A time series is **an ordered sequence of observations.**

• Ordering **is typically through equally spaced time intervals**.

• Possibly through space as well.

We will begin our time series discussions with univariate time series (only one time series…one variable, we will call it Y). • Multivariate time series will be in Fall 2.

CAREFUL: Since we are assuming equally spaced, you will need to take care of missing values !!

Time series can have a trend – an overall pattern to the data (linear, quadratic; positive, negative)

Time series can have a seasonal pattern – a systematic up and down pattern

Time Series = Signal + Noise

Explained variation( Trend/cycle, seasonality) + Unexplained Variation( error/remainder/irregular)

Forecasts extrapolate signal portion of model

Confidence intervals account for uncertainty.

• If a time series **only has trend/cycle patterns, there is no need to decompose** •

If a time series has both trend/cycle patterns AND seasonal variation, we can decompose series into these individual parts:

• Trend/Cycle patterns

• Seasonal variation (In order to decompose a time series, you must specify a seasonal component)

• Error

The whole time series can now be thought of like the equations below.

• Additive: • Multiplicative: 𝑌𝑡 = 𝑇𝑡 + 𝑆𝑡 + 𝑅𝑡 𝑌𝑡 = 𝑇𝑡 × 𝑆𝑡 × 𝑅�

log(𝑌𝑡) = log(𝑇𝑡) + log(𝑆𝑡) + log(𝑅𝑡)

– Additive - magnitude of variation around trend / cycle remains constant.

-Multiplicative – magnitude of the variation around trend / cycle proportionally changes.

One advantage of time series decomposition is that we are able to create seasonally adjusted data (i.e. remove the “effect of Seasonality**”) This allows analysts to understand the trend of the series The seasonal length of the time series is the length of one season (how long til the series repeats the “**pattern”)

𝑌𝑡 − 𝑆𝑡 = (𝑇𝑡 + 𝑅𝑡)

The seasonal length of the time series is the length of one season (how long til the series repeats the “pattern”)

There are many different ways to calculate the trend/cycle and seasonal effects inside time series data.

• Here are 3 common techniques:

1. Classical Decomposition

a. Default in SAS (Can be done in R)

b. Trend – Uses Moving / Rolling Average Smoothing

c. Seasonal – Average De-trended Values Across Seasons

---------------------------------------

X-13 ARIMA Decomposition

------------------------------------------------

STL (Seasonal and Trend using LOESS estimation) Decomposition

a. Default of stl Function in R (Not available in SAS)

b. Uses LOcal regrESSion Techniques to Estimate Trend and Seasonality

c. Allows Changing Effects for Trend and Season

d. Adapted to Handle Outliers

Decomposition will NOT tell you if you have seasonal data (nor the length of seasonality)

• Not a really good test, but…

Measures provided by Hyndman and Athanasopoulos

• Values of F close to 0 indicate little strength and values close to 1 indicate high strength

-Ordering is typically equally spaced time intervals.

-Time series 1 - we will focus on univariate.

-Since we are assuming equally spaced we need to takecare of missing values.

-Time series can have a trend – an overall pattern to the data (linear, quadratic; positive, negative)

-Time series can have a seasonal pattern – a systematic up and down pattern

-Forecasting(process):

----------Propose model + fitmodel (forecasts) + Diagnose model + Repeat + (Data cleaning) + ………………..

 Signal & Noise

Time series = Signal(explained variation: trend/cycle seasonality) + noise(unexplained variation: error)

 ARIMA is more advanced type of modeling. Captures signal based on dependency structure.

Forecasts extrapolate signal portion of the model.

Confidence intervals account for uncertainty.

Time Series Decomposition:

 If a time series only has trend/cycle patterns, there is no need to decompose

• If a time series has both trend/cycle patterns AND seasonal variation, we can decompose series into these individual parts:

• Trend/Cycle patterns

• Seasonal variation (In order to decompose a time series, you must specify a seasonal component)

• Error

 Time series = Signal(trend/cycle seasonality) + noise(error/remainder/irregular)

 𝑌𝑡 = 𝑇𝑡 + 𝑆𝑡 + 𝑅t

𝑌𝑡 = 𝑇𝑡 × 𝑆𝑡 × 𝑅t

 log(𝑌𝑡) = log(𝑇𝑡) + log(𝑆𝑡) + log(𝑅𝑡)

 Additive – magnitude of variation around trend / cycle remains constant.

Multiplicative – magnitude of the variation around trend / cycle proportionally changes.

 advantage of time series decomposition

we are able to create seasonally adjusted data (i.e. remove the “effect of Seasonality”) .

analysts to understand the trend of the series.

 -seasonal length of the time series is the length of one season (how long til the series repeats the “pattern”)

 𝑌𝑡 − 𝑆𝑡 = (𝑇𝑡 + 𝑅𝑡)

 Stl - does additive ( to get multiplicative we can do log)

 We can plot individual subseries plots

Overlay trend

Overlay seasonally adjusted

------------------------------------

 There are many different ways to calculate the trend/cycle and seasonal effects inside time series data.

 • Here are 3 common techniques:

1. Classical Decomposition ( pro- we can do multiplicative, cons- seasonal is exactly same every seasonal window)

a. Default in SAS (Can be done in R)

b. Trend – Uses Moving / Rolling Average Smoothing

c. Seasonal – Average De-trended Values Across Seasons

 2.X-13 ARIMA Decomposition (self study) ( complex, forecast, handle outliers, govt uses)

a. Trend – Uses Moving / Rolling Average Smoothing

b. Seasonal – Uses Moving / Rolling Average Smoothing

c. Iteratively Repeats Above Methods and ARIMA Modeling

d. Can handle outliers

 3.STL (Seasonal and Trend using LOESS estimation) Decomposition ( can only do additive)

a. Default of stl Function in R (Not available in SAS)

b. Uses LOcal regrESSion Techniques to Estimate Trend and Seasonality

c. Allows Changing Effects for Trend and Season

d. Adapted to Handle Outliers

Eyeball or expert opinion - to decide to have or not seasonality.

 Caution of decomposition:

Decomposition will NOT tell you if you have seasonal data (nor the length of seasonality)

• Not a really good test, but…

 Measures for “strength” of trend and/or seasonality

Measures provided by Hyndman and Athanasopoulos

• Values of F close to 0 indicate little strength and values close to 1 indicate high strength