Distributional Properties of Stock Returns

Glaxosmithkline Pharmaceuticals Limited

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Executive summary

This analysis examines the statistical properties of **Glaxosmithkline Pharmaceuticals Limited** daily stock returns for over a 1-year period from September 2022 to August 2023. The goal is to test whether returns exhibit stylized facts commonly found in financial return distributions. It begins by taking the data, calculating daily returns and log daily returns. Further calculating Descriptive Statistics for the same. Basic results of which falls out to be as: Mean 0.000395983972323965, Median -0.00096833298924, Mode 0, skewness 1.6150479408691, kurtosis 8.05649213594032. To Test whether returns exhibit stylized facts we use graphical methods like Q-Q plot, Histogram plots as well as Parametric tests. All this Normality Tests exhibits that data of daily returns is not normally Distributed.

In summary, analysis of **Glaxosmithkline Pharmaceuticals Limited** return distribution shows characteristics consistent with established features of stock returns - fat tails, asymmetry, and aggregated normality. This provides insights into the risk dynamics and statistical behavior of this individual stock. The results contribute empirical evidence on the distributional properties of security returns in financial markets.

Introduction

Stock returns are known to be volatile and unpredictable. But like the stock market itself, they also exhibit certain patterns that can be identified and analyzed. These patterns, known as stylized facts, provide valuable insights into the dynamics of stock prices and the behavior of investors.This research project will investigate the stylized facts of stock returns using a variety of statistical methods. The goal is to gain a better understanding of the dynamics of stock prices and the behavior of investors. The findings of this project could be used to develop more effective investment strategies and to inform the design of financial regulations.

One of the most well-known stylized facts is that stock returns have fat tails. This means that extreme events, such as large gains or losses, are more likely to occur than they would under a normal distribution. This is why it is important for investors to be prepared for the possibility of large losses, even when investing in seemingly safe assets. Another stylized fact is that stock returns are asymmetric. This means that negative returns tend to be larger than positive returns. This asymmetry is often attributed to the fact that investors are more risk-averse than risk-loving. As a result, they are more likely to sell stocks when they experience losses than they are to buy stocks when they experience gains.

Finally, stock returns are said to exhibit aggregated normality. This means that the distribution of stock returns becomes more normal as the frequency of the returns increases. For example, the distribution of daily returns is more likely to be skewed and fat-tailed than the distribution of monthly or annual returns.
We Take data from 1st September 2022 to 30th September 2023, of Glaxosmithkline Pharmaceuticals Limited for this analysis.The data is used to calculate simple and logarithmic returns. Descriptive statistics provide an initial view of the distribution's shape. Graphical methods including histograms, Q-Q plots, and probability plots visually assess normality. Parametric statistical tests like Jarque-Bera, Shapiro-Wilk, KolmogorovSmirnov, Lilliefors, and Anderson-Darling quantitatively test for normality. Finally, the tails, skewness, and aggregate distribution are examined to determine.

ANALYSIS

Distributional Properties of Stock Returns

R Markdown

read daily_returns

```
library(moments)
#Loading the data
data<- read.csv("C:/Users/rajat/Downloads/GLAXO.NS.csv")
head(data)
```

```
##         Date    Open    High     Low   Close Adj.Close Volume
## 1 2022-09-01 1458.00 1462.50 1439.00 1445.35  1413.036  14040
## 2 2022-09-02 1455.90 1459.75 1426.30 1433.75  1401.695  24075
## 3 2022-09-05 1441.30 1449.00 1430.35 1440.15  1407.952  17498
## 4 2022-09-06 1440.15 1461.90 1415.20 1417.50  1385.809 188084
## 5 2022-09-07 1428.75 1431.40 1417.00 1424.20  1392.359  24313
## 6 2022-09-08 1431.10 1444.00 1426.10 1438.10  1405.948  20804
```

```
#Finding the Length of data.
n<-length(data$Adj.Close)
#Calculating Daily Returns.
daily_returns<-(data$Adj.Close[-1]/data$Adj.Close[-n])-1
daily_returns
```

```
##   [1] -8.025769e-03  4.463851e-03 -1.572749e-02  4.726606e-03
9.759865e-03
##   [6] -6.432111e-03 -6.193764e-03 -1.619776e-03 -7.088865e-03
-1.243252e-03
##  [11]  1.838682e-02 -1.616904e-02 -6.105344e-03  1.074998e-02
2.120106e-03
```

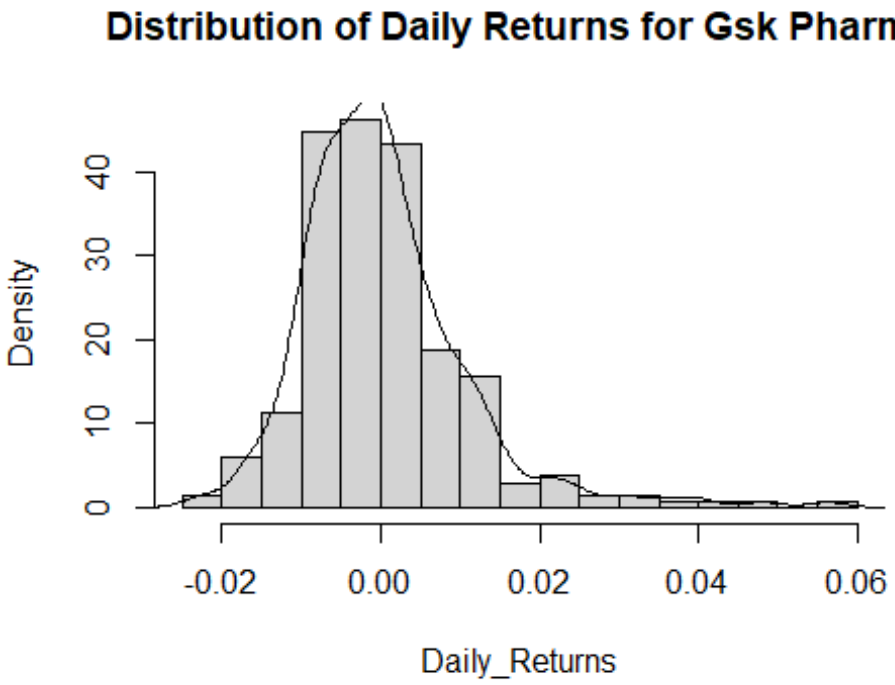
```
##  [16] -9.731751e-03 -8.260580e-03 -6.031726e-03  1.025829e-02
3.457401e-02
##  [21] -1.548242e-02 -6.248266e-03 -7.347224e-03  2.526562e-03
-9.654691e-03
##  [26] -1.146988e-03 -5.705233e-03 -5.051251e-04 -4.802151e-03
3.627663e-04
##  [31] -2.756353e-03  2.218424e-03 -7.402546e-03 -3.290211e-03
-5.318354e-03
##  [36]  1.283233e-02 -7.063036e-03  1.540022e-03  6.662958e-03
1.818368e-03
##  [41]  9.075344e-04 -6.129336e-03 -6.495661e-03 -1.134980e-02
-5.647268e-03
##  [46]  2.054968e-03 -4.399847e-03 -7.303071e-03  9.356303e-03
-6.653141e-03
##  [51]  3.763329e-04 -1.053243e-03 -6.438770e-03 -8.185795e-03
3.056302e-04
##  [56] -6.493830e-03  7.700401e-05  2.548918e-02 -3.336547e-03
-1.504819e-04
##  [61]  6.094609e-03 -1.342418e-02  1.284879e-02  4.265947e-03
-1.020976e-02
##  [66]  8.206955e-03 -3.622071e-03 -1.873771e-03 -9.386442e-04
4.547377e-03
##  [71]  3.928127e-03  1.266999e-03  7.071898e-04 -7.958970e-03
-3.261651e-03
##  [76]  1.184796e-02 -2.229710e-04 -3.420703e-03 -6.976502e-03
-4.132824e-04
##  [81]  7.517250e-04  8.074802e-03 -1.736148e-02 -1.857850e-03
-9.458314e-03
##  [86] -1.457241e-03  2.304567e-04 -1.075121e-03 -2.190853e-03
5.624075e-03
##  [91] -3.639006e-03  1.268694e-02 -9.377084e-03 -1.954418e-03
2.534251e-03
##  [96] -5.745490e-04 -5.020220e-03 -6.894503e-03 -8.959024e-03
-5.009232e-03
## [101] -7.197643e-03  7.131001e-04 -4.235912e-03 -9.104349e-03
3.049308e-03
## [106] -1.179995e-02  7.974077e-03 -5.822809e-03  1.858025e-03
3.132688e-02
## [111] -1.004684e-02 -1.070184e-02  4.949818e-03 -1.139985e-02
4.258920e-03
## [116] -8.521680e-03  2.421057e-03  2.926499e-02  1.329731e-02
-3.357859e-03
## [121]  6.273654e-03  1.016021e-02  5.371801e-03  1.273261e-02
1.870711e-04
## [126] -8.043385e-03 -7.543041e-04 -2.207965e-02 -9.417217e-03
1.032502e-02
## [131]  7.712920e-04  2.696335e-04 -4.430149e-03 -1.064121e-02
-1.443217e-02
## [136]  2.178669e-02 -3.728496e-03  1.418992e-02 -1.356856e-02
9.663745e-03
```

```
## [141] -5.480410e-03 -1.548367e-02  4.927049e-03  7.452044e-04
3.844957e-02
## [146] -2.279673e-02  6.565967e-03 -2.302238e-03 -7.461362e-03
-6.897377e-03
## [151] -1.131528e-02 -7.221974e-03 -6.479654e-03 -9.202501e-03
6.057387e-03
## [156] -8.910987e-03  4.576465e-03  6.168391e-03 -2.083583e-03
-9.074484e-03
## [161]  1.053527e-02 -4.049813e-03 -9.098961e-03  1.426131e-02
-3.365063e-03
## [166]  4.180331e-03  8.886020e-03  1.404477e-02  3.090990e-03
2.223241e-03
## [171] -6.810719e-03  3.095616e-03  7.500396e-03  4.303720e-03
-1.050109e-02
## [176]  6.983984e-03  7.090553e-03  8.848899e-03 -1.105958e-03
-3.970525e-03
## [181]  3.488035e-03 -3.705031e-03  1.840256e-03 -9.184851e-04
1.673877e-02
## [186]  4.803344e-02  2.120933e-03 -3.658787e-03 -3.780200e-03
-1.120314e-02
## [191] -1.571577e-03  1.577708e-02  6.162415e-03  1.160455e-02
-7.576770e-03
## [196]  1.262927e-02 -2.783174e-03  1.130537e-02  1.222752e-03
3.314722e-03
## [201] -1.599726e-02  1.109737e-02  5.942606e-04  0.000000e+00
1.843774e-02
## [206] -3.754106e-03  7.396013e-04  2.814625e-04 -4.010661e-03
-1.063232e-02
## [211] -2.249207e-03 -5.689596e-03  3.994708e-03  4.373056e-03
-9.707335e-03
## [216]  2.079427e-02 -1.977087e-03 -8.206852e-03 -5.813764e-03
3.336461e-03
## [221] -4.612545e-03  7.831040e-03 -9.980218e-04 -7.849115e-04
-3.642147e-03
## [226]  6.450867e-04  6.374919e-03  0.000000e+00 -1.992917e-03
-4.278812e-04
## [231] -1.783676e-03  1.107889e-03  2.331062e-02 -1.186125e-03
6.985192e-03
## [236] -1.838235e-02  8.833298e-04 -5.295301e-03  9.582106e-04
-3.971050e-03
## [241] -2.100208e-03  1.419757e-02 -7.104989e-03  6.341049e-03
-5.385824e-03
## [246]  5.308795e-04  4.598684e-04  1.085456e-02  6.156033e-03
-8.482286e-03
## [251]  2.201811e-02 -7.272711e-03 -1.831518e-03  1.194392e-02
-7.184735e-04
## [256]  8.901702e-04  5.630241e-02 -3.562061e-03  4.010266e-02
-4.561818e-03
## [261] -1.512915e-02 -8.318148e-03  3.053092e-03 -1.339273e-02
```

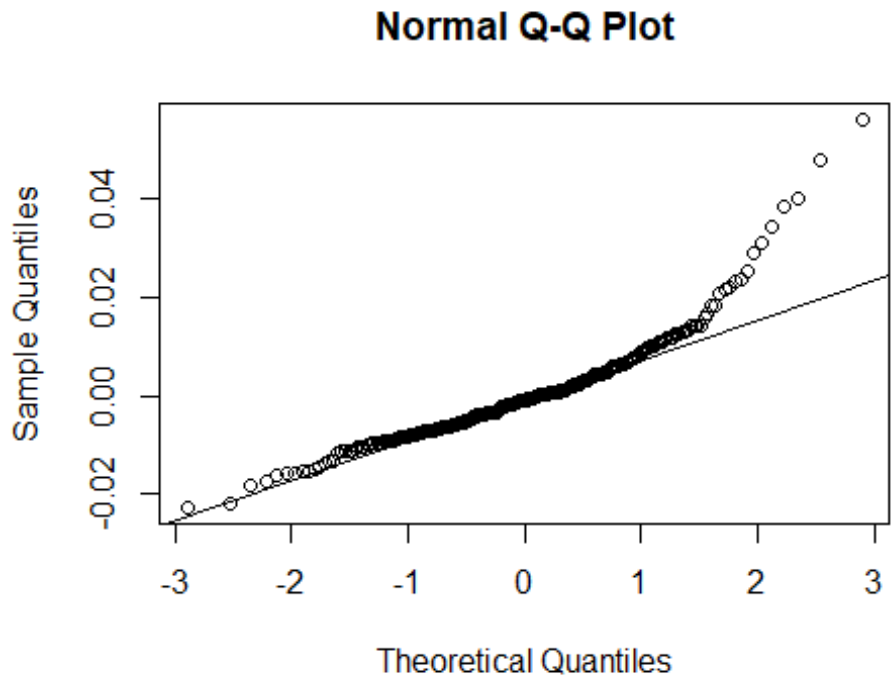
```
-9.645033e-03
## [266]  3.279118e-04 -8.621271e-03  2.387328e-02

#Calculating Daily Log Returns.
log_daily_returns<-log(data$Adj.Close[-1]/data$Adj.Close[-n])
log_daily_returns

##   [1] -8.058148e-03  4.453917e-03 -1.585248e-02  4.715471e-03
9.712545e-03
##   [6] -6.452886e-03 -6.213025e-03 -1.621089e-03 -7.114110e-03
-1.244025e-03
##  [11]  1.821983e-02 -1.630118e-02 -6.124058e-03  1.069261e-02
2.117862e-03
##  [16] -9.779414e-03 -8.294887e-03 -6.049990e-03  1.020603e-02
3.398975e-02
##  [21] -1.560353e-02 -6.267868e-03 -7.374348e-03  2.523376e-03
-9.701599e-03
##  [26] -1.147646e-03 -5.721570e-03 -5.052527e-04 -4.813719e-03
3.627005e-04
##  [31] -2.760158e-03  2.215967e-03 -7.430081e-03 -3.295636e-03
-5.332547e-03
##  [36]  1.275070e-02 -7.088097e-03  1.538838e-03  6.640858e-03
1.816717e-03
##  [41]  9.071228e-04 -6.148198e-03 -6.516850e-03 -1.141470e-02
-5.663274e-03
##  [46]  2.052860e-03 -4.409555e-03 -7.329869e-03  9.312804e-03
-6.675371e-03
##  [51]  3.762622e-04 -1.053798e-03 -6.459588e-03 -8.219482e-03
3.055835e-04
##  [56] -6.515006e-03  7.700104e-05  2.516975e-02 -3.342126e-03
-1.504932e-04
##  [61]  6.076112e-03 -1.351510e-02  1.276695e-02  4.256874e-03
-1.026224e-02
##  [66]  8.173462e-03 -3.628647e-03 -1.875528e-03 -9.390850e-04
4.537069e-03
##  [71]  3.920433e-03  1.266197e-03  7.069398e-04 -7.990812e-03
-3.266982e-03
##  [76]  1.177832e-02 -2.229959e-04 -3.426567e-03 -7.000952e-03
-4.133678e-04
##  [81]  7.514426e-04  8.042375e-03 -1.751396e-02 -1.859578e-03
-9.503328e-03
##  [86] -1.458304e-03  2.304302e-04 -1.075700e-03 -2.193257e-03
5.608319e-03
##  [91] -3.645644e-03  1.260713e-02 -9.421325e-03 -1.956331e-03
2.531045e-03
##  [96] -5.747141e-04 -5.032863e-03 -6.918380e-03 -8.999398e-03
-5.021821e-03
## [101] -7.223671e-03  7.128460e-04 -4.244909e-03 -9.146047e-03
3.044668e-03
## [106] -1.187012e-02  7.942452e-03 -5.839828e-03  1.856301e-03
```

```
3.084620e-02
## [111] -1.009765e-02 -1.075952e-02  4.937608e-03 -1.146532e-02
4.249877e-03
## [116] -8.558197e-03  2.418131e-03  2.884495e-02  1.320968e-02
-3.363510e-03
## [121]  6.254057e-03  1.010895e-02  5.357424e-03  1.265223e-02
1.870536e-04
## [126] -8.075908e-03 -7.545887e-04 -2.232706e-02 -9.461840e-03
1.027208e-02
## [131]  7.709947e-04  2.695972e-04 -4.439991e-03 -1.069823e-02
-1.453733e-02
## [136]  2.155275e-02 -3.735464e-03  1.409019e-02 -1.366145e-02
9.617349e-03
## [141] -5.495483e-03 -1.560479e-02  4.914950e-03  7.449269e-04
3.772881e-02
## [146] -2.306059e-02  6.544504e-03 -2.304892e-03 -7.489338e-03
-6.921274e-03
## [151] -1.137978e-02 -7.248179e-03 -6.500738e-03 -9.245105e-03
6.039114e-03
## [156] -8.950927e-03  4.566025e-03  6.149444e-03 -2.085757e-03
-9.115908e-03
## [161]  1.048016e-02 -4.058036e-03 -9.140610e-03  1.416057e-02
-3.370738e-03
## [166]  4.171618e-03  8.846772e-03  1.394706e-02  3.086223e-03
2.220773e-03
## [171] -6.834017e-03  3.090834e-03  7.472407e-03  4.294485e-03
-1.055661e-02
## [176]  6.959709e-03  7.065534e-03  8.809977e-03 -1.106570e-03
-3.978428e-03
## [181]  3.481966e-03 -3.711912e-03  1.838565e-03 -9.189072e-04
1.660022e-02
## [186]  4.691550e-02  2.118687e-03 -3.665497e-03 -3.787363e-03
-1.126637e-02
## [191] -1.572813e-03  1.565391e-02  6.143505e-03  1.153774e-02
-7.605620e-03
## [196]  1.255019e-02 -2.787054e-03  1.124194e-02  1.222005e-03
3.309240e-03
## [201] -1.612660e-02  1.103625e-02  5.940841e-04  0.000000e+00
1.826982e-02
## [206] -3.761170e-03  7.393280e-04  2.814229e-04 -4.018725e-03
-1.068925e-02
## [211] -2.251740e-03 -5.705844e-03  3.986751e-03  4.363522e-03
-9.754758e-03
## [216]  2.058102e-02 -1.979044e-03 -8.240714e-03 -5.830730e-03
3.330907e-03
## [221] -4.623215e-03  7.800537e-03 -9.985201e-04 -7.852197e-04
-3.648795e-03
## [226]  6.448788e-04  6.354685e-03  0.000000e+00 -1.994906e-03
-4.279728e-04
## [231] -1.785268e-03  1.107276e-03  2.304308e-02 -1.186829e-03
```

```
6.960908e-03
## [236] -1.855341e-02  8.829399e-04 -5.309371e-03  9.577518e-04
-3.978956e-03
## [241] -2.102416e-03  1.409773e-02 -7.130350e-03  6.321029e-03
-5.400379e-03
## [246]  5.307386e-04  4.597627e-04  1.079607e-02  6.137162e-03
-8.518466e-03
## [251]  2.177921e-02 -7.299286e-03 -1.833198e-03  1.187315e-02
-7.187317e-04
## [256]  8.897742e-04  5.477452e-02 -3.568420e-03  3.931942e-02
-4.572255e-03
## [261] -1.524476e-02 -8.352937e-03  3.048440e-03 -1.348322e-02
-9.691847e-03
## [266]  3.278581e-04 -8.658649e-03  2.359277e-02

#Generating Descriptive Statistics of the daily_returns.
summary(daily_returns)

##       Min.    1st Qu.     Median       Mean    3rd Qu.       Max.
## -0.0227967 -0.0064490 -0.0009683  0.0003960  0.0045547  0.0563024

skew<-skewness(daily_returns)
kurt<-kurtosis(daily_returns)
skew

## [1] 1.615048

kurt

## [1] 8.056492

mean_as=mean(daily_returns)
median_as=median(daily_returns)
mode_as=mode(daily_returns)
descStat<-data.frame(c("Mean","Median","Mode","skewness","kurtosis"),c(mean_a
s,median_as,mode_as,skew,kurt))
colnames(descStat)<-c("statistic","Values")
descStat

##   statistic                Values
## 1      Mean  0.000395983972323965
## 2    Median -0.000968332989242315
## 3      Mode               numeric
## 4  skewness       1.6150479408691
## 5  kurtosis      8.05649213594032

#Conducting normality test::

##Histogram Plot.
hist(daily_returns,freq = FALSE,main="Distribution of Daily Returns for Gsk
Pharma",xlab = "Daily_Returns",ylab = "Density",breaks = 20)
lines(density(daily_returns))
```




```
#Q-Q Plot.

car<-mtcars
qqnorm(daily_returns)
qqline(daily_returns)


#Parametric Tests:

#Jarque_Bera Test
library(tseries)

## Warning: package 'tseries' was built under R version 4.2.3

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




```
jarque.bera.test(daily_returns)
```

```
##
##  Jarque Bera Test
##
## data:  daily_returns
## X-squared = 402.02, df = 2, p-value < 2.2e-16
```

```
#Shapiro Wilk Test
shapiro.test(daily_returns)
```

```
##
##  Shapiro-Wilk normality test
##
## data:  daily_returns
## W = 0.89507, p-value = 1.104e-12
```

```
# Kolmogorov_Smirnov Goodness of Fit Test
ks.test(daily_returns, "pnorm")
```

```
## Warning in ks.test.default(daily_returns, "pnorm"): ties should not be
present
## for the Kolmogorov-Smirnov test

##
##  Asymptotic one-sample Kolmogorov-Smirnov test
##
## data:  daily_returns
```

```
## D = 0.49091, p-value < 2.2e-16
## alternative hypothesis: two-sided

# Lilliefors Test (using the nortest package)
library(nortest)
lillie.test(daily_returns)

##
##  Lilliefors (Kolmogorov-Smirnov) normality test
##
## data:  daily_returns
## D = 0.1131, p-value = 7.822e-09

# Anderson-Darling Test (using the nortest package)
ad.test(daily_returns)

##
##  Anderson-Darling normality test
##
## data:  daily_returns
## A = 5.6362, p-value = 6.396e-14
```

INTERPRETATIONS:

1.Mean: The mean return is approximately 0.0003960, which indicates that, on average, the stock tends to have a positive daily return.

2. **Median:** The median return is approximately -0.0009683.

when all returns are sorted from lowest to highest. This value being slightly negative.Suggesting that there might be some days where the returns are lower, dragging the median down.

3. **Mode:** The mode is 0

4. **Variance:** The variance is 0.0003, which indicates the spread or dispersion of daily returns around the mean. A lower variance generally implies less volatility in the stock's daily returns.

5. **Standard Deviation** (STD DEV): The standard deviation is approximately 0.0173. It is a measure of how spread out the returns are from the mean. A higher standard deviation indicates greater volatility or risk.

6. **Kurtosis:** The kurtosis value of 8.05649213594032 is greater than 3. This suggests that the distribution of returns has heavier tails than a normal distribution. In stock terms, this means that there may be occasional extreme returns, both positive and negative, more frequently than a normal distribution would suggest.

7. **Skewness:** The skewness value of 1.6150479408691 is positive, indicating that the distribution of returns is slightly skewed to the right (positively skewed). This suggests that there may be more positive returns or "up" days than negative returns or "down" days, though the skewness is not extremely pronounced.

Histogram Plot

The histogram shows that the stock returns are very volatile, with a wide range of values. The density plot shows that the distribution of stock returns is skewed to the right, with more positive returns than negative returns. The density plot shows that the stock returns are not normally distributed. This is because the normal distribution is symmetrical, but the density plot is skewed to the left. The tails of the plot represent the probability of extreme positive or negative returns. If these tails are ‘fat’ or longer, it indicates a higher likelihood of extreme returns, which is a risk for investors.

Q-Q PLOT

According to the plot, the points on the QQ plot deviate from the straight line, particularly in the tails of the distribution. This suggests that the distribution of the daily stock returns is not normally distributed, especially at the end, i.e The tail .

-The points in the middle of the graph are closer to the straight line than the points in the tails. This means that the center of the sample distribution is closer to normality than the tails.

-The points in the lower tail of the graph deviate from the straight line more than the points in the upper tail. This means that there are more extreme values in the lower tail of the distribution than in the upper tail.

Parametric Tests

Null Hypothesis: Data follows Normal Distribution.

H_1 : Data is not Normally Distributed.

if the p-value is less than your chosen significance level -> 0.05, you would reject the null hypothesis.

Jarque-Bera Test: The p-value is extremely small (much less than 0.05), so you reject the null hypothesis. This suggests that the data does not follow a normal distribution.

Shapiro-Wilk Normality Test: The p-value is extremely small (much less than 0.05), so you reject the null hypothesis. This suggests that the data does not follow a normal distribution.

Kolmogorov-Smirnov (KS) Test: The p-value is extremely small (much less than 0.05), so you reject the null hypothesis. This suggests that the data does not follow a normal distribution.

Lilliefors Test: The p-value is extremely small (much less than 0.05), so you reject the null hypothesis. This suggests that the data does not follow a normal distribution.

Anderson-Darling Test: The p-value is extremely small (much less than 0.05), so you reject the null hypothesis. This suggests that the data does not follow a normal distribution.

Interpretation: Data is not Normally Distributed.

Conclusion:

This analysis of **Glaxosmithkline Pharmaceuticals Limited** daily returns exhibits fat tails, with a kurtosis of **8.05649213594032**. This exceeds the kurtosis of 3 for a normal distribution, indicating more extreme returns and outliers. The fat tails align with the empirical regularity that stock returns have excess kurtosis.

The distribution shows evidence of asymmetry, with a positive skewness of **1.6150479408691** This right skew suggests there are more large positive returns than negative ones. The gain/loss asymmetry is consistent with findings that stock return distributions tend to be skewed to the right rather than symmetric.

The daily returns do not follow a normal distribution based on statistical tests,although the Central Limit Theorem indicates that the aggregation of non-normal returns approaches a normal distribution with a large enough time period.Thus analysis of the distributional properties and normality tests confirms that **Glaxosmithkline Pharmaceuticals Limited** daily stock returns exhibit fat tails, asymmetry, and aggregated normality.