. We should use a Simple Exponential Smoothing model.





#### Choosing the Smoothing Parameter α

Choosing the correct smoothing parameter is often an iterative process. Luckily, advanced statistical tools, like Alteryx, will select the best smoothing parameter based upon minimizing forecasting error. Otherwise, you will need to test many smoothing parameters against each other to see which model best fits the data.

The advantage of exponential smoothing methods over simple moving averages is that new data is depreciated at a constant rate, gradually declining in its impact, whereas the impact of a large or small value in a moving average, will have a constant impact. However, this also means that exponential smoothing methods are more sensitive to sudden large or small values.

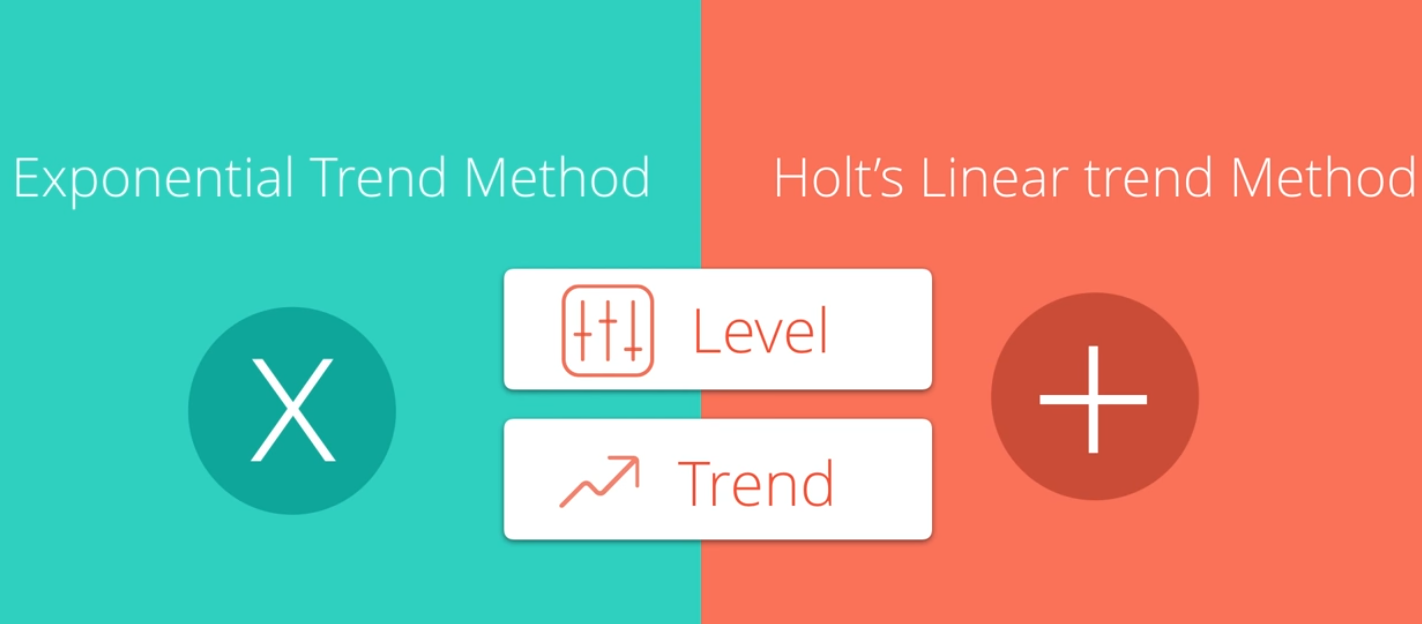
The simple exponential smoothing method does not account for any trend or seasonal components, rather, it only uses the decreasing weights to forecast future results. This makes the method suitable only for time series without trend and seasonality.

Reference: <https://www.otexts.org/fpp/7/1>

1. Holt's Linear Trend Method



1. Exponential Trend Method



1. Holt-Winters Seasonal Method



## What You've Learned So Far

Let's take a step back and understand what we've learned so far.

### Methods

There are several methods we need to pick in order to model any given time series appropriately:

1. Simple Exponential Smoothing
   * Finds the level of the time series
2. Holt's Linear Trend
   * Finds the level of the time series
   * Additive model for linear trend
3. Exponential Trend
   * Finds the level of the time series
   * Multiplicative model for exponential trend
4. Holt-Winters Seasonal
   * Finds the level of the time series
   * Additive for trend
   * Multiplicative and Additive for seasonal components

These methods help deal with different scenarios in our time series involving:

1. Linear or exponential trend
2. Constant or increasing seasonality components

For trends that are exponential, we would need to use a **multiplicative** model.

For increasing seasonality components, we would need to use a **multiplicative model** model as well.

### ETS

Therefore we can generalize all of these models using a naming system for ETS:

#### ETS (Error, Trend, Seasonality)

Error is the error line we saw in the time series decomposition part earlier in the course. If the error is increasing similar to an increasing seasonal components, we would need to consider a multiplicative design for the exponential model.

Therefore, for each component in the ETS system, we can assign None, Multiplicative, or Additive (or N, M, A) for each of the three components in our time series.

#### Examples

A time series model that has a constant error, linear trend, and increasing seasonal components means we would need to use an ETS model of:

##### ETS(N,A,M)

A time series model that has increasing error, exponential trend, and no seasonality means we would need to use an ETS model of:

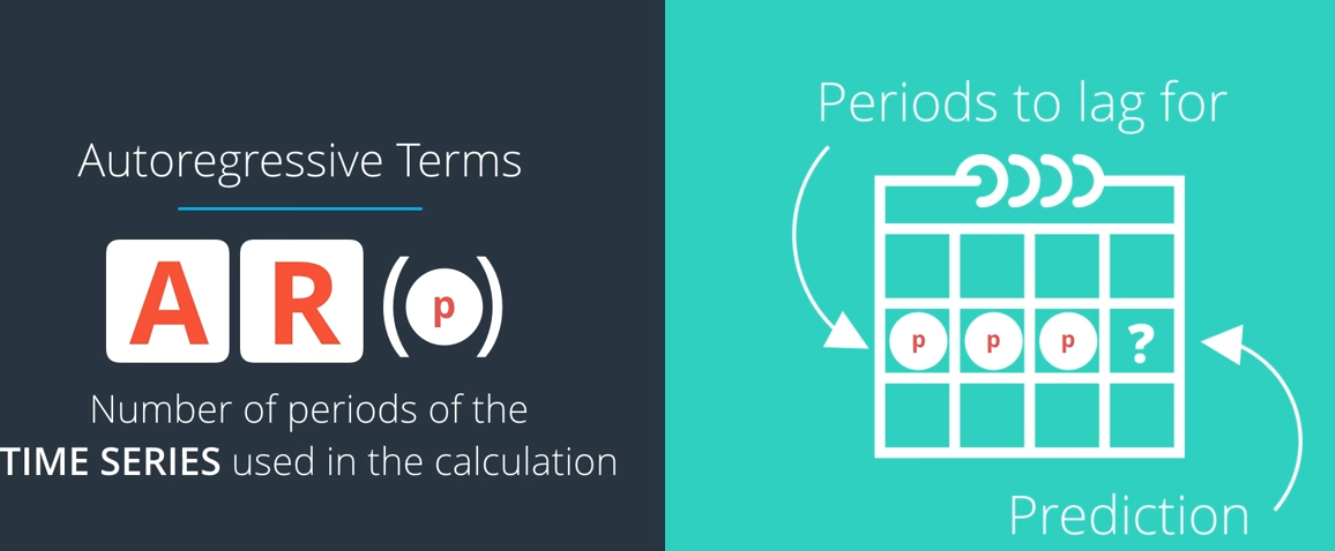
##### ETS(M,M,N)

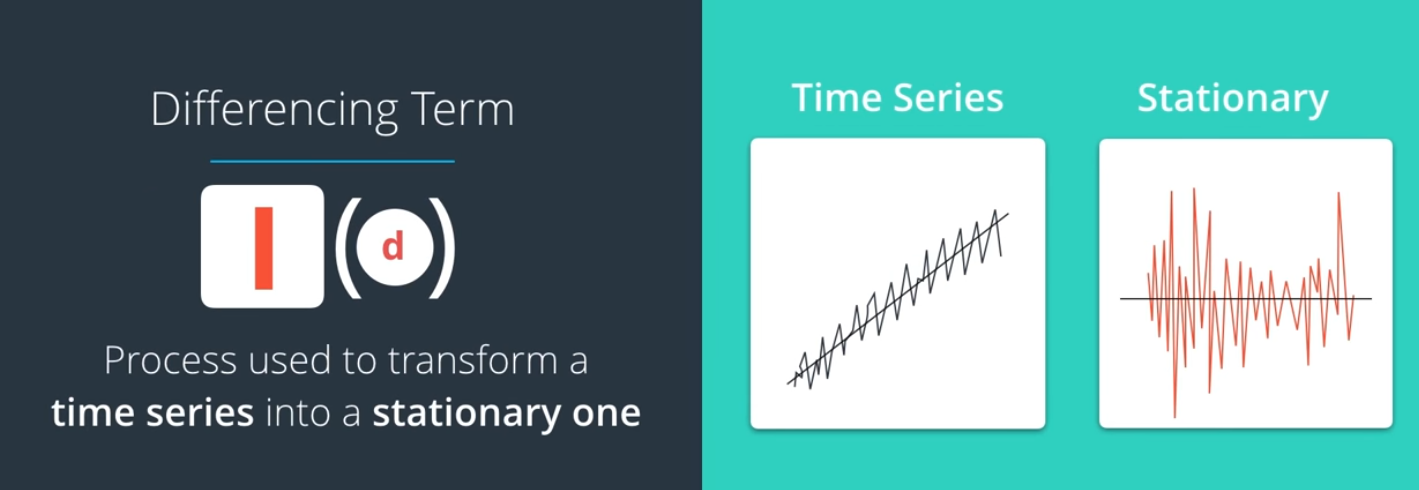
1. ARIMA (Autoregressive Integrated Moving Average)

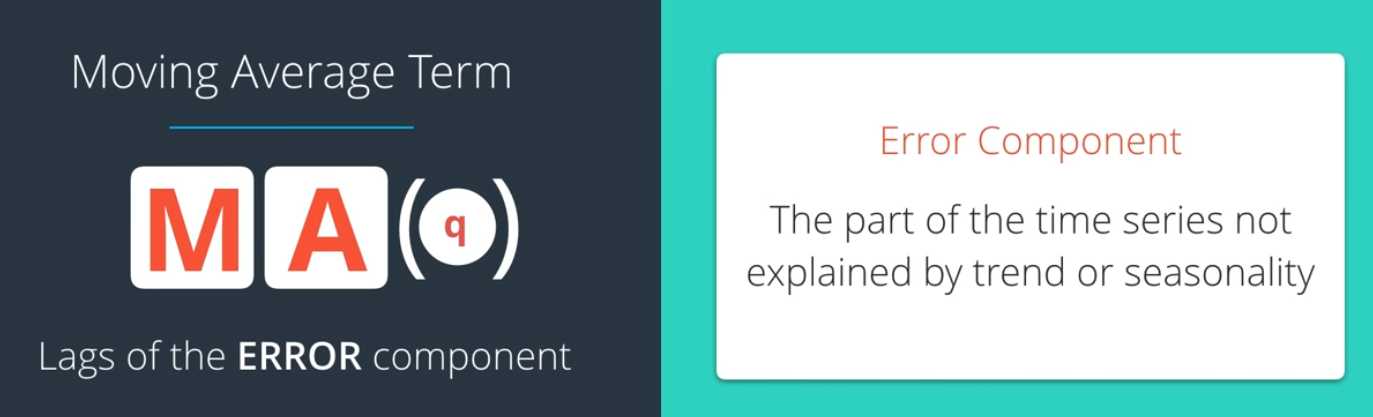
Seasonal ARIMA + Non seasonal ARIMA



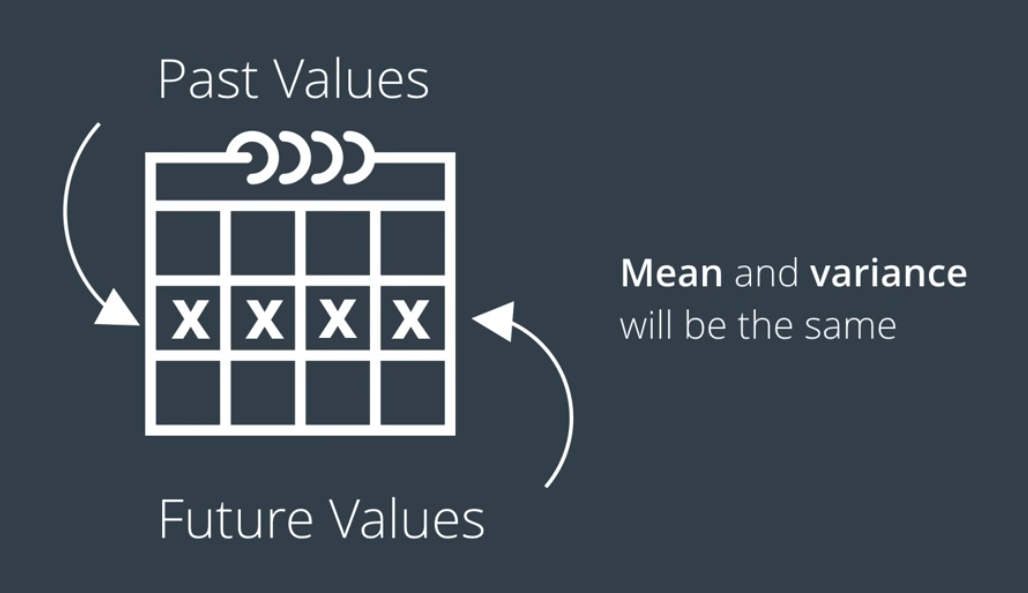
(p,d,q)







Stationary time series: Mean and the variance are constant over time.



1. Differencing

Differencing is a method of transforming a non-stationary time series to a stationary one. This is an important step in preparing data to be used in an ARIMA model. Let’s go through an example to understand differencing.

1. Autocorrelation

