Understanding Stock Price Beahavior using an R Based Analytical Framework

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10/8/2021

Introduction

Stock market behavior is a well researched area with plenty of historic information available free. Several studies link the stock price movement of a company to the perception of the market participant about that company.IBM Watson APIs enable tracking of company specific news and social media interactions through extensive text mining and help come out with a Sentiment (Negative and positive emotions expressed through words or text) Index for a business.Business Sentiment Index(BSI) is one such index calculated by TRaiCE Fintech at company level. In addition, to understand sensitivity of stock prices to Global events, Foreign Exchanges Rate is also introduced as an additional measure. Idea here is to demonstrate how to extract various relevant data elements from diverse sources, transform and load them into an analytic framework to visualize and understand the inherent relationships.

Objective

Primary objective is to develop an analysis system using various R libraries. Extracting and processing data from multiple sources, data cleaning, simplifying repetitive tasks using control structures and functions, use of data visualization techniques and application of statistical methods are the focus areas while building the framework in R. In other words, learn to write reproducible R code while analyzing stock price movement with respect to Business Sentiment Index(BSI) and Foreign Exchange Rate is the objective of this project.

List of Libraries

For this project the following Libraries are used for data validation, graphics and statistical analysis

```
library(ggplot2)
library(tidyr)
library(plyr)
library(lubridate)
library(scales)
library(reshape2)
library(summarytools) #dataframe summaries
library(ggfortify) #autoplot
library(sjPlot) #tabmodel
library(ggpubr) # wrapper for ggplot
```

Data sources, Extraction and Cleaning

Data files(.csv)used, Description and source

1.List of companies to Analyze: Internally created CSV

2.Foreign Exchange daily data for various currencies: https://www.federalreserve.gov

3.Daily Stock Prices: https://finance.yahoo.com

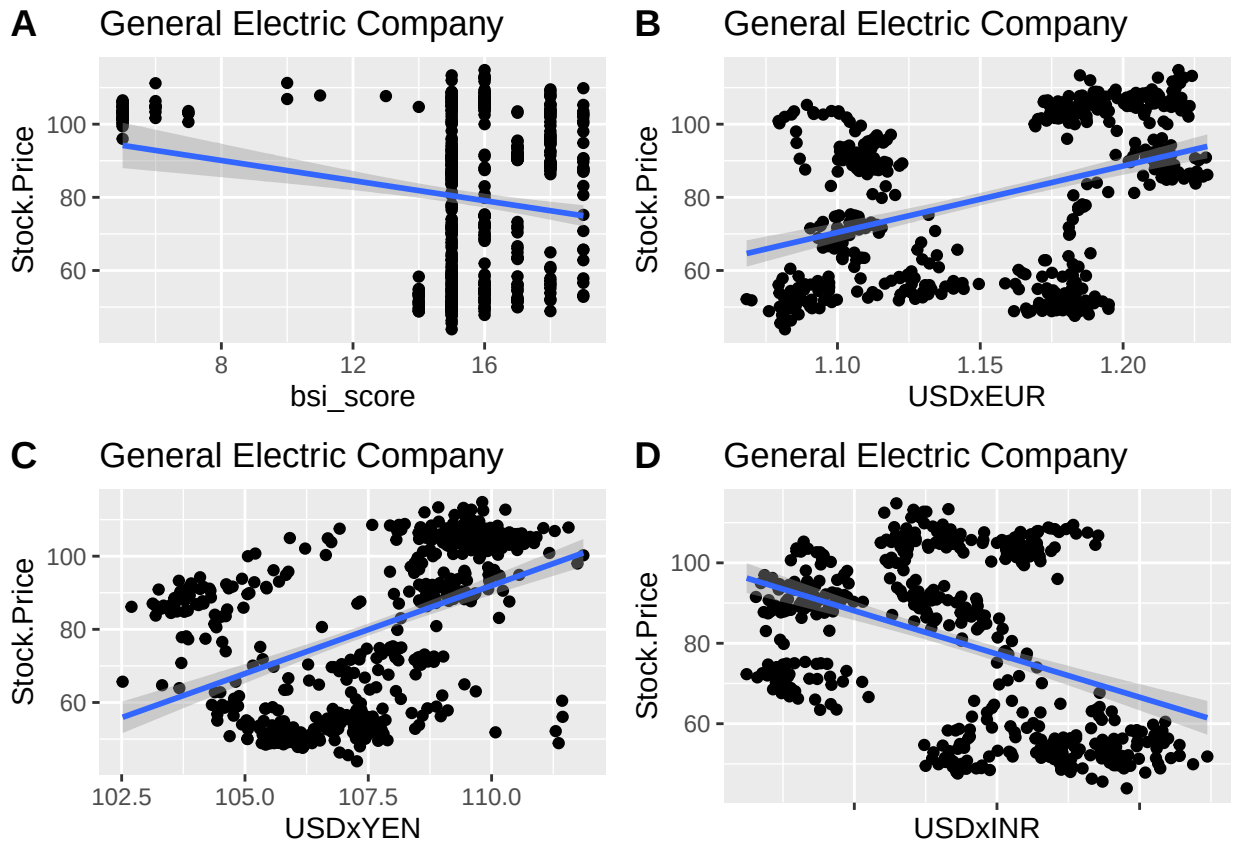
4.Business Sentiments Index(BSI,IBM Watson API based): https://www.traice.io

This project uses 6 different companies as test cases. However as long as the data files are available, companies can be added to the list and no code changes are necessary. Stock Price and BSI data will have 6 files each. Foreign Exchange is macro economic data so only one file with three different exchange rates are downloaded from the Federal Reserve. Daily data for two years(01-SEP-2019 to 31-AUG-2021) are used for the analysis.

Company Level Analysis -User Interface

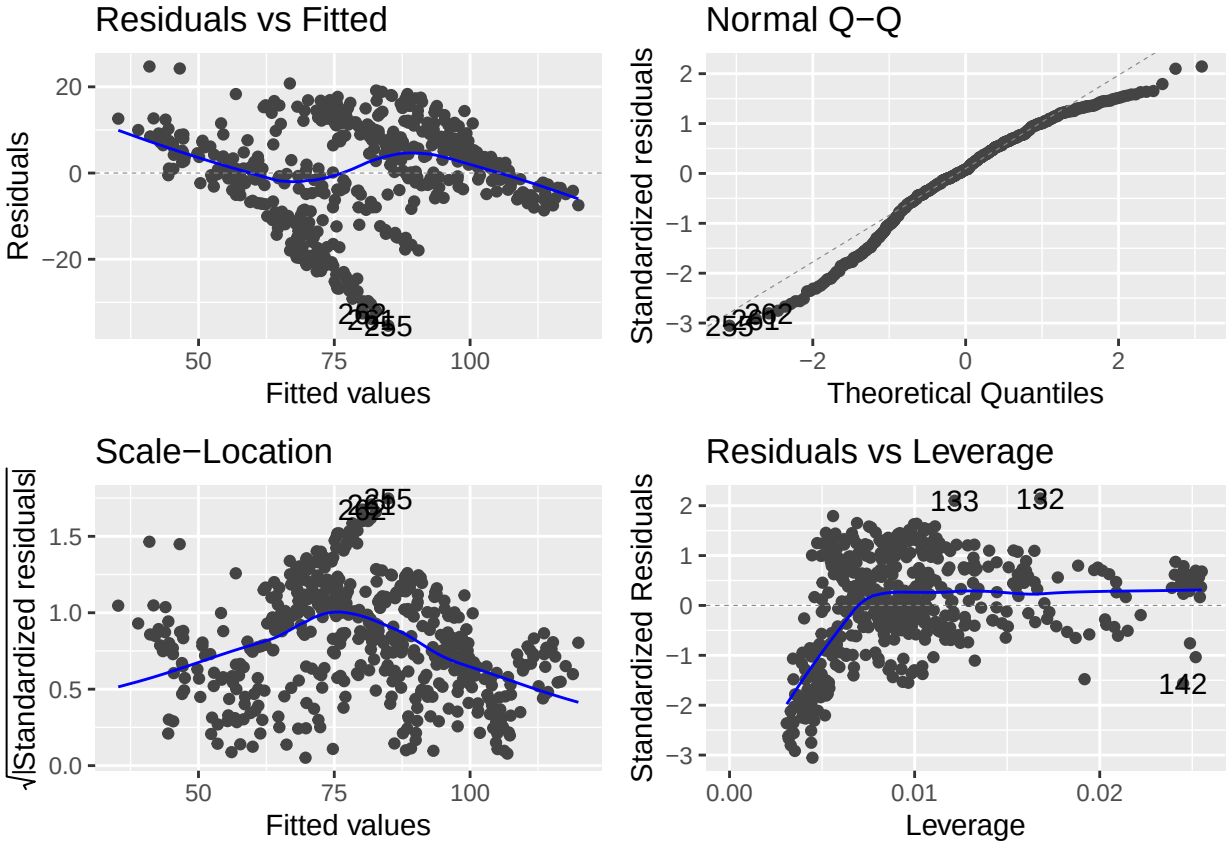
To Analyze a company users can call this function with appropriate parameter changes. The graphs and regression results will be presented for analysis and inference.

```
source("./src/fn_data_preperation.R")
fn.analysis("GE", "Stock.Price","bsi_score")
```



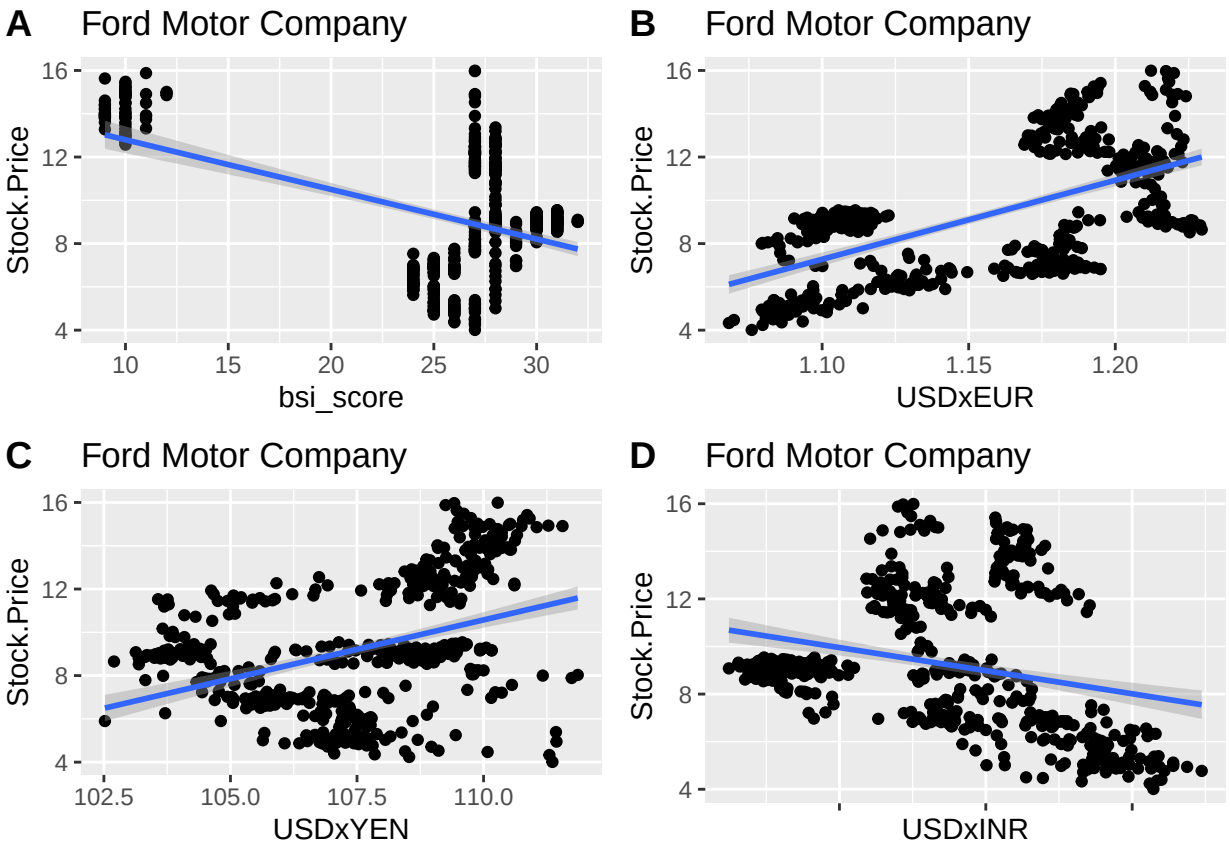

```
## MULTIPLE REGRESSION ANALYSIS RESULTS
## Call:
```

```
## lm(formula = Stock.Price ~ bsi_score + USDxEUR + USDxYEN + USDxINR,
##     data = df_all)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -35.418  -6.164   0.936   8.423  24.720
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) -577.9548    50.9904 -11.335   <2e-16 ***
## bsi_score      0.1159     0.1905   0.608    0.543
## USDxEUR      300.7839    13.0462  23.055   <2e-16 ***
## USDxYEN        6.4028     0.2780  23.028   <2e-16 ***
## USDxINR       -5.1636     0.3490 -14.797   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 11.63 on 493 degrees of freedom
## Multiple R-squared:  0.7071, Adjusted R-squared:  0.7047
## F-statistic: 297.6 on 4 and 493 DF,  p-value: < 2.2e-16
```

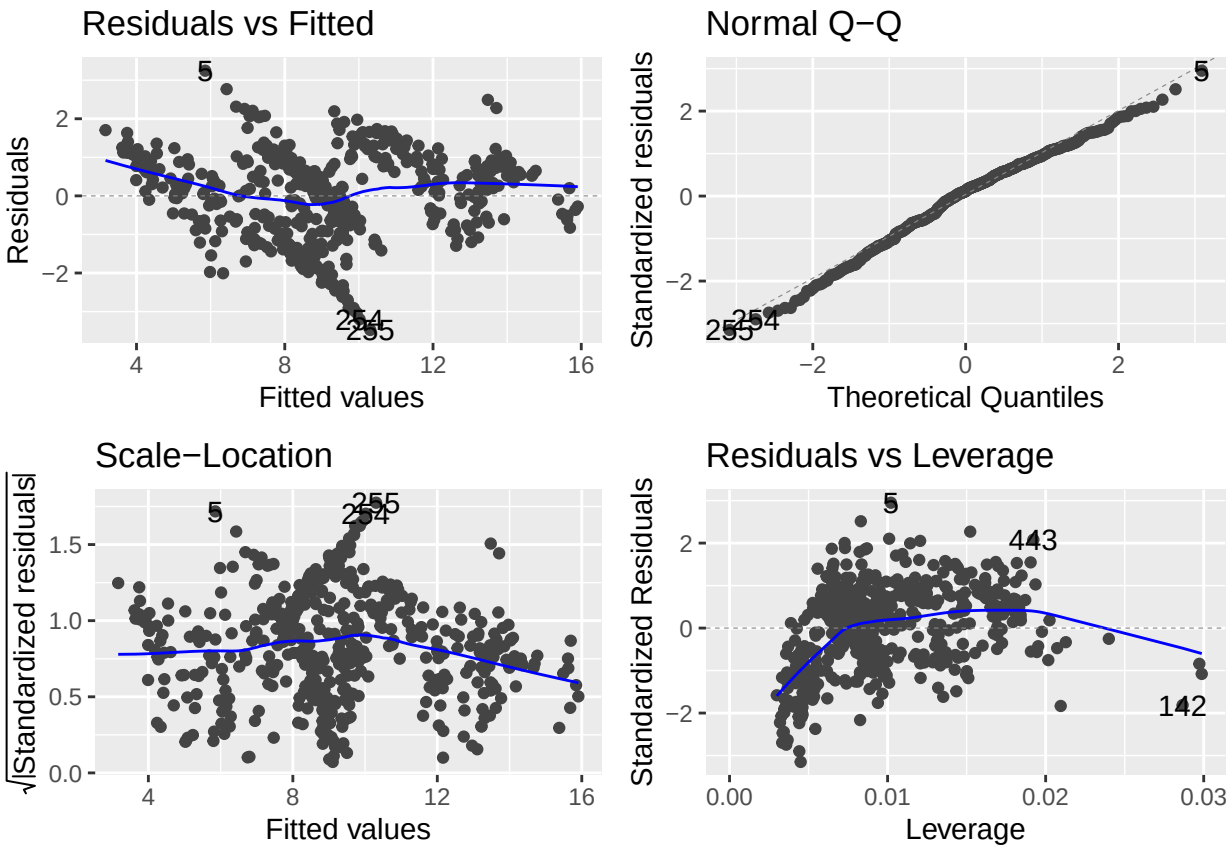



```
## [1] TRUE
```

```
fn.analysis("F", "Stock.Price","USDxEUR")
```




```
## MULTIPLE REGRESSION ANALYSIS RESULTS
## Call:
## lm(formula = Stock.Price ~ bsi_score + USDxEUR + USDxYEN + USDxINR,
##     data = df_all)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -3.4760 -0.6867  0.1285  0.7732  3.2462
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) -53.04353    6.21800  -8.531   <2e-16 ***
## bsi_score    -0.13374    0.01185 -11.282   <2e-16 ***
## USDxEUR      43.87533    1.29572  33.862   <2e-16 ***
## USDxYEN       0.65139    0.03109  20.951   <2e-16 ***
## USDxINR      -0.74859    0.03840 -19.495   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.106 on 493 degrees of freedom
## Multiple R-squared:  0.8544, Adjusted R-squared:  0.8532
## F-statistic:   723 on 4 and 493 DF,  p-value: < 2.2e-16
```



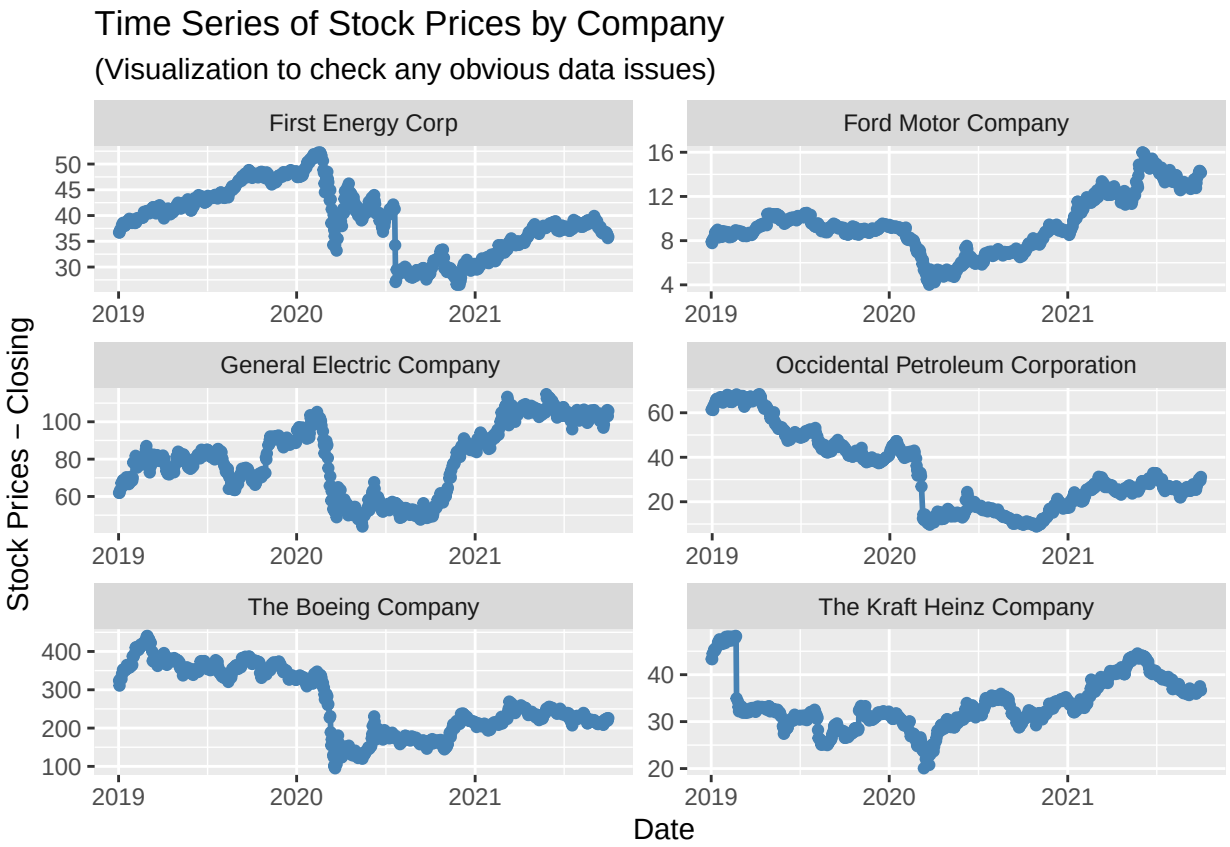

```
## [1] TRUE
```

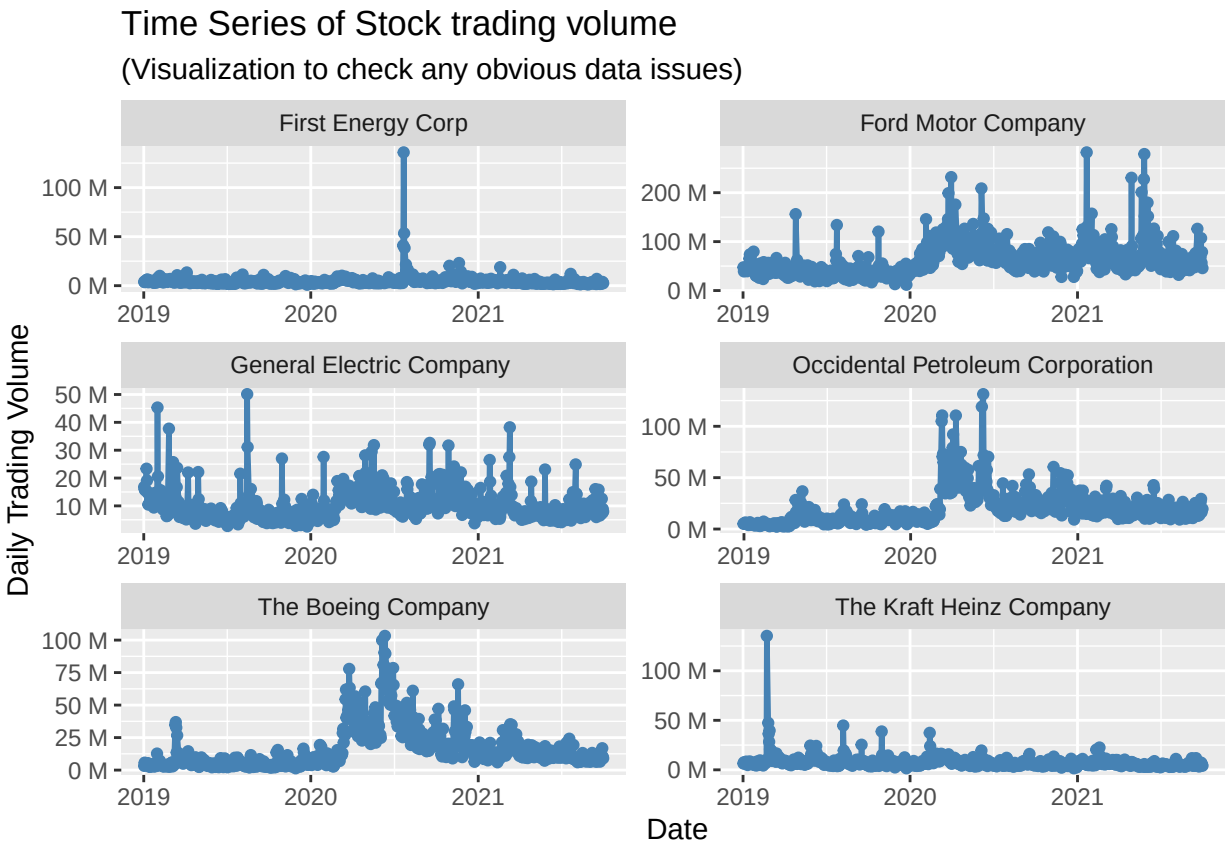
Data Diagnostics-Understanding the input data better

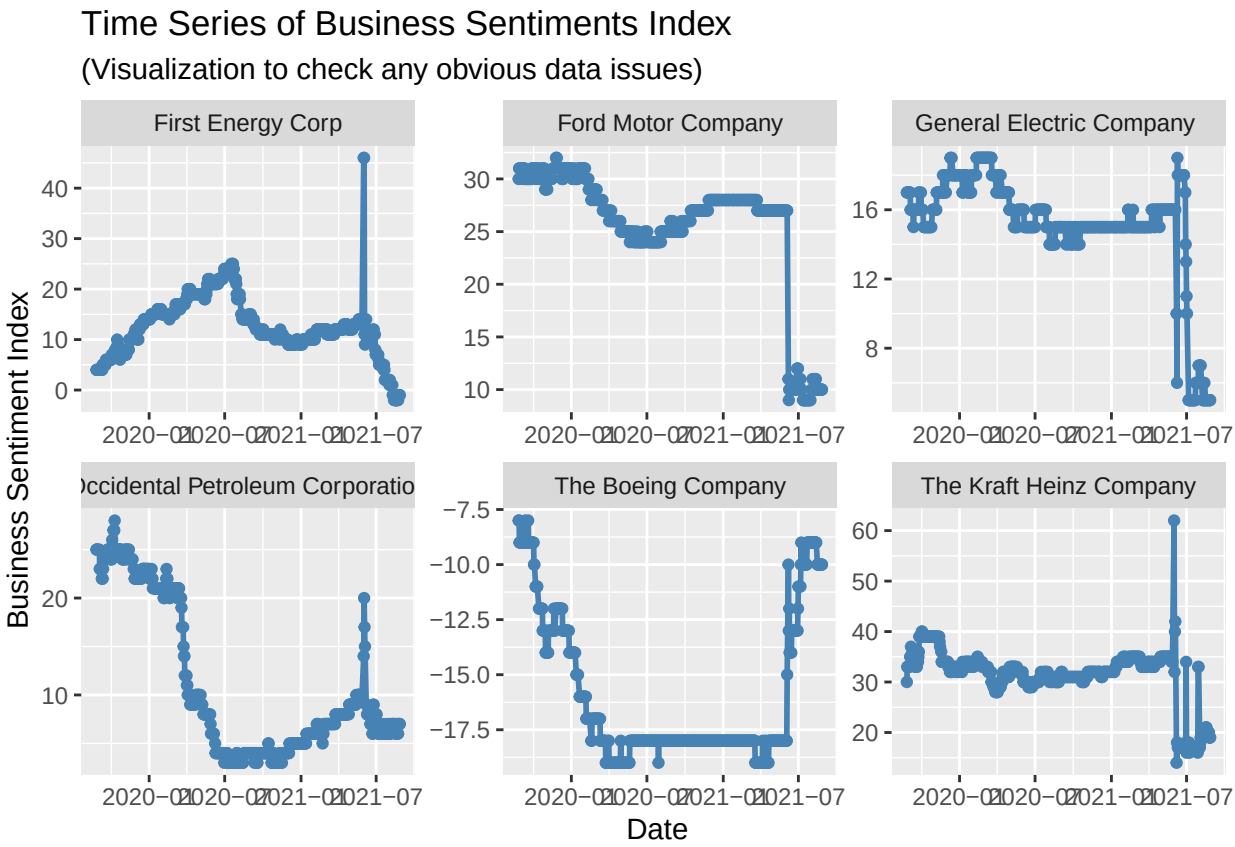
Processing CSV files(Items 1-4 in Data sources, Extraction and Cleaning sections listed above)

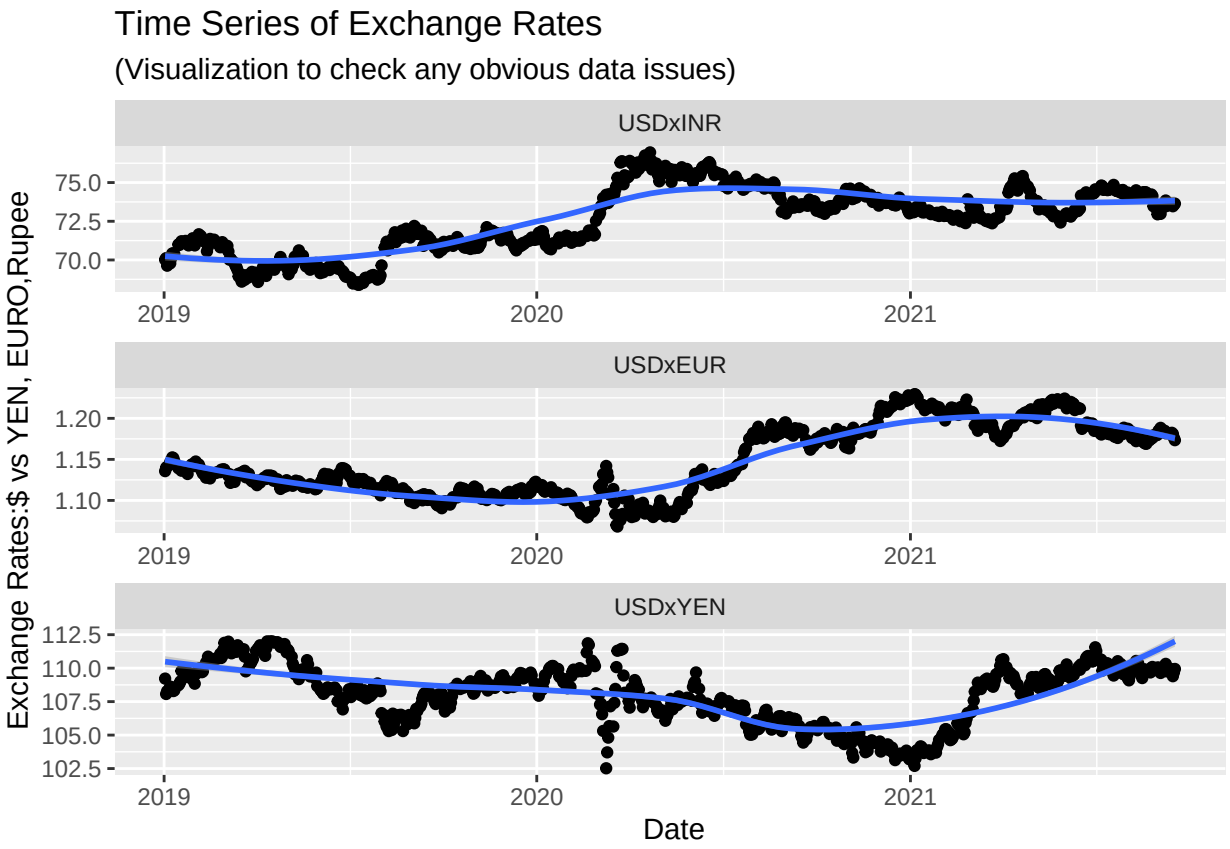
Validates source csv files are existing for the companies and alerts the user otherwise.Process the files iteratively Displays data summaries and charts to detect anomalies in the data

```
fn.data_diagnostics()
```


Time Series of Stock Prices by Company
(Visualization to check any obvious data issues)
First Energy Corp
Ford Motor Company
General Electric Company
Occidental Petroleum Corporation
The Boeing Company
The Kraft Heinz Company
Stock Prices – Closing
Date
2019
2020
2021


Time Series of Stock trading volume
(Visualization to check any obvious data issues)
First Energy Corp
Ford Motor Company
General Electric Company
Occidental Petroleum Corporation
The Boeing Company
The Kraft Heinz Company
Daily Trading Volume
Date
100 M
50 M
0 M
200 M
40 M
30 M
20 M
10 M
75 M
25 M
2019
2020
2021


Time Series of Business Sentiments Index
(Visualization to check any obvious data issues)
First Energy Corp
Ford Motor Company
General Electric Company
ccidental Petroleum Corporatio
The Boeing Company
The Kraft Heinz Company
Business Sentiment Index
Date
2020−01
2020−07
2021−01
2021−07



R Code and Funtions used for analysis and diagnostics

fn.analysis

```
fn.analysis <- function(company,var.Y,var.X){

CompanyNames <- './data/CompanyNames.csv'

# error trap and validation added - Peer review

  if (class(try(read.csv(CompanyNames, header = T),silent=T)) == "try-error") {
    print(message("Please change your Knit/Knit directory to 'Project Directory or
    Current Working Directory'. This error normally appears when
    R Markdown knit/Knit Direcotry is set to 'Document directory'"))
   break  }
  else {
    df_companies <- read.csv(CompanyNames, header = T)
  }



  ForexFile <- './data/FederalReserve_CurrencyXchangeRate.csv'
  headers <- read.csv(ForexFile, skip = 5 , header = F, nrows = 1) #header at row #6
  df_forex <- read.csv(ForexFile, skip = 6, header = F) #data begins at row #7
  colnames(df_forex) <- headers #apply headers
```

```r
df_forex$period <- as.Date(df_forex$`Time Period`) #format as date

df_forex$USDxINR <- as.numeric(gsub("ND","",df_forex$RXI_N.B.IN)) #clean & frmt as nmbr
df_forex$USDxEUR <- as.numeric(gsub("ND","",df_forex$`RXI$US_N.B.EU`))
df_forex$USDxYEN <- as.numeric(gsub("ND","",df_forex$RXI_N.B.JA))

df_forex <- subset(df_forex,select = c(period, USDxINR, USDxEUR, USDxYEN))
df_forex <- df_forex[!duplicated(df_forex$period),] # remove duplicates
df_forex2 <- melt(df_forex, id.vars="period") # for all in one graphs

sapply(df_forex, class)



for (i in df_companies$ticker) {

  if (!file.exists(paste0("./data/",i, ".csv"))) {
    print("Please remove the Company. Files Missing for:")
    print(i)
    break
  }

  #process stock price/volume files from data directory
  #pick the csv file of every company in the input list and create a dataframe in a loop

  df_c <- read.csv(paste0("./data/",i, ".csv"), header = T)
  df_c$period <- as.Date(df_c$Date) # add a date field
  df_c$ticker <- i # attach ticker
  df_companies_subset <- subset(df_companies, ticker==i)
  df_c <- merge(x=df_c, y=df_companies_subset, by="ticker",all.x=TRUE )#to get name
  assign(paste0("df_",i), df_c) #create a new data frame for later use

  # Appends company data frames to one for graphs.

  if (exists("df_c_all")) {
    df_c_all <- rbind(df_c_all, df_c)

  }else {
    df_c_all=df_c}

  # Process Sentiments Index from data directory

  df_bsi <- read.csv(paste0("./data/",i, "_BSI.csv"), header = T)
  df_bsi$period <- as.Date(parse_date_time(df_bsi$created_date,c('%Y-%m-%d','%m/%d/%y')))
  df_bsi$ticker <- i # attach ticker
  df_bsi <- merge(x=df_bsi, y=df_companies_subset, by="ticker",all.x=TRUE )##to get name
  df_bsi <- df_bsi[c('ticker','period','name','bsi_score')]

  assign(paste0("df_",i,"_BSI"), df_bsi) #create a new data frame forlater use

  # create a data frame to append  every data frame for graphs

  if (exists("df_bsi_all")) {
```

```
     df_bsi_all <- rbind(df_bsi_all, df_bsi)

   }else {
     df_bsi_all <- df_bsi}

 }

 #### End of data extraction and cleaning process ####



fn.regress <- function(company,var.Y,var.X){

  #create local dataframes based on the company names

  if (!exists(paste0("df_",company))) {
    print("Company Datafiles Missing.Process Terminated")
    return(FALSE)
  }else {

    df_b  <- get(paste0("df_",company,"_BSI"))
    df_s  <- get(paste0("df_",company))
    df_cname <- df_companies[df_companies[,1]  == company, ]
  }


  # check all three datasets for data issues and make it global

  d1 <- dfSummary(df_forex, style = "grid", plain.ascii = TRUE)
  # view(dfSummary(df_forex, style = "grid", plain.ascii = TRUE))
  d2 <- dfSummary(df_s, style = "grid", plain.ascii = TRUE)
  d3 <- dfSummary(df_b, style = "grid", plain.ascii = TRUE)

  df_forex <- na.omit(df_forex)
  d4 <- dfSummary(df_forex, style = "grid", plain.ascii = TRUE)

  # cat(df_cname[1,2])
  # print(d1)
  # print(d2)
  # print(d4)

  # merge all three datasets

  df_all <- merge(df_b, df_forex, by="period",all.x=TRUE )  # merge with Forex file

  df_all <- merge(x=df_all, y=df_s, by="period",all.x=TRUE )  # merge with stock price

  df_all <- subset(na.omit(df_all),select=c(period,    ticker.x,   name.x, bsi_score,
                                    USDxINR,    USDxEUR,    USDxYEN,    Close,  Volume))

  # dfSummary(df_all, style = "grid", plain.ascii = TRUE)
```

```
  df_all <- rename(df_all, c("ticker.x"="ticker", "name.x"="CompanyName",
                             "Close"="Stock.Price", "Volume"="Stock.Volume"))

  d5 <- dfSummary(df_all, style = "grid", plain.ascii = TRUE) #output saved global

  # Scatterplot the variable relationship to visualize.Output saved global

  scatter <- ggplot(df_all, aes(x=df_all[,var.X], y=df_all[,var.Y])) +
    geom_point()+
    geom_smooth(formula = y ~ x,method=lm)+ ggtitle(df_cname[1,2] ) +
    xlab(var.X) + ylab(var.Y)


  # Fit the simple regression model and create a summary


  multi.fit <- lm(Stock.Price~bsi_score+USDxEUR+USDxYEN+USDxINR, data=df_all)
  std_results <- summary(multi.fit) # std model results
  tab_results <- tab_model(multi.fit) # tabulated results
  residual_plot <- autoplot(multi.fit) # residuals plot

  print(scatter)
  cat("MULTIPLE REGRESSION ANALYSIS RESULTS")
  print(std_results)
  print(residual_plot)

  return(TRUE)
}

fn.regress(company, var.Y,var.X)

}
```

User Defined Function for Company Level Analysis

A generic function "fn.regres" was defined and it takes company name, dependent(x) and independent(y) variables for the regression analysis. It ensures that necessary data frames to conduct the analysis exists and polots, analysis summaries and other visual diagnostics are available in the results set.

Executing the user defined Function to Test a Company with no data

Expectation is that even if the user added a company name in to the list of companies to analyze and there is no data downloaded for that company, this should not result in an error and the user should be alerted about missing data.

Executing the Analysis Function Repeatedly for various Companies in the list

This outputs a scatterplot that shows the relationship between the variables, Standard Summary results of a regression function, Tabulated results of a regression function with coefficients and plots residuals for better diagnostics. Simple regression can be performed for any company and any set of variables. The coefficients and p values quantify the sensitivity of the variable and degree of confidence. Multiple regression and tests of time series properties are for the future development.

Summary of the Analysis

Scatterplot and regression analysis demonstrate a significant relationship between Stock Prices and Business Sentiment Index and Stock Prices and USDvsEuro foreign exchange rates in case of General Electric Company. The same analysis can be repeated for any 6 companies in our test list by calling the function "fn_regression()" repeatedly with simply changing the function arguments.This is a rudimentary analysis with simple regression however significant effort was spent on reading and cleaning data from various sources and made several data series consumable for various advanced algorithms that R offers. In the future, multiple regression approach and time series models like co-integration can be explored and that will add more analytic content to this project.

References

1. Understanding Diagnostic Plots for Linear Regression Analysis. https://data.library.virginia.edu/diagnostic-plots