Timeseries

Clear all variables in workspace and install packages

```
rm(list=ls())

#install.packages('quantmod')
#install.packages('TTR')

#suppress `getSymbols` message
options("getSymbols.warning4.0"=FALSE)
```

Load the forecasting package

```
## Registered S3 method overwritten by 'quantmod':
##   method            from
##   as.zoo.data.frame zoo
```

```
## -- Attaching packages --------------------------------------------- fpp2 2.4 --
```

```
## v ggplot2   3.3.5      v fma        2.4
## v forecast  8.15       v expsmooth 2.3
```

```
##
```

```
## Loading required package: xts
```

```
## Loading required package: zoo
```

```
##
## Attaching package: 'zoo'
```

```
## The following objects are masked from 'package:base':
##
##     as.Date, as.Date.numeric
```

Load Dataset

Data is collected from Yahoo Finance using the Quantitative Financial Modeling Framework (Quantmod). Data obtained in eXtensible-Time-Series format is being used for data exploration.

```
#Download data from yahoo finance
df_tsm <- getSymbols('TSM',src='yahoo',auto.assign=FALSE,from="2011-01-01")

#Check the contents of the data
class(df_tsm)
```

```
## [1] "xts" "zoo"
```

```
#List the number of rows in the data
nrow(df_tsm)
```

```
## [1] 2774
```

```
#Print the last 6 rows of the data
tail(df_tsm)
```

```
##            TSM.Open TSM.High TSM.Low TSM.Close TSM.Volume TSM.Adjusted
## 2021-12-31   121.35   121.75  120.22    120.31    3887600       120.31
## 2022-01-03   124.13   129.59  124.00    128.80   18592000       128.80
## 2022-01-04   130.87   135.50  130.30    133.40   25554900       133.40
## 2022-01-05   130.71   130.88  126.88    127.06   17891200       127.06
## 2022-01-06   127.00   129.00  124.81    128.47   16249000       128.47
## 2022-01-07   126.55   127.14  123.31    123.50   21239000       123.50
```
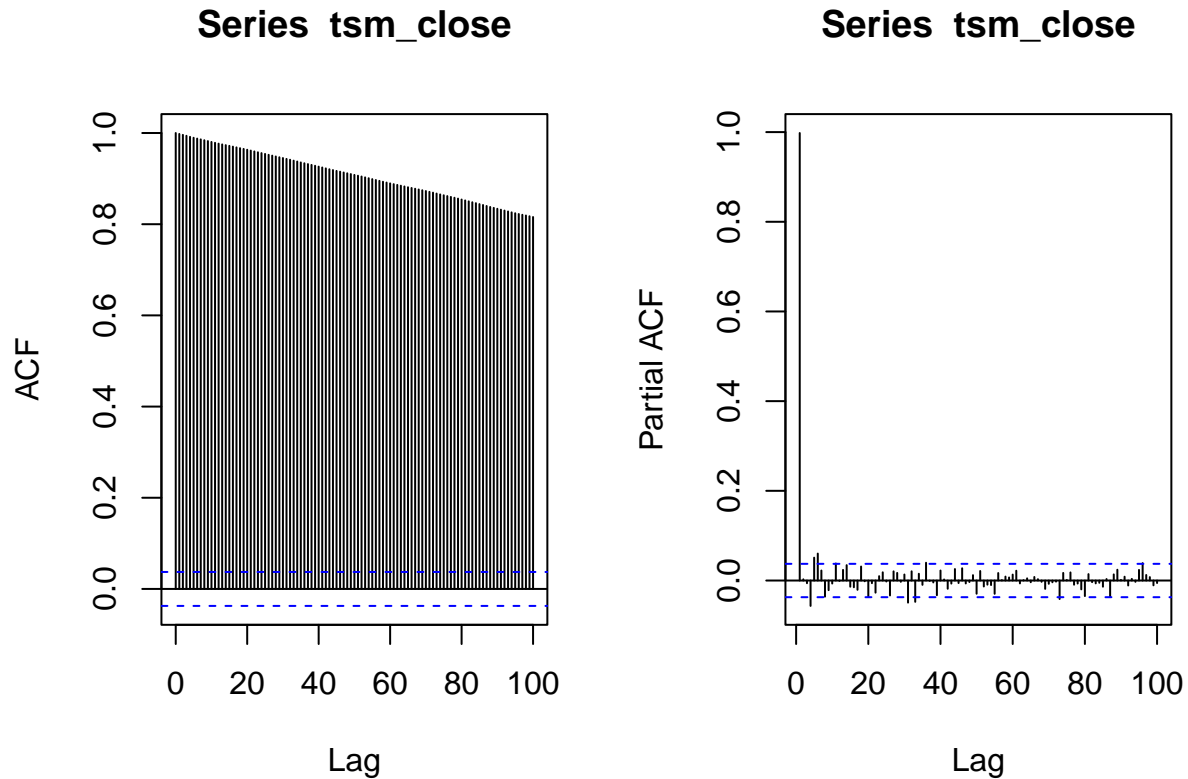
Time plot of the data

```
tsm_title = "Taiwan Semiconductor Manufacturing Company Limited Stock Price (TSM) (2011-2022)"
tsm_close = df_tsm$TSM.Adjusted
#plot(df_tsm$TSM.Close,main = tsm_title)
chart_Series(tsm_close,name=tsm_title)
```
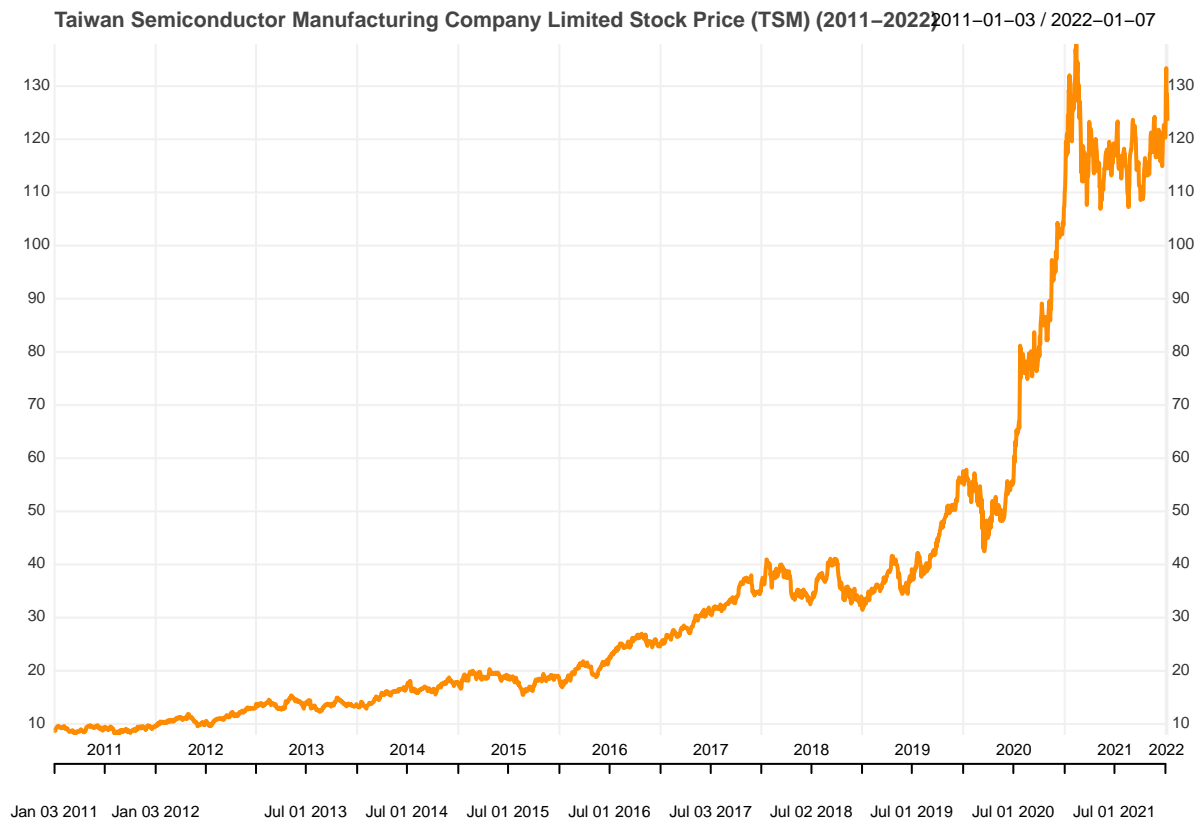
From the figure above TSM stock price has a `strong positive trend`.This shows that it is `non-stationary`

```
par(mfrow=c(1,2))
acf(tsm_close, lag=100)
pacf(tsm_close ,lag=100)
```
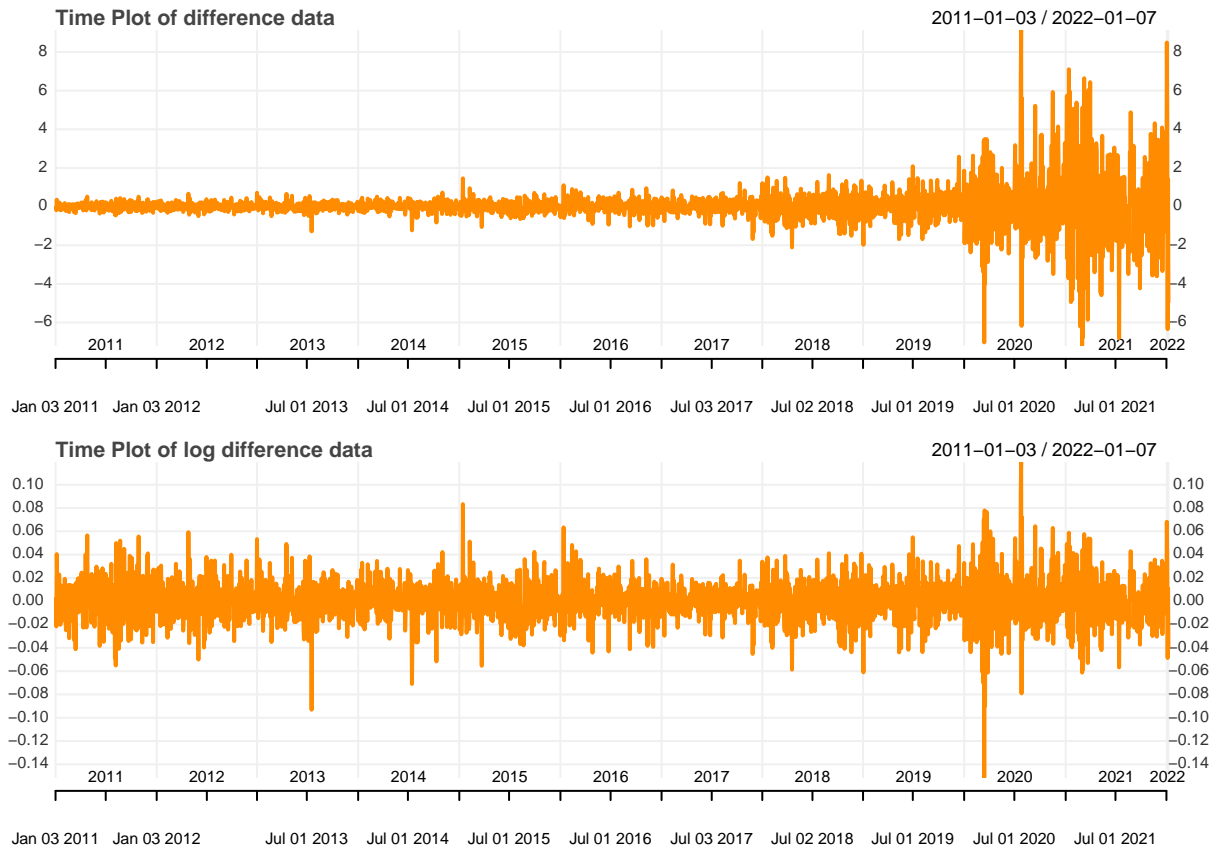

The trend can be removed by `differensing` the data to remove the trend

```
par(mfrow=c(2,1))

dy = diff(tsm_close,lag = 1)
chart_Series(dy,name="Time Plot of difference data")

wld = diff(log(tsm_close))
chart_Series(wld,name="Time Plot of log difference data")
```

Time Plot of difference data   2011–01–03 / 2022–01–07

Jan 03 2011 Jan 03 2012   Jul 01 2013 Jul 01 2014 Jul 01 2015 Jul 01 2016 Jul 03 2017 Jul 02 2018 Jul 01 2019 Jul 01 2020 Jul 01 2021

Time Plot of log difference data   2011–01–03 / 2022–01–07

Jan 03 2011 Jan 03 2012   Jul 01 2013 Jul 01 2014 Jul 01 2015 Jul 01 2016 Jul 03 2017 Jul 02 2018 Jul 01 2019 Jul 01 2020 Jul 01 2021

Check for residuals

```
try(checkresiduals(tsm_close))
```

```
## Error in checkresiduals(tsm_close) : No residuals found
```

Fit arima

```
# differencing is set to 1 d=1
# TRACE prints out all models that have been tried
fit_arima = auto.arima(tsm_close,d=1,stepwise = FALSE,approximation = FALSE,trace = TRUE)
```

```
##
##  ARIMA(0,1,0)                    : 7939.4
##  ARIMA(0,1,0) with drift         : 7936.775
##  ARIMA(0,1,1)                    : 7868.281
##  ARIMA(0,1,1) with drift         : 7863.535
##  ARIMA(0,1,2)                    : 7855.506
##  ARIMA(0,1,2) with drift         : 7851.703
##  ARIMA(0,1,3)                    : 7857.291
##  ARIMA(0,1,3) with drift         : 7853.606
##  ARIMA(0,1,4)                    : 7850.029
##  ARIMA(0,1,4) with drift         : 7845.685
##  ARIMA(0,1,5)                    : 7851.619
```

```
##  ARIMA(0,1,5) with drift         : 7847.131
##  ARIMA(1,1,0)                    : 7860.483
##  ARIMA(1,1,0) with drift         : 7855.864
##  ARIMA(1,1,1)                    : 7860.379
##  ARIMA(1,1,1) with drift         : 7855.994
##  ARIMA(1,1,2)                    : 7857.428
##  ARIMA(1,1,2) with drift         : 7853.673
##  ARIMA(1,1,3)                    : 7841.548
##  ARIMA(1,1,3) with drift         : 7838.026
##  ARIMA(1,1,4)                    : 7850.762
##  ARIMA(1,1,4) with drift         : 7846.1
##  ARIMA(2,1,0)                    : 7859.093
##  ARIMA(2,1,0) with drift         : 7854.922
##  ARIMA(2,1,1)                    : 7859.855
##  ARIMA(2,1,1) with drift         : 7855.907
##  ARIMA(2,1,2)                    : 7855.258
##  ARIMA(2,1,2) with drift         : 7852.113
##  ARIMA(2,1,3)                    : 7830.176
##  ARIMA(2,1,3) with drift         : 7825.472
##  ARIMA(3,1,0)                    : 7855.832
##  ARIMA(3,1,0) with drift         : 7852.21
##  ARIMA(3,1,1)                    : 7839.055
##  ARIMA(3,1,1) with drift         : 7835.218
##  ARIMA(3,1,2)                    : 7840.995
##  ARIMA(3,1,2) with drift         : 7837.102
##  ARIMA(4,1,0)                    : 7849.034
##  ARIMA(4,1,0) with drift         : 7844.689
##  ARIMA(4,1,1)                    : 7850.884
##  ARIMA(4,1,1) with drift         : 7846.281
##  ARIMA(5,1,0)                    : 7850.977
##  ARIMA(5,1,0) with drift         : 7846.68
##
##
##
##  Best model: ARIMA(2,1,3) with drift
```

```
print(summary(fit_arima))
```

```
## Series: tsm_close
## ARIMA(2,1,3) with drift
##
## Coefficients:
##          ar1      ar2      ma1     ma2      ma3    drift
##       0.9907  -0.7472  -1.1623  0.9987  -0.1962   0.0414
## s.e.  0.0864   0.0565   0.0862  0.0578   0.0219   0.0159
##
## sigma^2 estimated as 0.9814:  log likelihood=-3905.72
## AIC=7825.43   AICc=7825.47   BIC=7866.92
##
## Training set error measures:
##                          ME      RMSE       MAE        MPE     MAPE      MASE
## Training set 1.970854e-05 0.9893951  0.499054  -0.147819  1.30891 0.9921017
##                     ACF1
## Training set 0.0005326475
```