Financial Econometrics Assignment 3

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Due data: November 11, 2024

Question 1. Please see JD.csv data which includes some monthly stock price information like adjusted closing price etc. for JD.com.

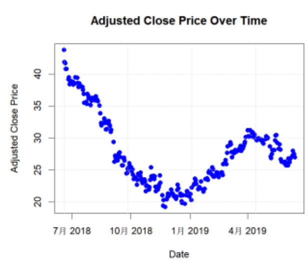
a. Write R code to calculate monthly returns for JD stock using adjusted closing prices.

```
> # Read data
> JD_data <- read.csv("JD.csv")
>
> # 计算每日对数收益率
> JD_data$Return <- c(NA, diff(log(JD_data$Adj.Close)))
>
> # 移除包含 NA 的行
> JD_data <- na.omit(JD_data)
>
> # 输出计算后的收益率
> print(JD_data$Return)
```

```
  [1]  0.0038923462 -0.0436730013 -0.0050257136 -0.0208492401
  [5]  0.0000000000 -0.0410057449  0.0073745025 -0.0277439320
  [9]  0.0139681787  0.0005136364 -0.0041162908 -0.0106259906
 [13]  0.0041601723  0.0235907863 -0.0015216082 -0.0207726915
 [17] -0.0167236454  0.0149080567 -0.0065112875 -0.0060280355
 [21] -0.0013152441 -0.0121824333 -0.0174711607 -0.0378551352
 [25]  0.0042153218 -0.0098633742  0.0445871172 -0.0076128430
 [29] -0.0118052164 -0.0294262233  0.0197134232  0.0116441016
 [33]  0.0002756511 -0.0033122581 -0.0074926395  0.0165749094
 [37] -0.0137933221  0.0005554013 -0.0064057870 -0.0203224886
 [41] -0.0348164268 -0.0456065142 -0.0121251913  0.0077894770
 [45]  0.0251315701 -0.0072904940 -0.0141236308 -0.0298155152
 [49]  0.0003185539  0.0396492715 -0.0157337201 -0.0065512322
 [53] -0.0301850076  0.0096308611 -0.0616035034 -0.1124456611
 [57]  0.0354846199 -0.0110701866 -0.0157071286  0.0208884503
 [61]  0.0197374466  0.0046940329 -0.0236934352 -0.0522450741
 [65]  0.0007770008  0.0444348777  0.0003714020 -0.0164736035
 [69] -0.0776861057  0.0012232825  0.0265395542  0.0090855452
 [73]  0.0256225197 -0.0232658808 -0.0234184149  0.0095923599
 [77] -0.0331611063 -0.0292052040  0.0113660664 -0.0046149862
 [81] -0.0460396212  0.0333436829  0.0404812619 -0.0127600826
 [85]  0.0200949973 -0.0393343615 -0.0148907240 -0.0138111820
 [89]  0.0227722403 -0.0132565975 -0.0653711248  0.0361049603
 [93]  0.0008861764 -0.0269316097  0.0180347092  0.0496834648
 [97]  0.0788646593 -0.0565808273  0.0041494251 -0.0230376681
[101]  0.0197195398 -0.0719052929 -0.0317486522  0.0141845889
[105]  0.0171174904  0.0163902233  0.0613480652 -0.0486869484
[109] -0.0879188168 -0.0798453957  0.0426878771 -0.0540399082
[113]  0.0599222292  0.0184025052  0.0255816419 -0.0193630616
[117]  0.0123224785  0.0360816198 -0.0257722035 -0.0103094163
[121] -0.0142317393 -0.0202709644  0.0193149414  0.0458023524
[125]  0.0367754462 -0.0240652885 -0.0376882840 -0.0146263043
[129] -0.0422290834 -0.0129742339  0.0571026056 -0.0651712323
[133]  0.0661195491  0.0280392661  0.0004606312 -0.0365894014
[137]  0.0161140928 -0.0442167173  0.0901595694  0.0217641280
[141]  0.0083133708  0.0317350803 -0.0123170380 -0.0224728996
[145] -0.0374040931  0.0094829790  0.0035890572 -0.0085451837
[149]  0.0493492650 -0.0703449705  0.0132876643  0.0058997676
[153]  0.0669394404  0.0038014831 -0.0084674089  0.0465199751
[157]  0.0084866545 -0.0088925810 -0.0139003873  0.0454714816
[161] -0.0122700528 -0.0460460634  0.0004169273  0.0120159305
```

```
[165]  0.0163401917 -0.0028402940 -0.0114427482 -0.0153244253
[169]  0.0279853666  0.0016221010 -0.0167521793  0.0669306284
[173]  0.0092060486  0.0151575086 -0.0235932181  0.0648513356
[177]  0.0361485502  0.0055536069  0.0157970664 -0.0109627338
[181] -0.0418559770 -0.0287868671  0.0208532159  0.0175852363
[185]  0.0007111665 -0.0085684212  0.0014332142  0.0074906362
[189]  0.0060230477 -0.0081574846  0.0239279537 -0.0267810227
[193]  0.0138324251  0.0146855791  0.0120753928  0.0085368454
[197]  0.0248501706  0.0361544018 -0.0315216669  0.0006600000
[201] -0.0019814736  0.0322031405 -0.0145093306  0.0035661895
[205] -0.0239081307  0.0009939043  0.0121771784 -0.0302197992
[209]  0.0083935359 -0.0020080328  0.0053458196 -0.0120685340
[213]  0.0043749354 -0.0040377241 -0.0146037576 -0.0034270425
[217]  0.0249186895  0.0134698968 -0.0023151655 -0.0069779647
[221]  0.0019986349 -0.0459654701 -0.0562570678 -0.0088856567
[225]  0.0227951418  0.0237080070  0.0003549246  0.0515239278
[229]  0.0256211315  0.0006567488 -0.0384855940 -0.0329489837
[233]  0.0240387119 -0.0286332066 -0.0557216394 -0.0143344964
[237] -0.0011404297 -0.0107075973  0.0129871955 -0.0226453738
[241]  0.0000000000  0.0395789490 -0.0230241535  0.0019072674
[245]  0.0211168861  0.0170185761  0.0267840839 -0.0275180289
[249]  0.0109530483 -0.0179525613
```

b. Fit the generalized t distribution (see the functions that I defined in the Appendix) to the daily returns of JD. You are not allowed to use external packages. (You can of course use optim function of R.) You need to use maximum likelihood method to estimate the three parameters (location, scale, and degrees of freedom) of the t distribution. For the same purpose we can use fitdistrplus package. Please compare the results from these two different ways of distribution fitting.



Observing the graph, the data shows a clear downward trend followed by a relatively stable fluctuation phase, which may suggest the presence of some outliers or data skewness. These characteristics could make the t-distribution a suitable choice for fitting the data, particularly when the sample size is small. So I anticipate that the fit of the t-distribution should be relatively good. Next, actual fitting will be conducted to further determine the degree of fit.

```
> # Define the PDF and CDF
> dt_G <- function(x, params) {
+     location <- params[1]
+     scale <- params[2]
+     shape <- params[3]
+     return(dt((x - location) / scale, df = shape) / scale)
+ }
> # Create a function for the probability density function (PDF) of the Gene
ralized t-distribution
>
> pt_G <- function(q, location, scale, shape) {
+     return(pt((q - location) / scale, df = shape))
+ }
> # Create a function for the cumulative distribution function (CDF) of the
Generalized t-distribution
>
> # Fit a Generalized t Distribution Using MLE
> neg_log_likelihood <- function(params, data) {
+     log_density <- sapply(data, function(x) log(dt_G(x, params)))
+     return(-sum(log_density))
```

```
+ }
> # Define the negative log-likelihood function for Maximum Likelihood Estim
ation (MLE)
>
> returns_data <- JD_data$Return
> initial_params <- c(location = mean(returns_data), scale = sd(returns_dat
a), shape = 5)
> mle_result <- optim(par = initial_params, fn = neg_log_likelihood, data =
returns_data,
+                      method = "L-BFGS-B", lower = c(-Inf, 0.001, 2), upper
= c(Inf, Inf, Inf))
> mle_params <- mle_result$par
> # Perform MLE to estimate the parameters of the Generalized t-distribution
>
> # Utilize the fitdistrplus package for comparison
> library(fitdistrplus)
> # Load the fitdistrplus package for additional fitting methods
>
> # Define the PDF and CDF required for fitdistrplus
> ddt_G_fitdistr <- function(x, location, scale, shape) {
+     return(dt((x - location) / scale, df = shape) / scale)
+ }
> pdt_G_fitdistr <- function(q, location, scale, shape) {
+     return(pt((q - location) / scale, df = shape))
+ }
> # Create functions for fitdistrplus to use the Generalized t-distribution
>
> fit_result <- fitdist(JD_data$Return, "dt_G_fitdistr", start = list(locati
on = mean(returns_data), scale = sd(returns_data), shape = 5))
> # Fit the distribution using fitdistrplus with initial parameter estimates
>
> # Compare the results of MLE and fitdistrplus
> cat("MLE Results:\n")
MLE Results:
> print(mle_params)
    location        scale        shape
-0.001561329  0.025491936  6.711448675
> # Print the parameters estimated by MLE
>
> cat("\nfitdistrplus Results:\n")
fitdistrplus Results:
> print(fit_result$estimate)
    location        scale        shape
-0.001564296  0.025456360  6.708586251
> # Print the parameters estimated by fitdistrplus
```

Conclusion:

The closeness of the parameter estimates obtained from MLE and the ‘fitdistrplus’ package indicates the robustness of the parameter estimation and the rationality of model selection, providing a solid foundation for further statistical analysis.

1. Consistency in Parameter Estimation:

The parameter estimates obtained through Maximum Likelihood Estimation (MLE) and the `fitdistrplus` package are very close. This indicates that both methods are consistent when estimating the parameters of the Generalized t-distribution.

2. Reliability of the Methods:

The similarity in results from two distinct methods bolsters confidence in the reliability of the parameter estimates, indicating that both direct optimization and specialized statistical software yield robust estimates.

Appendix.

```
# for maximum likelihood method
# Density of t distribution with location, scale, and degrees of freedom
dt_G<-function(x,params){#density
  loc<-params[1]
  sc<-params[2]
  nu<-params[3]
  dt((x-loc)/sc,nu)/sc
}

# for fitdistrplus package
dt_G<-
  function(x,loc,sc,nu){ dt((x
  -loc)/sc,nu)/sc
}

# CDF of t distribution with location, scale, and degrees of freedom
pt_G<-
  function(q,loc,sc,nu){ pt((q
  -loc)/sc,nu)
}
```