DELHI SCHOOL OF MANAGEMENT

(DELHI TECHNOLOGICAL UNIVERSITY)

TERM PROJECT

Submitted By

Pankaj Verma - 2K21/EMBA/30

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APPLICATION OF ARTIFICIAL INTELLIGENCE MODELS IN THE INVESTMENT PORTFOLIO

Declaration

I hereby declare that the work presented in the report entitled **"Application of Artificial Intelligence Models In the Investment Portfolio"** submitted in partial fulfilment of the requirement for award of the Degree of Master of Business Administration, Delhi School Of Management, is an authentic record of my own work carried out under the supervision of **Mr Mohit Beniwal ,**Assistant Professor, Delhi School of Management, Delhi Technological University(DTU).

Date:
Place: Delhi

Lt Col Pankaj Verma
2K21/EMBA/30
Delhi School of Management
Delhi Technological University

CERTIFICATE

This is to certify that the above statement made by the candidate is correct to the best of my knowledge.

Date:

(Name of Supervisor)
Designation & Affiliation

Acknowledgement

Successful Completion of any project work cannot be done without proper guidance and encouragement of many people, this acknowledgment transcends the reality. Hence, we express our deep sense of gratitude to all those who have directly or indirectly helped in completion of this seminar report.

I am deeply indebted to my supervisor **Mr Mohit Beniwal**, Assistant Professor, Delhi School of Management, Delhi Technological University(DTU) for his valuable guidance, constant encouragement throughout the course of project work. I am fortunate to be associated with such an amazing and helping guide who helped in every possible way at all stages of the seminar.

Finally, I am obligated to my parents for their love, care, encouragement, my Wife and children without whose support , this work would not have been possible.

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APPLICATION OF ARTIFICIAL INTELLIGENCE MODELS IN THE INVESTMENT PORTFOLIO

1. INTRODUCTION

Artificial intelligence and Big Data Analytics are the most sorted out fields in the world today and its application in virtually every field is gaining momentum due to the fact that it makes the life analytically easier and enhances decision making capability through analytics that can fetch rich dividends.

The entire world today has realized the fact that fruitful utilization and analysis of data existing and available can help innovate in varied dimensions and fields. One of the most important vertical of Artificial Intelligence incorporates Big Data Analytics that can be effectively utilized in the investment domain for reaping the fruits of higher returns. A large research is being carried out in this field however its application in certain other fields such as the defence forces has still not yet been explored. India is on the verge of becoming a major manufacturing hub after China and hence has opened up a wide horizon and a large perspective of becoming a trillion-dollar economy. A large number of FII and DII are investing into the Indian markets seeing its capability and its lucrative returns that can be fetched by rigorous analysis

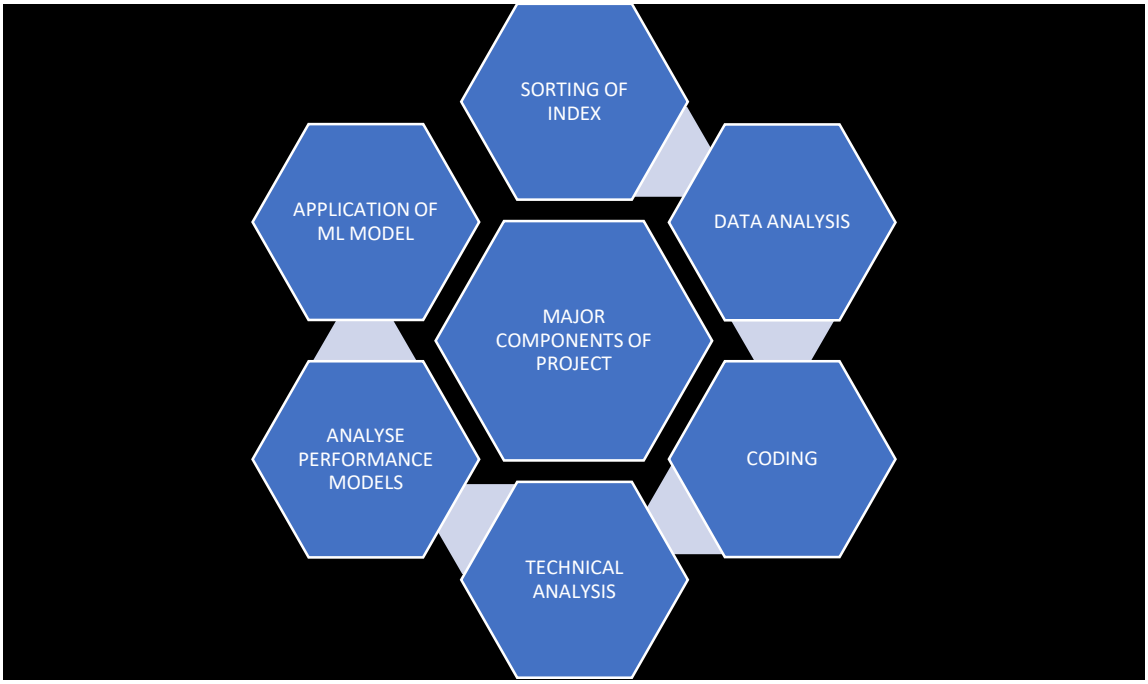
2. MAJOR COMPONENTS OF THE PROJECT

Investment Portfolio forms the most sorted out field in the todays world and a large scope still persists in uncovering the facets of trading that can help maximize the profits of the investors and traders. Algo based trading is gaining momentum in the present era and has amicably utilized the machine learning and Artificial Intelligence in deriving the results forecasting the index.

The major components of the project includes the following :

(a) Sorting out the Index to be Analysed
(b) Analysing the Two years Data of the Securities
(c) Sorting out the Securities to be analysed
(d) Code the application

(e) Conduct Technical Analysis and Fundamental Analysis
(f) Analyse Performance Parameters
(g) Application of a suitable AI Model



3. **Project Review** - Certain important aspects that need to be considered while analysing and implementing the projects are appended below :-

(a) Segregating the Index where AI/ML model can be applied

(b) Collection/Retrieving of Data

(c) Pre processing of Data

(d) Conduct of Data Analysis

(e) Coding the parameters

(f) Conduct technical analysis including MACD

(g) Conduct Fundamental Analysis including Standard Deviation

(h) Conduct Performance analysis including Monthly Returns, Sharpe Ratio

(i) Application of a suitable AI/ML model

4. Segregating The Index – A large number of Indices are available in India that includes NIFTY 50, NIFTY 100, BANK NIFTY and also in the USA unlike NASDEQ etc where AI/ML models can be applied in order to train , validate and test the data of the securities of the Index which has been selected. The data can be easily accessed through yahoo finance website.

5. **Methodology**

(a) Conduct the technical analysis of the securities of NASDEQ 100 and based on technical analysis, select the securities which are indicating an upward trend as per MACD. The securities must give the indication of the Bullish market trend.

(b) Based on the technical analysis using MACD, ten securities were selected for which the fundamental analysis would be conducted.

(c) Post the completion of the technical analysis , the fundamental analysis of the securities would be conducted and out of them, ten securities with least Standard Deviation would be selected.

(d) Now the comparison of technical analysis and the fundamental analysis would result in the selection of the best six stocks.

(e) Further the fundamental analysis considering the following would also be conducted :

(i) PE Ratio
(ii) ROE
(iii) Debt to Equity Ratio

(f) Application of AI model that is LSTM for training and testing purposes

6. Analysing the two years data of NASDEQ 100 – The NASDEQ 100 Index of the USA has been selected for analysing the data. The NASDEQ 100 comprises of some major share holders in the world market that includes Amazon, Google, E bay, Net Flix etc. The analysis of the securities has been done by coding in R Language. The codes along with the analysed chart is listed below :

7. **Coding and conduct of Technical Analysis of Securities :**

(a) **APPLE (AAPL)**

We would conduct technical MACD analysis of APPLE INC

aapl <- getSymbols.yahoo("AAPL", from = "2021-1-1", to = "2023-4-18", auto.assign=F)

aaplclose <- getSymbols.yahoo("AAPL", from = "2021-1-1", to = "2023-4-18", auto.assign=FALSE)[,4]

macdaapl <- MACD(aaplclose, nFast = 12, nslow = 26, nsig = 9)

The technical analysis chart is pasted below

(b) **AEP**

We would conduct technical MACD analysis of AMERICAN ELECTRIC POWER COMPANY INC

aep <- getSymbols.yahoo("AEP", from = "2021-1-1", to = "2023-4-18", auto.assign=F)

aepclose <- getSymbols.yahoo("AEP", from = "2021-1-1", to = "2023-4-18", auto.assign=FALSE)[,4]

macdaapl <- MACD(aepclose, nFast = 12, nslow = 26, nsig = 9)

(c) **ASML HOLDINGS**

We would conduct technical MACD analysis of ASML HOLDING NV

asml <- getSymbols.yahoo("ASML", from = "2021-1-1", to = "2023-4-18", auto.assign=F)

asmlclose <- getSymbols.yahoo("ASML", from = "2021-1-1", to = "2023-4-18", auto.assign=FALSE)[,4]

macdasml <- MACD(asmlclose, nFast = 12, nslow = 26, nsig = 9)

(d) **ASTRAZENECA**

We would conduct technical MACD analysis of ASTRAZENECA PLC

azn <- getSymbols.yahoo("AZN", from = "2021-1-1", to = "2023-4-18", auto.assign=F)

aznclose <- getSymbols.yahoo("AZN", from = "2021-1-1", to = "2023-4-18", auto.assign=FALSE)[,4]

macdazn <- MACD(aznclose, nFast = 12, nslow = 26, nsig = 9)

(e) **ADP**

We would conduct technical MACD analysis of ADP

adp <- getSymbols.yahoo("ADP", from = "2021-1-1", to = "2023-4-18", auto.assign=F)

adpclose <- getSymbols.yahoo("ADP", from = "2021-1-1", to = "2023-4-18", auto.assign=FALSE)[,4]

macdadp <- MACD(adpclose, nFast = 12, nslow = 26, nsig = 9)

(f) **BAKER HUGES COMPANY**

We would conduct technical MACD analysis of BAKER HUGHES COMPANY

```
bkr <- getSymbols.yahoo("BKR", from = "2021-1-1", to = "2023-4-18", auto.assign=F)

bkrclose <- getSymbols.yahoo("BKR", from = "2021-1-1", to = "2023-4-18", auto.assign=FALSE)[,4]

macdbkr <- MACD(bkrclose, nFast = 12, nslow = 26, nsig = 9)
```

(g) **BIOGEN INC**

We would conduct technical MACD analysis of BIOGEN INC

```
biib <- getSymbols.yahoo("BIIB", from = "2021-1-1", to = "2023-4-18", auto.assign=F)

biibclose <- getSymbols.yahoo("BIIB", from = "2021-1-1", to = "2023-4-18", auto.assign=FALSE)[,4]

macdbiib <- MACD(biibclose, nFast = 12, nslow = 26, nsig = 9)
```

(h) **BIOMARIN PHARMECEUTICAL**

We would conduct technical MACD analysis of BIOMARIN PHARMACEUTICAL

```
bmrn <- getSymbols.yahoo("BMRN", from = "2021-1-1", to = "2023-4-18", auto.assign=F)

bmrnclose <- getSymbols.yahoo("BMRN", from = "2021-1-1", to = "2023-4-18", auto.assign=FALSE)[,4]


macdbmrn <- MACD(bmrnclose, nFast = 12, nslow = 26, nsig = 9)
```

(i) <u>COPART INC</u>

We would conduct technical MACD analysis of COPART INC

cprt <- getSymbols.yahoo("CPRT", from = "2021-1-1", to = "2023-4-18", auto.assign=F)

cprtclose <- getSymbols.yahoo("CPRT", from = "2021-1-1", to = "2023-4-18", auto.assign=FALSE)[,4]

macdcprt <- MACD(cprtclose, nFast = 12, nslow = 26, nsig = 9)

(j) **COSTAR GROUP**

We would conduct technical MACD analysis of COSTAR GROUP INC

csgp <- getSymbols.yahoo("CSGP", from = "2021-1-1", to = "2023-4-18", auto.assign=F)

csgpclose <- getSymbols.yahoo("CSGP", from = "2021-1-1", to = "2023-4-18", auto.assign=FALSE)[,4]

macdcsgp <- MACD(csgpclose, nFast = 12, nslow = 26, nsig = 9)

(k) **CINATAS CORP**

We would conduct technical MACD analysis of CINATAS CORP

ctas <- getSymbols.yahoo("CTAS", from = "2021-1-1", to = "2023-4-18", auto.assign=F)

ctasclose <- getSymbols.yahoo("CTAS", from = "2021-1-1", to = "2023-4-18", auto.assign=FALSE)[,4]

macdctas <- MACD(ctasclose, nFast = 12, nslow = 26, nsig = 9)

(l) **COMCAST CORPORATION**

We would conduct technical MACD analysis of COMCAST CORP

cmcsa <- getSymbols.yahoo("CMCSA", from = "2021-1-1", to = "2023-4-18", auto.assign=F)

cmcsaclose <- getSymbols.yahoo("CMCSA", from = "2021-1-1", to = "2023-4-18", auto.assign=FALSE)[,4]

macdcmcsa <- MACD(cmcsaclose, nFast = 12, nslow = 26, nsig = 9)

(m) **COSTCO WHOLESALE**

We would conduct technical MACD analysis of COSTCO WHOLESALE

```
cost <- getSymbols.yahoo("COST", from = "2021-1-1", to = "2023-4-18", auto.assign=F)

costclose <- getSymbols.yahoo("COST", from = "2021-1-1", to = "2023-4-18", auto.assign=FALSE)[,4]


macdcost <- MACD(costclose, nFast = 12, nslow = 26, nsig = 9)
```

(n) **CSX CORP**

We would conduct technical MACD analysis of CSX CORP

csx <- getSymbols.yahoo("CSX", from = "2021-1-1", to = "2023-4-18", auto.assign=F)

csxclose <- getSymbols.yahoo("CSX", from = "2021-1-1", to = "2023-4-18", auto.assign=FALSE)[,4]

macdcsx <- MACD(csxclose, nFast = 12, nslow = 26, nsig = 9)

(o) **DIAMONDBACK ENERGY**

We would conduct technical MACD analysis of DIAMONDBACK ENERGY INC

```
fang <- getSymbols.yahoo("FANG", from = "2021-1-1", to = "2023-4-18", auto.assign=F)

fangclose <- getSymbols.yahoo("FANG", from = "2021-1-1", to = "2023-4-18", auto.assign=FALSE)[,4]


macdfang <- MACD(fangclose, nFast = 12, nslow = 26, nsig = 9)
```

(p) **DOLLAR TREE**

We would conduct technical MACD analysis of DOLLAR TREE

dltr <- getSymbols.yahoo("DLTR", from = "2021-1-1", to = "2023-4-18", auto.assign=F)

dltrclose <- getSymbols.yahoo("DLTR", from = "2021-1-1", to = "2023-4-18", auto.assign=FALSE)[,4]

macddltr <- MACD(dltrclose, nFast = 12, nslow = 26, nsig = 9)

(q) **ELECTRONIC ARTS**

We would conduct technical MACD analysis of ELECTRONIC ARTS

```
ea <- getSymbols.yahoo("EA", from = "2021-1-1", to = "2023-4-18", auto.assign=F)

eaclose <- getSymbols.yahoo("EA", from = "2021-1-1", to = "2023-4-18", auto.assign=FALSE)[,4]


macdea <- MACD(eaclose, nFast = 12, nslow = 26, nsig = 9)
```

(r) **EBAY**

We would conduct technical MACD analysis of EBAY

```
ebay <- getSymbols.yahoo("EBAY", from = "2021-1-1", to = "2023-4-18", auto.assign=F)

ebayclose <- getSymbols.yahoo("EBAY", from = "2021-1-1", to = "2023-4-18", auto.assign=FALSE)[,4]

macdebay <- MACD(ebayclose, nFast = 12, nslow = 26, nsig = 9)
```

(s) **HONEYWELL INTERNATIONAL**

We would conduct technical MACD analysis of honeywell international

```
hon <- getSymbols.yahoo("HON", from = "2021-1-1", to = "2023-4-18", auto.assign=F)

honclose <- getSymbols.yahoo("HON", from = "2021-1-1", to = "2023-4-18", auto.assign=FALSE)[,4]

macdhon <- MACD(honclose, nFast = 12, nslow = 26, nsig = 9)
```

(t) **KHC**

We would conduct technical MACD analysis of KHC

khc <- getSymbols.yahoo("KHC", from = "2021-1-1", to = "2023-4-18", auto.assign=F)

khcclose <- getSymbols.yahoo("KHC", from = "2021-1-1", to = "2023-4-18", auto.assign=FALSE)[,4]

macdkhc <- MACD(khclose, nFast = 12, nslow = 26, nsig = 9)

(u) **MARRIOT INC**

We would conduct technical MACD analysis of MARRIOT INC

mar <- getSymbols.yahoo("MAR", from = "2021-1-1", to = "2023-4-18", auto.assign=F)

marclose <- getSymbols.yahoo("MAR", from = "2021-1-1", to = "2023-4-18", auto.assign=FALSE)[,4]

macdmar <- MACD(marclose, nFast = 12, nslow = 26, nsig = 9)

(v) **MODERNA INC**

We would conduct technical MACD analysis of MODERNA INC

mrna <- getSymbols.yahoo("MRNA", from = "2021-1-1", to = "2023-4-18", auto.assign=F)

mrnaclose <- getSymbols.yahoo("MRNA", from = "2021-1-1", to = "2023-4-18", auto.assign=FALSE)[,4]

macdmrna <- MACD(mrnaclose, nFast = 12, nslow = 26, nsig = 9)

(w) **MICRON TECHNOLOGIES**

We would conduct technical MACD analysis of MICRON TECH

mu <- getSymbols.yahoo("MU", from = "2021-1-1", to = "2023-4-18", auto.assign=F)

muclose <- getSymbols.yahoo("MU", from = "2021-1-1", to = "2023-4-18", auto.assign=FALSE)[,4]

macdmu <- MACD(muclose, nFast = 12, nslow = 26, nsig = 9)

(x) **ROSS STORES**

We would conduct technical MACD analysis of ROSS STORES

```
rost <- getSymbols.yahoo("ROST", from = "2021-1-1", to = "2023-4-18", auto.assign=F)

rostclose <- getSymbols.yahoo("ROST", from = "2021-1-1", to = "2023-4-18", auto.assign=FALSE)[,4]

macdrost <- MACD(rostclose, nFast = 12, nslow = 26, nsig = 9)
```

(y) **XCEL ENERGY INC**

We would conduct technical MACD analysis of XCEL ENERGY INC

xel <- getSymbols.yahoo("XEL", from = "2021-1-1", to = "2023-4-18", auto.assign=F)

xelclose <- getSymbols.yahoo("XEL", from = "2021-1-1", to = "2023-4-18", auto.assign=FALSE)[,4]

macdxel <- MACD(xelclose, nFast = 12, nslow = 26, nsig = 9)

(z) **NETFLIX INC**

We would conduct technical MACD analysis of NETFLIX INC

```
nflx <- getSymbols.yahoo("NFLX", from = "2021-1-1", to = "2023-4-18", auto.assign=F)

nflxclose <- getSymbols.yahoo("NFLX", from = "2021-1-1", to = "2023-4-18", auto.assign=FALSE)[,4]

macdnflx <- MACD(nflxclose, nFast = 12, nslow = 26, nsig = 9)
```

(aa) **ALPHABET C**

We would conduct technical MACD analysis of ALPHABET C

goog <- getSymbols.yahoo("GOOG", from = "2021-1-1", to = "2023-4-18", auto.assign=F)

googclose <- getSymbols.yahoo("GOOG", from = "2021-1-1", to = "2023-4-18", auto.assign=FALSE)[,4]

macdgoog <- MACD(googclose, nFast = 12, nslow = 26, nsig = 9)

(ab) **ALPHABET A**

We would conduct technical MACD analysis of ALPHABET A

```
googl <- getSymbols.yahoo("GOOGL", from = "2021-1-1", to = "2023-4-18", auto.assign=F)

googlclose <- getSymbols.yahoo("GOOGL", from = "2021-1-1", to = "2023-4-18", auto.assign=FALSE)[,4]

macdgoogl <- MACD(googlclose, nFast = 12, nslow = 26, nsig = 9)
```

(ac) **AMAZON INC**

We would conduct technical MACD analysis of AMAZON

```
amzn <- getSymbols.yahoo("AMZN", from = "2021-1-1", to = "2023-4-18", auto.assign=F)

amznclose <- getSymbols.yahoo("AMZN", from = "2021-1-1", to = "2023-4-18", auto.assign=FALSE)[,4]

macdamzn <- MACD(amznclose, nFast = 12, nslow = 26, nsig = 9)
```

(ad) **MICROSOFT INC**

We would conduct technical MACD analysis of MICTOSOFT

```
msft <- getSymbols.yahoo("MSFT", from = "2021-1-1", to = "2023-4-18", auto.assign=F)

msftclose <- getSymbols.yahoo("MSFT", from = "2021-1-1", to = "2023-4-18", auto.assign=FALSE)[,4]

macdmsft <- MACD(msftclose, nFast = 12, nslow = 26, nsig = 9)
```

8. Based on the Technical analysis considering the MACD as depicted above , ten stocks have been finalized that would be used for conducting the fundamental analysis using Standard Deviation method. The stocks are as listed below :

(a) Astrazeneca

(b) Biogen Inc

(c) Diamondback Energy

(d) Electronic Arts

(e) E Bay

(f) Moderna Inc

(f) Marriot Inc

(g) Baker Huges Company

(h) XCEL Energy Inc

(i) Honeywell International

9. **Conduct of Fundamental Analysis** – The Fundamental analysis of the stocks have been done by doing the taking out the standard deviation of the securities for a period of two years. The code for the same is appended below :

```
sd(aapl$AAPL.Adjusted)

sd(adp$ADP.Adjusted)

sd(aep$AEP.Adjusted)

sd(amgn$AMGN.Adjusted)

sd(asml$ASML.Adjusted)

sd(azn$AZN.Adjusted)

sd(biib$BIIB.Adjusted)

sd(bkr$BKR.Adjusted)

sd(bmrn$BMRN.Adjusted)

sd(cmcsa$CMCSA.Adjusted)

sd(cost$COST.Adjusted)

sd(cpi$CPI.Adjusted)

sd(csx$CSX.Adjusted)

sd(ctas$CTAS.Adjusted)

sd(dltr$DLTR.Adjusted)

sd(ea$EA.Adjusted)

sd(ebay$EBAY.Adjusted)

sd(fang$FANG.Adjusted)

sd(goog$GOOG.Adjusted)

sd(googl$GOOGL.Adjusted)

sd(hon$HON.Adjusted)
```

sd(khc$KHC.Adjusted)

sd(mar$MAR.Adjusted)

sd(mrna$MRNA.Adjusted)

sd(nflx$NFLX.Adjusted)

sd(rost$ROST.Adjusted)

sd(xel$XEL.Adjusted)

10. The results of the Standard Deviations are listed below :

```
sd(aapl$AAPL.Adjusted)
[1] 15.09056
> sd(adp$ADP.Adjusted)
[1] 24.35709
> sd(aep$AEP.Adjusted)
[1] 7.709606
> sd(amgn$AMGN.Adjusted)
[1] NA
> sd(asml$ASML.Adjusted)
[1] 108.6529
> sd(azn$AZN.Adjusted)
[1] 6.702033
> sd(biib$BIIB.Adjusted)
[1] 45.4134
> sd(bkr$BKR.Adjusted)
[1] 4.60317
> sd(bmrn$BMRN.Adjusted)
[1] 9.612395
> sd(cmcsa$CMCSA.Adjusted)
[1] 7.986875
> sd(cost$COST.Adjusted)
[1] 67.41962
> sd(cpi$CPI.Adjusted)
[1] NA
> sd(csx$CSX.Adjusted)
[1] 2.348779
> sd(ctas$CTAS.Adjusted)
[1] 38.70636
> sd(dltr$DLTR.Adjusted)
[1] 24.04647
> sd(ea$EA.Adjusted)
[1] 8.838654
> sd(ebay$EBAY.Adjusted)
[1] 10.75033
> sd(fang$FANG.Adjusted)
[1] 29.21803
> sd(goog$GOOG.Adjusted)
[1] 18.5135
> sd(googl$GOOGL.Adjusted)
[1] 18.39421
> sd(hon$HON.Adjusted)
[1] 14.72625
> sd(khc$KHC.Adjusted)
[1] 2.764323
> sd(mar$MAR.Adjusted)
```

```
[1] 13.85948
> sd(mrna$MRNA.Adjusted)
[1] 81.3499
> sd(nflx$NFLX.Adjusted)
[1] 150.3317
> sd(rost$ROST.Adjusted)
[1] 14.62361
> sd(xel$XEL.Adjusted)
[1] 4.284547
```

11. So based on the above values of Standard deviations, six stocks have been selected whose values are the least amongst the all. The stocks are

("AZN", "EBAY", "EA", "BKR", "HON", "XEL")

12. **Conduct of Performance Analysis -** The performance analysis of the stocks has been done by writing the R code for calculating the Returns, Variance Co variance Matrix and also by calculating the Sharpe Ratio of the Portfolio. The code is appended below :

```
>
> portfolioReturns
GMT
                    AZN          EBAY           EA           BKR          HON           XEL
2021-01-05  0.0035629514  0.0102912384  0.0129740727  0.0114176863  2.452560e-03 -0.0097472888
2021-01-06  0.0041419937  0.0228714678 -0.0319841780  0.0423330014  1.822886e-02  0.0221470704
2021-01-07 -0.0141426286 -0.0030063856  0.0288011868  0.0230144509  1.648950e-03 -0.0195605694
2021-01-08  0.0133493127  0.0267621208  0.0079579016 -0.0088222656 -1.213490e-02  0.0092080792
2021-01-11 -0.0058985300 -0.0100954340 -0.0045114859  0.0080106947 -7.951236e-03 -0.0206812738
2021-01-12 -0.0053401988  0.0391248025 -0.0152953098  0.0172186006  2.495701e-03 -0.0155279499
2021-01-13  0.0117319575 -0.0058886835 -0.0195599113 -0.0017361508 -8.904637e-03  0.0253943308
2021-01-14  0.0080581729 -0.0078980189  0.0190700174  0.0308695254  7.680400e-03 -0.0223042719
2021-01-15  0.0009748340  0.0027139083  0.0004318235 -0.0354280168 -1.265519e-02  0.0220263952
2021-01-19  0.0239579186  0.0281487085  0.0174819617  0.0000000000  3.835477e-03 -0.0038485222
2021-01-20 -0.0062773068 -0.0142155384  0.0294846471  0.0008744447  6.384249e-03  0.0111265837
```

We further calculate the Sharpe Ratio of the portfolio and the code is appended below

```
library(PortfolioAnalytics)

library(PerformanceAnalytics)

install.packages("PortfolioAnalytics")



# Load the packages needed

library(PerformanceAnalytics)

library(quantmod)
```

```
# Define the portfolio

tickers <- c("AZN", "EBAY", "EA", "BKR", "HON", "XEL")
```

We have already calculated the average return of the portfolio above and so we would put that value in the calculations of the Sharpe Ratio.

```
# Calculate the standard deviation of the returns of the portfolio

standard_deviation_portfolio <- sd(portfolioReturns)


# Set the risk-free rate

risk_free_rate <- 0.02/252


# Calculate the Sharpe ratio

sharpe_ratio_portfolio <- (average_return_portfolio - risk_free_rate) / standard_deviation_portfolio


# Print the Sharpe ratio

sharpe_ratio_portfolio
```

16. The code for finding out the Variance Covariance Matrix is given below :

output matrix

```
cor_matrix <- cor(portfolioReturns)
```

cov_matrix <- cov(portfolioReturns)

write.csv(cov_matrix, "covmatrix.csv")

cor_matrix

cov_matrix

The output that has been derived is :

```
cor_matrix
            AZN       EBAY         EA        BKR        HON        XEL
AZN  1.0000000 0.2047740 0.1922434 0.1159792 0.2534748 0.2958422
EBAY 0.2047740 1.0000000 0.2270167 0.2051834 0.4149210 0.2252814
EA   0.1922434 0.2270167 1.0000000 0.1169569 0.2352783 0.1734959
BKR  0.1159792 0.2051834 0.1169569 1.0000000 0.3169874 0.1236457
HON  0.2534748 0.4149210 0.2352783 0.3169874 1.0000000 0.3724797
XEL  0.2958422 0.2252814 0.1734959 0.1236457 0.3724797 1.0000000
> cov_matrix
               AZN          EBAY            EA           BKR           HON
XEL
AZN  2.340978e-04 6.854058e-05 4.652647e-05 4.500118e-05 5.340565e-05 6.02282
8e-05
EBAY 6.854058e-05 4.785735e-04 7.855651e-05 1.138313e-04 1.249952e-04 6.55754
7e-05
EA   4.652647e-05 7.855651e-05 2.502075e-04 4.691601e-05 5.124904e-05 3.65158
2e-05
BKR  4.500118e-05 1.138313e-04 4.691601e-05 6.431175e-04 1.106983e-04 4.17220
8e-05
HON  5.340565e-05 1.249952e-04 5.124904e-05 1.106983e-04 1.896302e-04 6.82492
7e-05
XEL  6.022828e-05 6.557547e-05 3.651582e-05 4.172208e-05 6.824927e-05 1.77044
8e-04
```

13. There are certain artificial intelligence models that can be applied in portfolio for predicting the prices of securities, predicting the monthly returns and calculate the risk on investment. Such models are as listed below :

(a) Linear Regression

(b) Logistic Regression

(c) Artificial Neural Networks (ANN)

(d) Convolution Neural Networks (CNN)

(e) Recurrent Neural Networks (RNN)

(f) Long Short Term Memory Networks(LSTM)

14. <u>Code for application of LSTM model –</u> The LSTM is basically a Recurrent Network which are capable of remembering the information for a very long period of time. Further the data analysis of the Index requires a large amount of past data to be fed to the model so that the LSTM model could work upon.

We would now split the data into train and test sets

```
train_size <- floor(0.7 * nrow(data))

train_data_model <- data[1:train_size, ]

test_data_model <- data[(train_size + 1):nrow(data), ]
```

Define the model

```
model <- keras_model_sequential() %>%
  layer_lstm(units = 32, input_shape = c(1, ncol(data)), return_sequences = TRUE) %>%
  layer_dropout(0.3) %>%
  layer_lstm(units = 16) %>%
  layer_dropout(0.3) %>%
  layer_dense(units = 1)
```

Compile the model

```
 model %>% compile(
  loss = function(y_true, y_pred) -K.mean(y_true*y_pred),
  optimizer = optimizer_adam(lr = 0.001)
)
```

Define a custom callback to track the portfolio returns during training

```
portfolioReturns <- function() {
  portfolioReturns <- list()
```

```
  function(epoch, logs) {
    portfolioReturns[[epoch+1]] <<- sum(test_data_model * logs$outputs)
  }
}

# Train the model with the custom callback
history <- model %>% fit(
  x = array(train_data, dim = c(nrow(train_data_model), 1, ncol(train_data_model))),
  y = array(train_data_model, dim = c(nrow(train_data_model), 1)),
  epochs = 20,
  batch_size = 32,
  validation_split = 0.3,
  callbacks = list(callback_portfolioReturns)
  # Evaluate the model on test data
  test_returns <- sum(test_data_model * model %>% predict(array(test_data_model, dim = c(nrow(test_data_model), 1, ncol(test_data_model)))))

  # Visualize the portfolio returns during training
  plot(0:length(portfolioReturns)-1, unlist(portfolioReturns), type = "l", xlab = "Epochs", ylab = "Portfolio Returns")
```

(14) **Training and Validation –** The Training and Validation phase forms a very important part of the project and must be conducted thoroughly with a robust Machine Learning Model so that a good AI model is build. A ratio of 70 : 30 has been taken as the test and train data during the course of this project.

(15) **CONCLUSION** - The portfolio analysis has been the topic of the past as well as is a hot topic in the present era. Due to the advent of technology, Artificial Intelligence and Machine Learning the algo trading is gaining momentum and is the future of trading.

An honest effort has been given to analyse the NASDEQ 100 Index and sort out the securities based on the fundamental and technical analysis and introduce a machine learning model in terms of LSTM that could be trained for portfolio analysis.

References:

1. Investments by Bodie, Kane, Marcus and Mohanty
2. Yahoo Finance Website for extracting data
3. Money Control Website for conducting Analysis
4. International Financial Management by Madura