Sane's STATS Academy of Statistics

Time Series Components

Introduction

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What is a Time Series?

- A **time series** is a sequence of numerical **data** points in successive order, usually occurring in uniform intervals.
- **Time series *analysis*** comprises methods for analyzing time series data in order to extract meaningful statistics and other characteristics of the data.
- **Time series *forecasting*** is the use of a model to predict future values based on previously observed values.

Courtesy: Wikipedia

Components of Time Series

- **Trend**: Indicates a long term increase or decrease in the data. It may be linear or non-linear.
- **Seasonal**: Seasonality is a pattern observed with regular intervals of time. e.g. Sale of woolen clothes increases in winter and is relatively low in other seasons.
- **Cyclic**: Data exhibits rise and fall not in regular time intervals. e.g. Recession and Boom
- **Random**: This is an error component. Also called irregular component.

Classical Decomposition

- There are two types of classical decompositions:
  - Additive
  - Multiplicative
- We assume here that the seasonal component is constant from year to year.
- Suppose that we have *m* seasonal periods. Then there are m seasonal values which are called *seasonal indices*.

Notations

- y_t: Value in time series at time t
- $\widehat{T}_t$: Trend-cycle component (Moving Average) calculated for time t
- $\widehat{S}_t$: Seasonal Index for time t

Additive Decomposition

1. If m is even number, then centered MA is calculated otherwise non-centered MA is calculated.
2. Calculate the de-trended series, y_t-$\widehat{T_t}$
3. For estimating the seasonal component for each month, a simple average is calculated for detrended values for that particular month. It is denoted by $\widehat{S_t}$.
4. The random component is calculated by subtracting seasonal and trend-cycle components. $\widehat{E_t} = \hat{y}_t$-$\widehat{T_t}$-$\widehat{S_t}$

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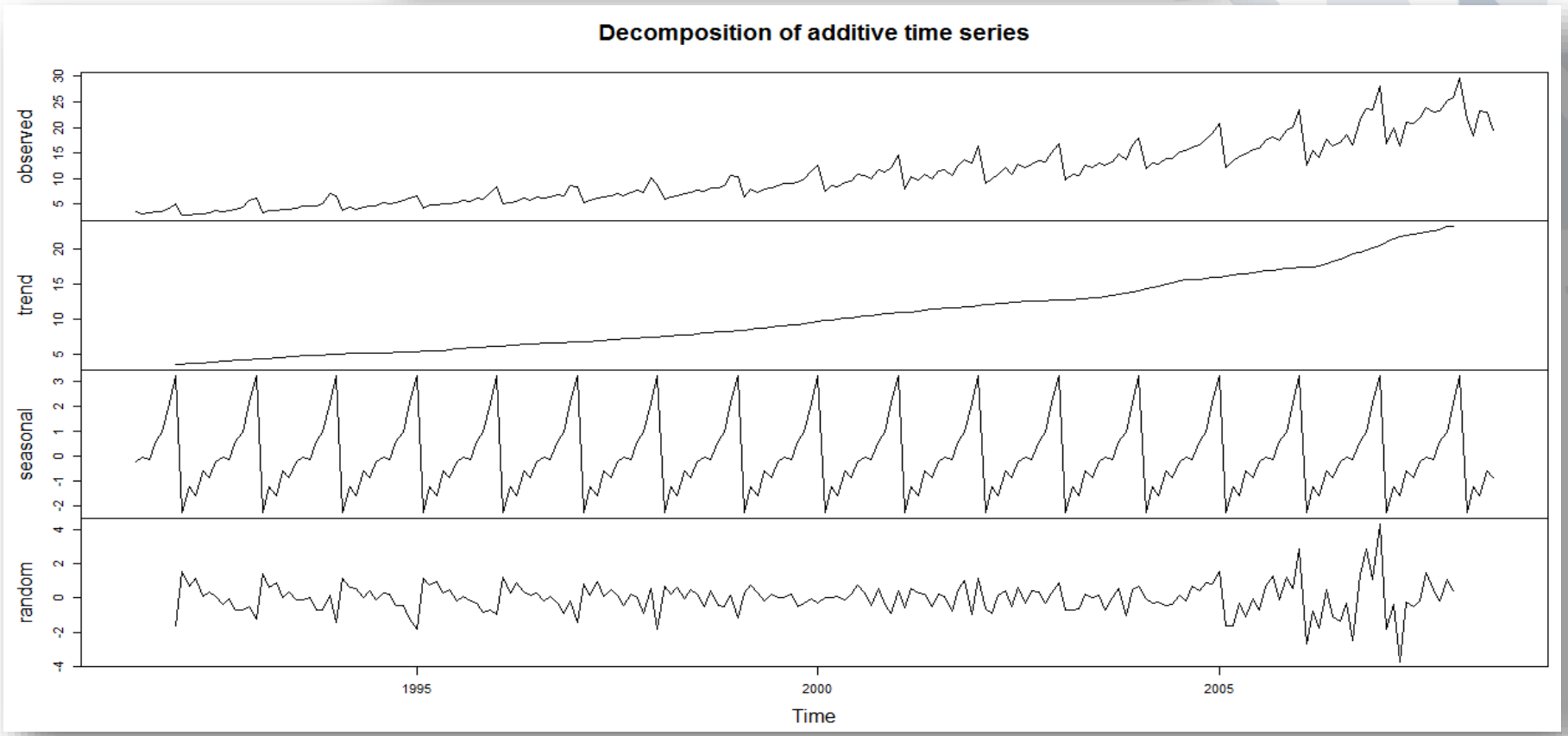
Example

```
##### Additive Decomposition ####
fit <- decompose(a10, type="additive")
plot(fit)
```



Multiplicative Decomposition

1. If m is even number, then centered MA is calculated otherwise non-centered MA is calculated.
2. Calculate the de-trended series, $y_t/\widehat{T_t}$
3. For estimating the seasonal component for each month, a simple average is calculated for de-trended values for that particular month. It is denoted by $\widehat{S_t}$.
4. The random component is calculated by subtracting seasonal and trend-cycle components. $\widehat{E_t} = \hat{y}_t/(\widehat{T_t}\widehat{S_t})$

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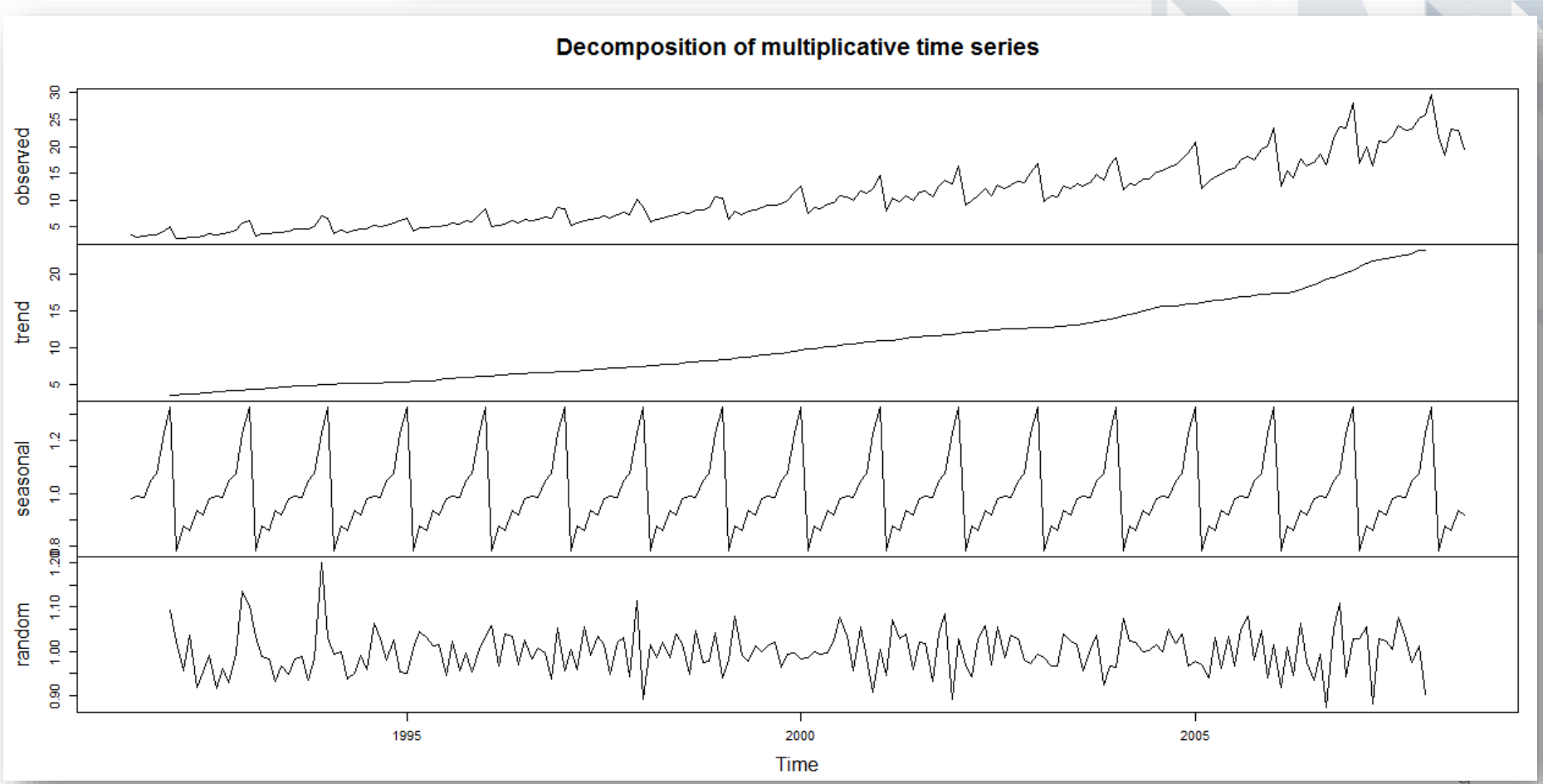
Example

```
##### Multiplicative Decomposition ####
fit <- decompose(a10, type="multiplicative")
plot(fit)
```



Object **ts**

- Data in the form of data frame / vector / matrix usually is not acceptable for time series functions in R
- For making the data compatible to be accepted for time series functions it need to be converted into objects like **ts** or **xts**
- We will be covering the object of class **ts**

Creating **ts** object

- Function *ts()* is used to create an object of class **ts**

Syntax : ts(data, start, end ,frequency,…)

Where

data : a vector or matrix or data frame of the observed time-series values

start : the time of the first observation

end : the time of the last observation

frequency : the number of observations per unit of time

- Only the data with even time periods can be specified in option frequency. Daily / weekly data won't be supported. It will require object **zoo**.

Example of quarterly **ts**

	Time	Ind_Consump
1	1999Q1	1251922
2	1999Q2	1293890
3	1999Q3	1318941
4	1999Q4	1380608
5	2000Q1	1361398
6	2000Q2	1397537
7	2000Q3	1412339

```
> consump_ts <- ts(consump$Ind_Consump,start=c(1999,1), frequency = 4)
> consump_ts
        Qtr1    Qtr2    Qtr3    Qtr4
1999 1251922 1293890 1318941 1380608
2000 1361398 1397537 1412339 1465181
2001 1418260 1463077 1469651 1514296
2002 1475115 1497850 1510240 1560610
2003 1495050 1518168 1538259 1580428
2004 1550330 1600974 1615831 1661971
2005 1618254 1671849 1692159 1745461
2006 1698194 1747479 1775513 1835561
2007 1790459 1839364 1862965 1913717
2008 1843048 1874908 1888253 1865200
2009 1735277 1771905 1790790 1824360
2010 1780739 1834178 1867221 1907550
2011 1859063 1887580 1904030 1933065
2012 1895564 1929374 1957807 1985057
2013 1903871 1935724 1960063 1997363
2014 1941423 1987915 2026006 2057259
2015 2023339 2080499 2118917 2143254
2016 2053311
```

Example of monthly **ts**

	Date	Value
1	30-04-1968	39.100
2	31-05-1968	42.000
3	30-06-1968	40.950
4	31-07-1968	38.900
5	31-08-1968	39.850
6	30-09-1968	39.700
7	31-10-1968	39.200
8	30-11-1968	39.850

```
> BUNDESBANK_ts <- ts(BUNDESBANK$Value,start=c(1968,4), frequency = 12)
> BUNDESBANK_ts
          Jan      Feb      Mar      Apr      May      Jun      Jul
1968                                39.100   42.000   40.950   38.900
1969   42.550   42.775   43.100   43.600   43.150   41.225   41.450
1970   34.980   35.000   35.300   35.850   35.500   35.510   35.290
1971   38.000   38.790   38.800   39.600   40.800   40.200   42.475
1972   46.950   48.400   48.375   49.500   59.300   64.100   68.900
1973   66.000   85.300   90.250   90.700  114.500  123.500  115.200
1974  133.250  169.500  173.000  168.500  156.500  146.750  154.000
1975  176.250  181.750  177.750  167.400  167.750  166.000  166.400
1976  128.000  132.300  129.500  128.150  125.250  123.800  112.400
```