

Calculating Univariate Volatility Estimation

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Installing relevant packages.

```
warning=FALSE  
library('rugarch')
```

```
## Loading required package: parallel
```

```
##
```

```
## Attaching package: 'rugarch'
```

```
## The following object is masked from 'package:stats':
```

```
##
```

```
##      sigma
```

```
library('evir')  
library('gmm')
```

```
## Warning: package 'gmm' was built under R version 4.3.3
```

```
## Loading required package: sandwich
```

```
library('ggplot2')
```

```
## Warning: package 'ggplot2' was built under R version 4.3.3
```

```
##
```

```
## Attaching package: 'ggplot2'
```

```
## The following object is masked from 'package:evir':
```

```
##
```

```
##      qplot
```

```
library('data.table')
```

```
## Warning: package 'data.table' was built under R version 4.3.2
```

Selecting the first ten stocks for analysis from the Finance dataset.

```
data(Finance)
```

```
mydata<-Finance[,1:10]/100
```

```
mydata<-log(mydata+1)
```

```
mydata$t<-1:nrow(Finance)
```

```
dt<-data.table(mydata)
```

```
dt
```

```
##           WMK      UIS      ORB      MAT      ABAX  
## 1: 0.000000000 0.04726949 0.000000000 0.0186414355 -0.04349182  
## 2: 0.004803862 0.03535627 0.074143224 0.0140545184 0.11564949
```

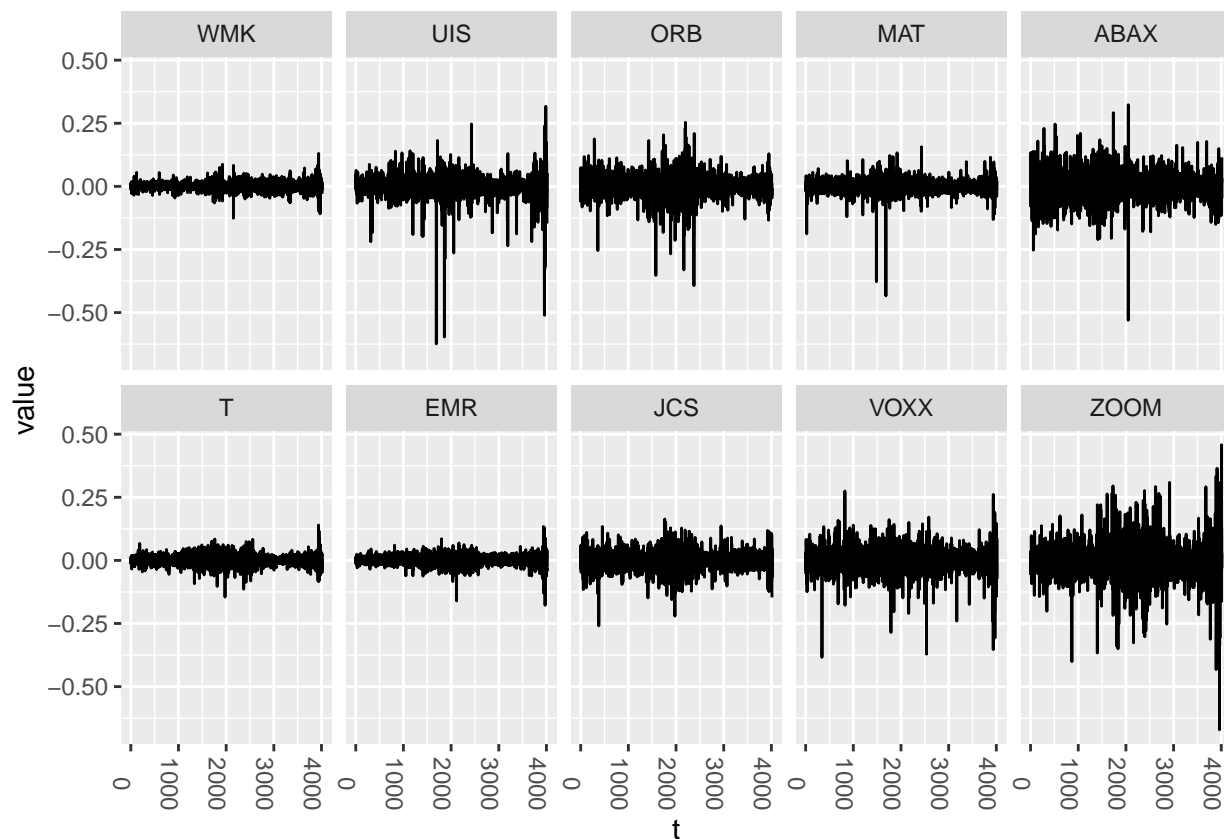
```
##      3:  0.004780895  0.00000000 -0.018869039 -0.0187235558  0.07149052
##      4: -0.009654212 -0.01128904 -0.060035510 -0.0202260911 -0.07699765
##      5: -0.014694404  0.00000000  0.038471118 -0.0194743062  0.13374461
##      ---
## 4008:  0.011169951  0.01149451  0.013226379 -0.0106455765  0.03295730
## 4009:  0.016779314  0.04397037  0.010244915  0.0006648937  0.01620931
## 4010: -0.010481079  0.05210721  0.005659340  0.0227440122  0.03206557
## 4011: -0.023023151 -0.11653482 -0.046817847 -0.0412835931 -0.04641190
## 4012: -0.028881338 -0.14717743 -0.006559379 -0.0415904401  0.11467029
##              T              EMR              JCS              VOXX              ZOOM      t
##      1: -0.0019821619  0.0039525795 -0.02339393  0.03173125 -0.05800306  1
##      2:  0.0098137006  0.0142862020 -0.02600291 -0.03277122  0.03491820  2
##      3:  0.0019588651 -0.0118268189  0.02534386 -0.01733420  0.03384435  3
##      4: -0.0139031276  0.0065274616  0.06047697  0.01703884 -0.04960593  4
##      5:  0.0000000000  0.0000000000 -0.03214159  0.03173125  0.02758821  5
##      ---
## 4008:  0.0264660246  0.0006157636  0.10161240 -0.01833096  0.03727579 4008
## 4009: -0.0347157433  0.0269655426 -0.06710833 -0.05367349  0.13010807 4009
## 4010: -0.0007719028  0.0397113449  0.01162817  0.08638418  0.07041093 4010
## 4011: -0.0485822091 -0.0422913318  0.04658023 -0.07374980 -0.03109305 4011
## 4012: -0.0036555727 -0.0302795375 -0.14662968 -0.05323989  0.03015536 4012
```

Melting and plotting volatility for the selected stocks.

```
dt.molten<-melt.data.table(data=dt,id.vars='t',variable.name='stock')
dt.molten
```

```
##      t stock      value
##      1:  1  WMK  0.000000000
##      2:  2  WMK  0.004803862
##      3:  3  WMK  0.004780895
##      4:  4  WMK -0.009654212
##      5:  5  WMK -0.014694404
##      ---
## 40116: 4008  ZOOM  0.037275792
## 40117: 4009  ZOOM  0.130108067
## 40118: 4010  ZOOM  0.070410932
## 40119: 4011  ZOOM -0.031093053
## 40120: 4012  ZOOM  0.030155358
```

```
ggplot(data=dt.molten,aes(x=t,y=value))+geom_line()+facet_wrap(~stock,ncol=5)+theme(axis.text.x=element.
```



Finding minimum volatility of the selected stocks.

```
apply(X=mydata[, -ncol(mydata)], MARGIN=2, FUN='min')
```

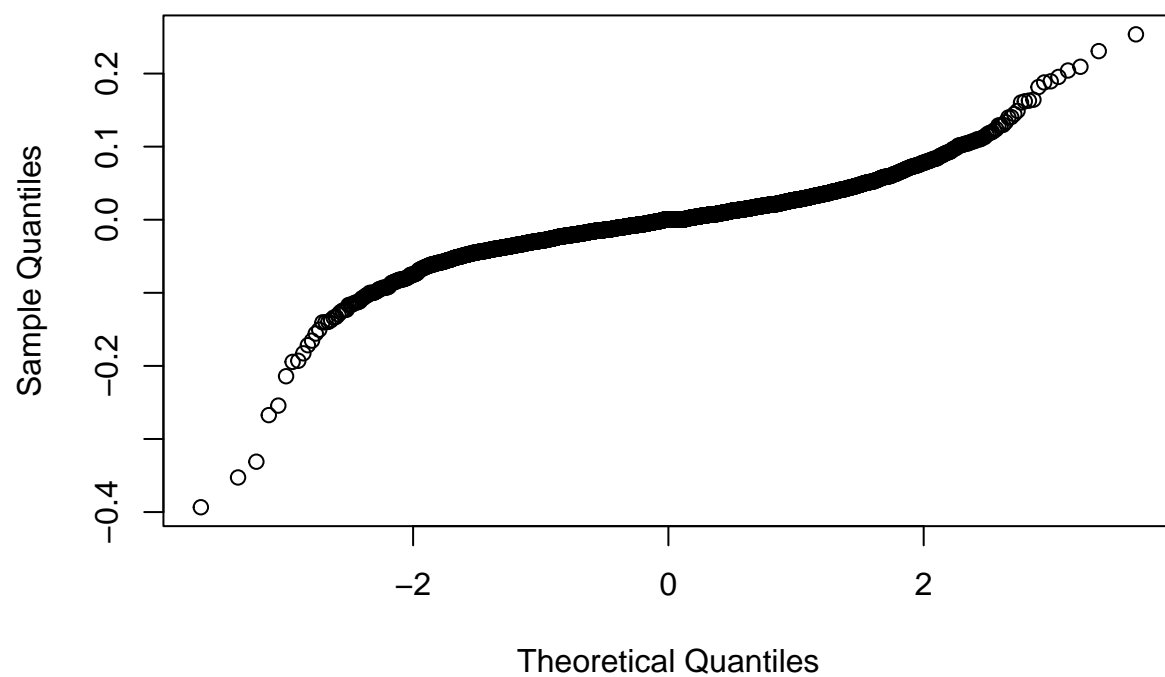
```
##      WMK      UIS      ORB      MAT      ABAX      T      EMR
## -0.1258112 -0.6239906 -0.3933755 -0.4336807 -0.5304193 -0.1452894 -0.1777719
##      JCS      VOXX      ZOOM
## -0.2592147 -0.3839840 -0.6710858
```

Analyzing ORB's volatility using qq-plot, hill plot, and plot of sample autocorrelations.

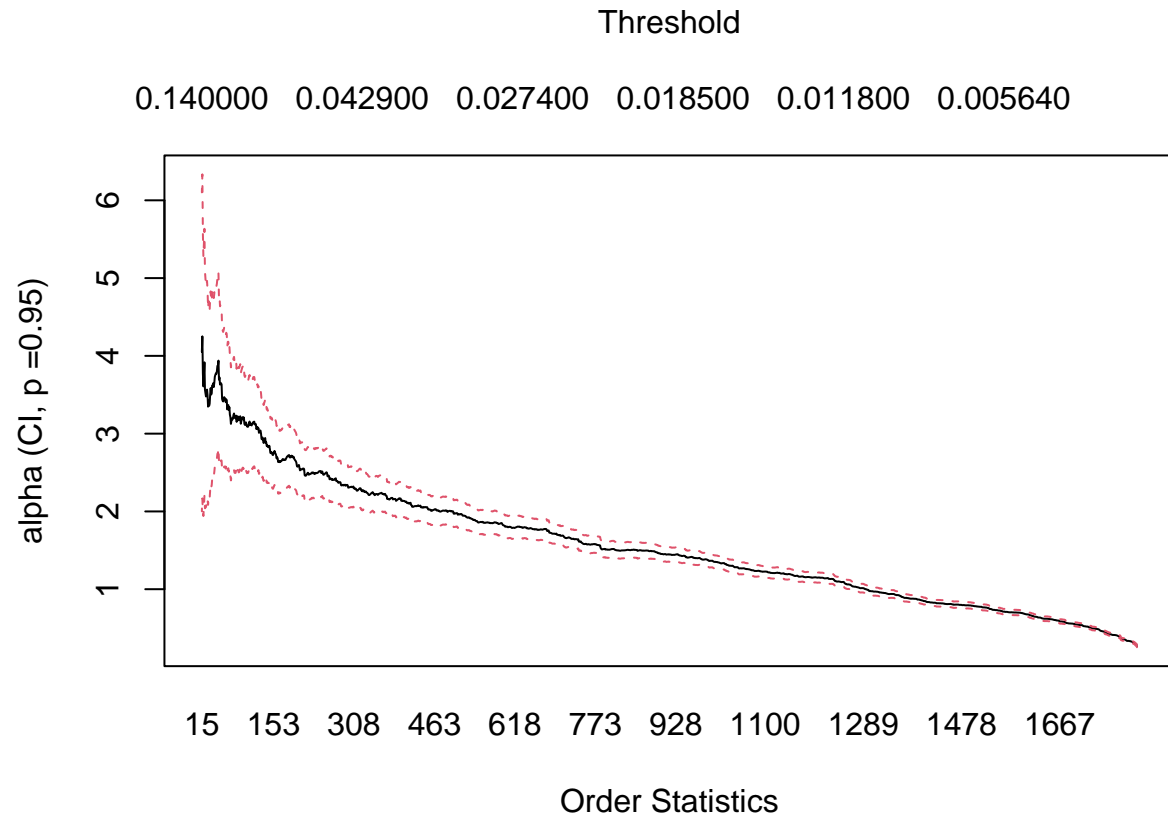
```
x<-mydata[, 'ORB'] # data
```

```
myqqnorm<-qqnorm(y=x)
```

Normal Q-Q Plot

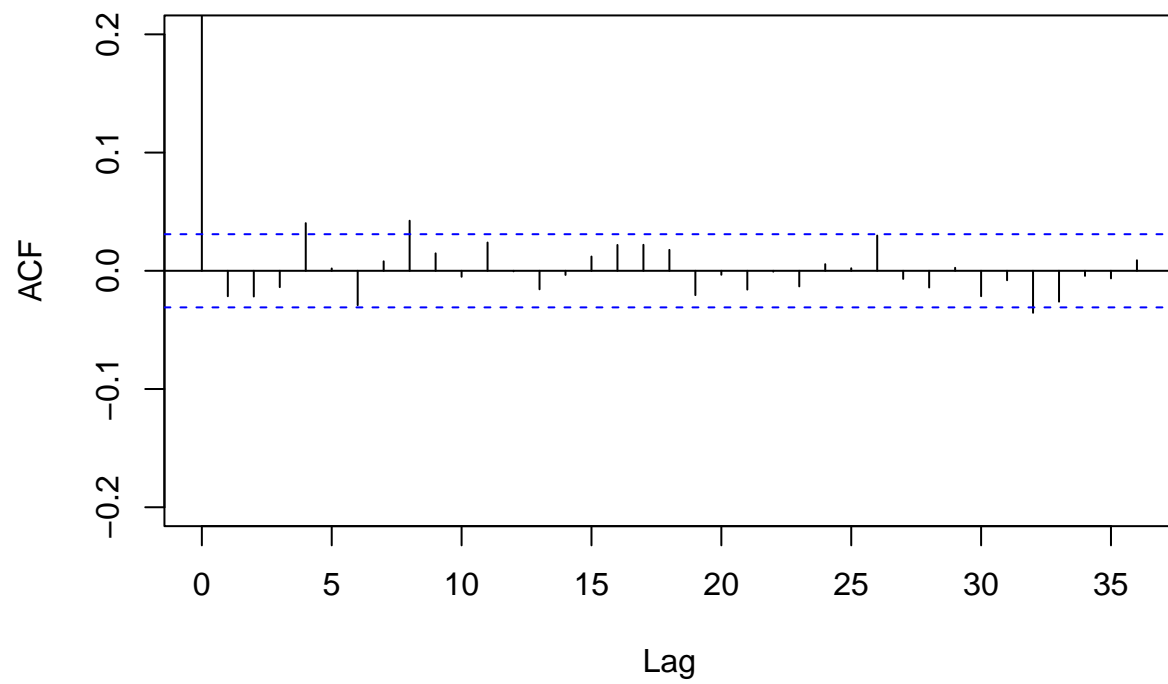


```
myhill<-hill(data=x)
```



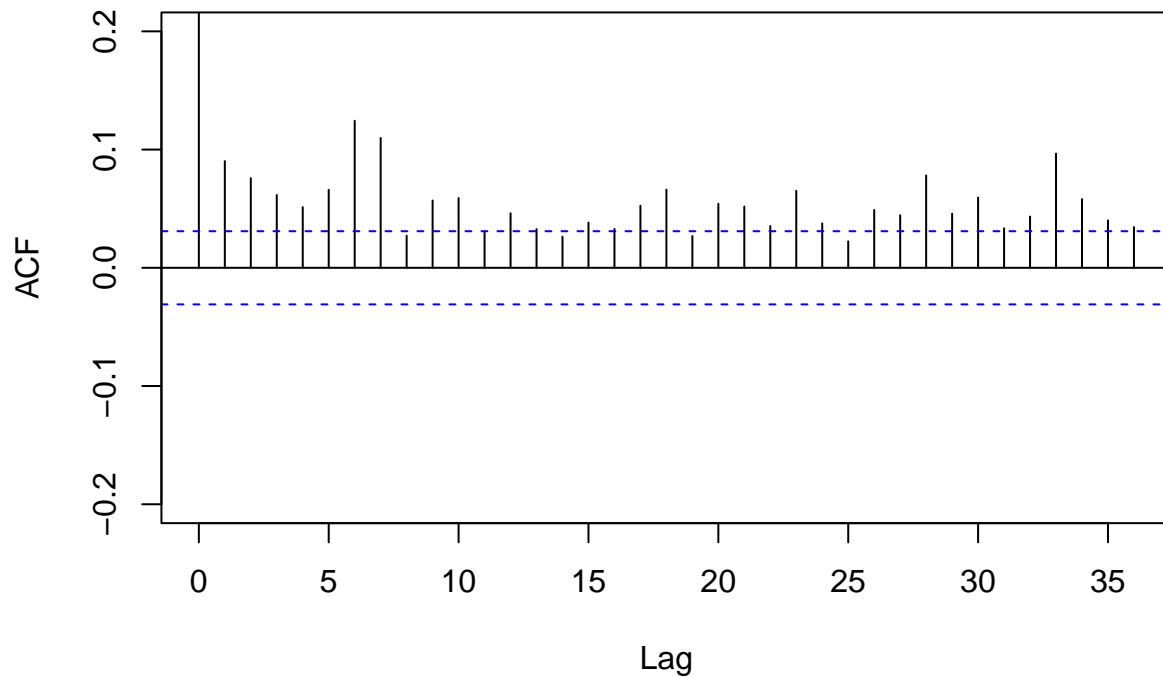
```
myacf<-acf(x=x,ylim=c(-0.2,0.2)) # correlogram of the data
```

Series x



```
myacf2<-acf(x=x^2,ylim=c(-0.2,0.2)) # correlogram of the squared data
```

Series x^2



Univariate volatility estimation using GARCH models

Estimating GARCH(1,1) model to calculate volatility.

```
spec1 = ugarchspec(variance.model=list(model="sGARCH", garchOrder=c(1,1),
                                       variance.targeting=TRUE),
                  mean.model=list(armaOrder=c(0,0), include.mean=TRUE),
                  distribution.model="std")#specifications for model (1)

fit1 = ugarchfit(data = x, spec = spec1)
names(fit1@fit)
```

## [1]	"hessian"	"cvar"	"var"	"sigma"
## [5]	"condH"	"z"	"LLH"	"log.likelihoods"
## [9]	"residuals"	"coef"	"robust.cvar"	"A"
## [13]	"B"	"scores"	"se.coef"	"tval"
## [17]	"matcoef"	"robust.se.coef"	"robust.tval"	"robust.matcoef"
## [21]	"fitted.values"	"convergence"	"kappa"	"persistence"
## [25]	"timer"	"ipars"	"solver"	

Calculating conditional volatility.

```
fit1@fit$matcoef
```

##		Estimate	Std. Error	t value	Pr(> t)
## mu		-2.150934e-04	3.950220e-04	-0.5445097	0.5860907
## alpha1		4.895427e-02	2.122273e-04	230.6690539	0.0000000
## beta1		9.446845e-01	7.164942e-05	13184.8167532	0.0000000

```
## shape 4.503119e+00 2.165887e-01 20.7911129 0.0000000
## omega 8.759378e-06 NA NA NA
```

```
fit1@fit$sigma
```

```
## [1] 0.03710785 0.03618819 0.03894329 0.03819010 0.03951896 0.03946371
## [7] 0.03870929 0.03799275 0.03912259 0.03836475 0.03959223 0.03883437
## [13] 0.04019809 0.04014243 0.03919207 0.03877953 0.03780777 0.03803841
## [19] 0.03941269 0.03867084 0.03795573 0.03798649 0.03703939 0.03717950
## [25] 0.03725423 0.03658249 0.03916559 0.03897292 0.03882817 0.03875490
## [31] 0.04186693 0.04104446 0.04240986 0.04132635 0.04027601 0.03925797
## [37] 0.03827138 0.03760491 0.03696463 0.03735492 0.03898414 0.03919363
## [43] 0.03931727 0.03832884 0.03737108 0.03644319 0.03681149 0.03622983
## [49] 0.03568707 0.03613028 0.03557613 0.03470464 0.03515887 0.03567011
## [55] 0.03513309 0.03461977 0.03377859 0.03332022 0.03252054 0.03328817
## [61] 0.03288708 0.03358862 0.03434458 0.03351215 0.03270631 0.03235041
## [67] 0.03203177 0.03293937 0.03255020 0.03346277 0.03265851 0.03230035
## [73] 0.03239262 0.03172984 0.04053573 0.03950969 0.04090947 0.04014334
## [79] 0.04192370 0.04092755 0.03997436 0.03926724 0.03956820 0.03864878
## [85] 0.03843377 0.03783467 0.03828892 0.04392125 0.04303431 0.04217918
## [91] 0.04136606 0.04132458 0.04027430 0.03988198 0.03893895 0.03803088
## [97] 0.03772108 0.04214052 0.04106525 0.04022937 0.04122552 0.04113174
## [103] 0.04008737 0.03932975 0.03861139 0.03764484 0.03699092 0.03607492
## [109] 0.03548219 0.03491315 0.03532797 0.03564059 0.03600765 0.03627747
## [115] 0.03538387 0.03574131 0.03486461 0.03401565 0.03350588 0.03512328
## [121] 0.03683212 0.03592110 0.03731020 0.03743442 0.03677695 0.03691395
## [127] 0.03600036 0.03511549 0.03541738 0.03563588 0.03537714 0.03511301
## [133] 0.03425617 0.03461324 0.03488146 0.03767101 0.03695858 0.03627038
## [139] 0.03537700 0.03451181 0.03367406 0.03488298 0.03789522 0.03782725
## [145] 0.03780820 0.03710596 0.03643185 0.03578161 0.03515808 0.03455689
## [151] 0.03371771 0.03290529 0.03316007 0.03580776 0.03580151 0.03492290
## [157] 0.03492659 0.03429067 0.03345996 0.03314054 0.03362692 0.03357089
## [163] 0.03295181 0.03236032 0.03232702 0.04154982 0.04049264 0.03990214
## [169] 0.03889563 0.03866942 0.03987125 0.04173741 0.04067448 0.04060555
## [175] 0.04001957 0.03900944 0.03814736 0.03821828 0.03726396 0.03658988
## [181] 0.03734837 0.03821739 0.03801174 0.03706385 0.03649512 0.03691280
## [187] 0.03607985 0.03554324 0.03599609 0.03519215 0.03664936 0.03612333
## [193] 0.03691759 0.03641321 0.03648519 0.03603864 0.03515256 0.03441380
## [199] 0.03462644 0.03389994 0.03320406 0.03888942 0.03910465 0.03941579
## [205] 0.04264916 0.04264715 0.04202836 0.04098714 0.04074500 0.03974178
## [211] 0.03903565 0.04090868 0.03998261 0.03975927 0.03879302 0.03794874
## [217] 0.03713739 0.03651073 0.03574175 0.03486503 0.03456044 0.03372115
## [223] 0.03290862 0.03347986 0.03303505 0.03328769 0.03488223 0.03437849
## [229] 0.03446317 0.03394870 0.03345501 0.03279977 0.03216352 0.03585430
## [235] 0.03497403 0.03424325 0.03455466 0.03478508 0.03397231 0.03446965
## [241] 0.03502117 0.03419701 0.03349060 0.03382050 0.03313378 0.03246659
## [247] 0.03224489 0.03162087 0.03228622 0.03151985 0.03210758 0.03149379
## [253] 0.03135208 0.03125242 0.03185967 0.03318095 0.03251389 0.03293878
## [259] 0.03228719 0.03152079 0.03110184 0.03069651 0.03143219 0.03073284
## [265] 0.03098566 0.03030448 0.02974439 0.02909423 0.02858866 0.02799037
## [271] 0.02740837 0.02680348 0.02693900 0.02653336 0.02675029 0.02700159
## [277] 0.02662295 0.02688122 0.02650072 0.02613033 0.02578191 0.02575679
## [283] 0.02572943 0.02619349 0.02563023 0.02508652 0.04831289 0.05169196
## [289] 0.05092489 0.05021828 0.04906477 0.04793549 0.05611135 0.05466139
## [295] 0.05365182 0.05243824 0.05276496 0.05148043 0.05178151 0.05047101
```


[301] 0.05075269 0.04997229 0.05060291 0.04949231 0.04842970 0.04774299
 ## [307] 0.04677029 0.04677597 0.04563712 0.04445560 0.04339290 0.04355494
 ## [313] 0.04274598 0.04298461 0.04196930 0.04089927 0.04021936 0.03956184
 ## [319] 0.03986850 0.03894551 0.03828482 0.03750050 0.03659109 0.03643238
 ## [325] 0.03698187 0.03727042 0.03694149 0.03611973 0.03552862 0.03517345
 ## [331] 0.03496797 0.03422381 0.03503337 0.03420805 0.03340513 0.03358155
 ## [337] 0.03322917 0.03702940 0.03613785 0.03527092 0.03440909 0.03357460
 ## [343] 0.03440564 0.03359760 0.03281213 0.03214081 0.03183182 0.03108017
 ## [349] 0.03047401 0.03088918 0.03029598 0.02987313 0.02947087 0.03001488
 ## [355] 0.02988606 0.03166399 0.03411734 0.03541667 0.03509957 0.03438503
 ## [361] 0.06546674 0.06568986 0.06473448 0.06319496 0.06151924 0.05986678
 ## [367] 0.05826268 0.05681485 0.05530041 0.05394948 0.05264559 0.05125436
 ## [373] 0.05101522 0.05088011 0.04954137 0.04838443 0.04726806 0.04603739
 ## [379] 0.04499636 0.04399306 0.04874082 0.04841376 0.04725440 0.04915247
 ## [385] 0.04786530 0.04931695 0.04813189 0.04790159 0.04709725 0.04633810
 ## [391] 0.04525624 0.04411934 0.04328144 0.04285192 0.04217000 0.04112622
 ## [397] 0.04008202 0.03910918 0.03842734 0.03835401 0.03771038 0.03795412
 ## [403] 0.03730342 0.03640862 0.03563952 0.03528475 0.03456710 0.03387983
 ## [409] 0.03363746 0.03419554 0.03336787 0.03386007 0.03318527 0.03238992
 ## [415] 0.03170710 0.03096763 0.03087194 0.03163545 0.03105633 0.03314603
 ## [421] 0.03252489 0.03175081 0.03100179 0.03045699 0.02975026 0.02925921
 ## [427] 0.02938062 0.02870946 0.02826704 0.02844634 0.03123904 0.03129120
 ## [433] 0.03055715 0.03067784 0.03017688 0.03556111 0.03561627 0.03505460
 ## [439] 0.03474112 0.03441404 0.03411384 0.03385859 0.03304166 0.03233940
 ## [445] 0.03898936 0.04200188 0.04167793 0.04070109 0.04082399 0.03981281
 ## [451] 0.03918909 0.03829877 0.03744071 0.03694157 0.03613775 0.03536632
 ## [457] 0.03494969 0.03552938 0.03466600 0.03447752 0.03507879 0.03470694
 ## [463] 0.03398871 0.03345288 0.03292787 0.03217016 0.03255705 0.03285963
 ## [469] 0.03207475 0.03246799 0.03292822 0.03227927 0.03165799 0.03154240
 ## [475] 0.03141684 0.03083176 0.03027320 0.02957251 0.02889498 0.02841611
 ## [481] 0.03297346 0.03270245 0.03205080 0.03129205 0.03069547 0.03053582
 ## [487] 0.02982650 0.03095058 0.03057920 0.03047067 0.03118377 0.03081151
 ## [493] 0.03045630 0.02991202 0.02992889 0.02923956 0.02875784 0.02851934
 ## [499] 0.02791799 0.02729583 0.02751253 0.02711182 0.02657477 0.02605189
 ## [505] 0.02629964 0.02761212 0.02778483 0.02720991 0.02704005 0.02649800
 ## [511] 0.02598500 0.02594324 0.02581272 0.02531228 0.02594455 0.02556949
 ## [517] 0.02521528 0.02512673 0.02464641 0.02458247 0.02452139 0.02480042
 ## [523] 0.02448543 0.02582281 0.02527239 0.02552595 0.02578418 0.02543822
 ## [529] 0.02494510 0.02491170 0.02444542 0.02400467 0.02648391 0.02663875
 ## [535] 0.02606015 0.02622324 0.02934575 0.02881683 0.02830458 0.03060751
 ## [541] 0.03048646 0.02991955 0.02927325 0.02894305 0.02874357 0.02917737
 ## [547] 0.02865485 0.02800790 0.02738270 0.02837579 0.02988251 0.02951261
 ## [553] 0.03002068 0.03041208 0.02970682 0.02905479 0.02918058 0.02901903
 ## [559] 0.03317343 0.04131427 0.04039174 0.04027081 0.03957866 0.03872341
 ## [565] 0.03790170 0.03695724 0.03661692 0.03630976 0.03599978 0.03606033
 ## [571] 0.03534396 0.03577644 0.03762402 0.03668822 0.03724228 0.03666764
 ## [577] 0.03670080 0.03594155 0.03952601 0.03932562 0.03862624 0.03817839
 ## [583] 0.03722531 0.03802933 0.03708876 0.03616970 0.03580280 0.03496233
 ## [589] 0.03440226 0.03483351 0.03398553 0.03316455 0.03294147 0.03229709
 ## [595] 0.03211482 0.03135400 0.03061790 0.02990587 0.02926293 0.02863508
 ## [601] 0.02798879 0.03665090 0.03705174 0.03642399 0.03567571 0.03495847
 ## [607] 0.04219796 0.04172656 0.04107205 0.04013458 0.03936829 0.03840868
 ## [613] 0.03771122 0.03703956 0.03624850 0.03535581 0.03452660 0.03618736
 ## [619] 0.03541723 0.03481589 0.03423960 0.03391933 0.03339248 0.03291680

[625] 0.03227627 0.03166361 0.03224093 0.03150786 0.03080575 0.03073489
 ## [631] 0.03005922 0.02936558 0.02874332 0.02810216 0.02748526 0.02727921
 ## [637] 0.02669092 0.02642862 0.02590150 0.02620816 0.02570126 0.02604065
 ## [643] 0.02553727 0.02521383 0.02489828 0.02460268 0.02414797 0.02736532
 ## [649] 0.02837722 0.02842275 0.02818237 0.03136148 0.03131898 0.03075664
 ## [655] 0.03008436 0.02955272 0.02927101 0.02878260 0.03072126 0.03060536
 ## [661] 0.03130813 0.03073234 0.03017299 0.03015529 0.02945849 0.02878474
 ## [667] 0.02831552 0.02772603 0.02715257 0.02656655 0.02664134 0.02612313
 ## [673] 0.02561844 0.02529873 0.02476659 0.02425317 0.02400133 0.02376891
 ## [679] 0.02329102 0.02310028 0.02380291 0.02361582 0.02381249 0.02435738
 ## [685] 0.02444459 0.02421410 0.02431910 0.02389477 0.02341236 0.02323968
 ## [691] 0.02306985 0.02269575 0.02234336 0.02191740 0.02225071 0.02190087
 ## [697] 0.02183065 0.02176910 0.02216617 0.02182518 0.02162703 0.02124753
 ## [703] 0.02124229 0.02094639 0.02435499 0.02385615 0.02406094 0.02363991
 ## [709] 0.02316666 0.02403089 0.02386923 0.02371123 0.02331012 0.02316396
 ## [715] 0.02278303 0.02584796 0.02537284 0.02845575 0.02870505 0.02828130
 ## [721] 0.02787019 0.02748372 0.02789075 0.02726951 0.02693408 0.02634536
 ## [727] 0.02606042 0.02579258 0.02592522 0.02921765 0.02967725 0.02899625
 ## [733] 0.02862579 0.02828255 0.02773112 0.02718851 0.02693506 0.02634630
 ## [739] 0.03148665 0.03081408 0.03122011 0.03077731 0.03035513 0.02965175
 ## [745] 0.03022996 0.02985339 0.02916656 0.02885057 0.02819708 0.02794045
 ## [751] 0.02873080 0.02842176 0.02778263 0.02726058 0.02854976 0.02820162
 ## [757] 0.03727267 0.03707935 0.03686768 0.03599795 0.03518778 0.03465078
 ## [763] 0.03493634 0.03588036 0.03530054 0.03455172 0.03390862 0.03871320
 ## [769] 0.03945569 0.03864999 0.03787008 0.03775301 0.03702228 0.03976638
 ## [775] 0.03898504 0.03853560 0.03762430 0.03693065 0.03626145 0.04079563
 ## [781] 0.03987062 0.03897237 0.03934745 0.03853635 0.03835650 0.03745073
 ## [787] 0.03877703 0.03798620 0.03783452 0.03709808 0.03639646 0.03604365
 ## [793] 0.03521176 0.03460095 0.03401168 0.03318987 0.03239437 0.03222976
 ## [799] 0.03146521 0.03079598 0.03007812 0.02966445 0.02904606 0.02867106
 ## [805] 0.02869713 0.02804876 0.02750692 0.02762626 0.02701397 0.02642252
 ## [811] 0.02618154 0.02570937 0.02584432 0.02536180 0.02482745 0.02438944
 ## [817] 0.02421785 0.02405850 0.02357023 0.02343904 0.02331842 0.02426593
 ## [823] 0.02411625 0.02396189 0.02485108 0.02508893 0.02464092 0.02532409
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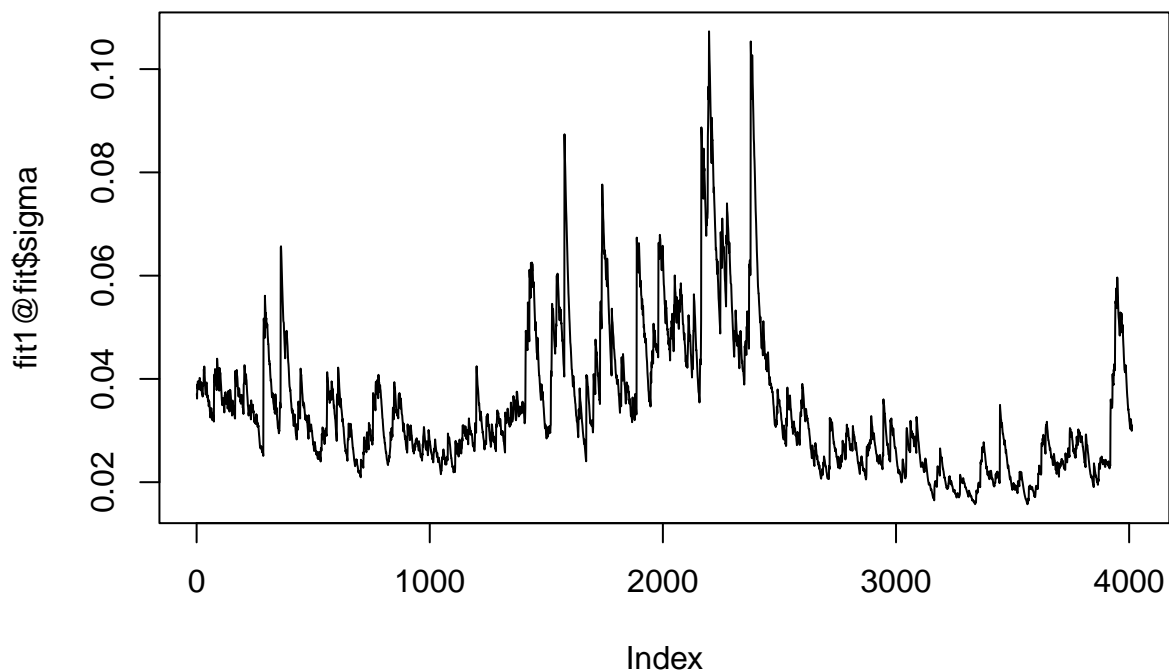
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```
plot(fit1@fit$sigma, type='l')
```



Estimating conditional variance.

```
fit1@fit$var
```

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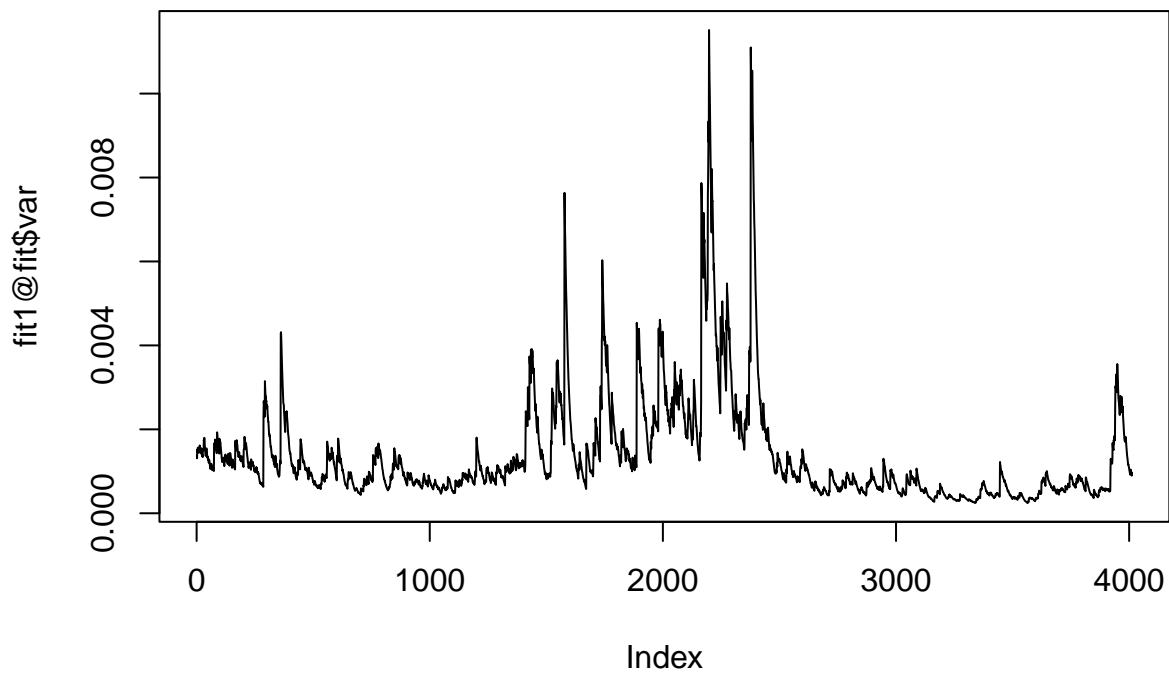
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##	[3696]	0.0004931779	0.0004748872	0.0004591857	0.0004433808	0.0005585847
##	[3701]	0.0005371940	0.0005288583	0.0005188088	0.0005477858	0.0005283373
##	[3706]	0.0005414331	0.0005521343	0.0005758488	0.0005628054	0.0005998905
##	[3711]	0.0005932383	0.0005966483	0.0005800824	0.0005597330	0.0005829533
##	[3716]	0.0005694717	0.0005554014	0.0005418903	0.0005378230	0.0005214958
##	[3721]	0.0005106579	0.0005250393	0.0005251739	0.0005168639	0.0005003808
##	[3726]	0.0005032887	0.0006553941	0.0006281585	0.0006120823	0.0006035447
##	[3731]	0.0005791055	0.0005858244	0.0005705449	0.0005680693	0.0006097536
##	[3736]	0.0006360233	0.0006210122	0.0007059574	0.0006849589	0.0006799940
##	[3741]	0.0006522219	0.0006253660	0.0006382386	0.0006196410	0.0008610572
##	[3746]	0.0009295609	0.0009087910	0.0009180440	0.0008761339	0.0008555072
##	[3751]	0.0008271536	0.0008865778	0.0008737730	0.0008358438	0.0008350396
##	[3756]	0.0007979698	0.0007873604	0.0007530755	0.0007273574	0.0006961494
##	[3761]	0.0006737251	0.0006898494	0.0006605019	0.0007012865	0.0006758042
##	[3766]	0.0006538267	0.0006280049	0.0006132670	0.0006224314	0.0006354309
##	[3771]	0.0006144421	0.0007355266	0.0007043794	0.0007005806	0.0008305188
##	[3776]	0.0007937311	0.0007625676	0.0007698606	0.0007374460	0.0007427128
##	[3781]	0.0008139332	0.0009139187	0.0008757576	0.0008965942	0.0008561323
##	[3786]	0.0008629280	0.0008407588	0.0008816183	0.0008422559	0.0008222253
##	[3791]	0.0008031762	0.0007696813	0.0008105844	0.0008089281	0.0007770909
##	[3796]	0.0008361547	0.0008024054	0.0007721338	0.0007755725	0.0007504025
##	[3801]	0.0007182646	0.0007216210	0.0006913475	0.0006735489	0.0006552546
##	[3806]	0.0006290254	0.0006029921	0.0005841317	0.0005625288	0.0005756396
##	[3811]	0.0005569543	0.0005367548	0.0005248841	0.0008521411	0.0008556411
##	[3816]	0.0008194053	0.0007828529	0.0007483106	0.0007157224	0.0007400096
##	[3821]	0.0007228014	0.0006992049	0.0006705339	0.0006540905	0.0006351126
##	[3826]	0.0006088265	0.0005864798	0.0005659795	0.0005445128	0.0005234432
##	[3831]	0.0005081191	0.0004929678	0.0004796952	0.0004631754	0.0004586552
##	[3836]	0.0004442325	0.0004365622	0.0004520000	0.0004387018	0.0004387667
##	[3841]	0.0004305509	0.0004192529	0.0004095987	0.0003963646	0.0003910460
##	[3846]	0.0003823519	0.0003715512	0.0003628818	0.0005600281	0.0005380627
##	[3851]	0.0005328497	0.0005179465	0.0004990502	0.0004843042	0.0004738078
##	[3856]	0.0004563603	0.0004439502	0.0004532085	0.0004371541	0.0004270894
##	[3861]	0.0004142203	0.0004031941	0.0004105879	0.0003971178	0.0003910710
##	[3866]	0.0003797901	0.0004251001	0.0004218145	0.0004074382	0.0005203413
##	[3871]	0.0005437221	0.0005577448	0.0005383005	0.0005175450	0.0005096065
##	[3876]	0.0005766583	0.0006097281	0.0006094729	0.0005966873	0.0005979344
##	[3881]	0.0005761432	0.0006235817	0.0006014526	0.0005769895	0.0005802045
##	[3886]	0.0005621841	0.0005508304	0.0005639871	0.0005564234	0.0005905396
##	[3891]	0.0005905093	0.0005678797	0.0005834003	0.0005748038	0.0005522732

```
## [3896] 0.0005315613 0.0005264475 0.0005299710 0.0005926954 0.0005882057
## [3901] 0.0005657250 0.0005688767 0.0005632464 0.0005676759 0.0005554310
## [3906] 0.0005516059 0.0005691589 0.0005703478 0.0005561917 0.0005367985
## [3911] 0.0005780190 0.0005563618 0.0005561026 0.0005380428 0.0005221632
## [3916] 0.0005143044 0.0005435523 0.0005474635 0.0005379281 0.0010658055
## [3921] 0.0012978934 0.0012530259 0.0012718151 0.0012141462 0.0012474297
## [3926] 0.0011997945 0.0011829354 0.0012545714 0.0016762037 0.0015935649
## [3931] 0.0015177784 0.0015295008 0.0015075153 0.0017483852 0.0016605691
## [3936] 0.0018380363 0.0017812072 0.0018251478 0.0017376088 0.0025260934
## [3941] 0.0029991374 0.0030345078 0.0029772896 0.0033088106 0.0031491297
## [3946] 0.0030188539 0.0028856839 0.0028855922 0.0035568122 0.0033711113
## [3951] 0.0031971034 0.0030541656 0.0029110683 0.0027645592 0.0026847965
## [3956] 0.0026392555 0.0025516293 0.0024606227 0.0023511938 0.0023421760
## [3961] 0.0025027293 0.0027965274 0.0026527371 0.0025159092 0.0027088800
## [3966] 0.0026442112 0.0027778699 0.0026953188 0.0026204272 0.0024878430
## [3971] 0.0023961266 0.0025466401 0.0024193153 0.0022945117 0.0021886673
## [3976] 0.0021065580 0.0020008102 0.0018989315 0.0018297621 0.0017424569
## [3981] 0.0017372442 0.0017049627 0.0017826181 0.0018029250 0.0018196299
## [3986] 0.0017502047 0.0016837053 0.0015996245 0.0015308583 0.0014557187
## [3991] 0.0013877285 0.0013396084 0.0013031331 0.0012415522 0.0011997166
## [3996] 0.0011575538 0.0011662800 0.0011156929 0.0011029367 0.0010647683
## [4001] 0.0010170553 0.0010000523 0.0009635263 0.0009217370 0.0009701214
## [4006] 0.0010408193 0.0009979583 0.0010167572 0.0009781188 0.0009381292
## [4011] 0.0008966849 0.0009621634
```

```
plot(fit1@fit$var, type='l')
```



Extracting model residuals.

```
fit1@fit$residuals
```

```
##      [1]  0.0002150934  0.0743583174 -0.0186539455 -0.0598204169  0.0386862114
##      [6] -0.0193940002 -0.0197862335  0.0568495610  0.0187346754 -0.0586419063
##     [11]  0.0194470538 -0.0610471159  0.0394409359 -0.0100861977 -0.0299935477
##     [16]  0.0002150934 -0.0423508130  0.0602516870  0.0198241993 -0.0197862335
##     [21]  0.0386862114  0.0002150934 -0.0397954733  0.0386862114 -0.0193940002
##     [26]  0.0730077854  0.0353100791 -0.0361564883 -0.0375296322 -0.0815066064
##     [31]  0.0202164336 -0.0636574136  0.0002150934  0.0002150934  0.0002150934
##     [36]  0.0002150934  0.0210499418 -0.0210630994 -0.0442438317  0.0627564851
##     [41] -0.0432767270  0.0418939505  0.0002150934  0.0002150934  0.0002150934
##     [46] -0.0432767270 -0.0220089481 -0.0225141252  0.0437072120 -0.0220089481
##     [51]  0.0002150934  0.0427812734 -0.0442438317  0.0219559457 -0.0220089481
##     [56]  0.0002150934  0.0219559457  0.0002150934 -0.0452549393 -0.0230428051
##     [61]  0.0446743441 -0.0463131237  0.0002150934  0.0002150934 -0.0235966671
##     [66] -0.0241775546  0.0467437012  0.0229443342 -0.0474217526  0.0002150934
##     [71]  0.0234730162  0.0334946681  0.0117709068  0.1181431345  0.0002150934
##     [76] -0.0623250225 -0.0210630994 -0.0680187460  0.0110066703  0.0117709068
##     [81]  0.0219559457 -0.0452549393  0.0110066703 -0.0342102516 -0.0235966671
##     [86] -0.0463131237  0.1045759152  0.0206246807 -0.0206197394 -0.0210630994
##     [91]  0.0410428764  0.0002150934 -0.0318038127 -0.0099978497  0.0103247858
##     [96]  0.0312405170  0.0929435328  0.0002150934  0.0183979180 -0.0575087980
##    [101] -0.0397954733  0.0002150934 -0.0201944796 -0.0206197394  0.0002150934
##    [106]  0.0206246807  0.0002150934 -0.0206197394  0.0206246807 -0.0423508130
##    [111]  0.0410428764 -0.0423508130  0.0410428764  0.0002150934  0.0418939505
##    [116]  0.0002150934  0.0002150934  0.0206246807  0.0579399105 -0.0610471159
##    [121]  0.0002150934  0.0579399105 -0.0397954733 -0.0201944796  0.0394409359
##    [126]  0.0002150934  0.0002150934 -0.0406124581  0.0394409359 -0.0296762386
##    [131]  0.0292388052  0.0002150934 -0.0406124581  0.0394409359  0.0730077854
##    [136]  0.0183979180 -0.0183044789  0.0002150934  0.0002150934  0.0002150934
##    [141]  0.0528713187 -0.0753270575  0.0365868209 -0.0375296322 -0.0190168557
##    [146]  0.0190841428 -0.0190168557  0.0190841428 -0.0190168557  0.0002150934
##    [151]  0.0002150934  0.0372606811  0.0692363308 -0.0355067207  0.0002150934
##    [156]  0.0347047479 -0.0173296624  0.0002150934  0.0255256102  0.0415384490
##    [161]  0.0319665019 -0.0159146355  0.0160887785  0.0309892184  0.1221475733
##    [166]  0.0002150934  0.0265339410  0.0002150934 -0.0342361065 -0.0586419063
##    [171]  0.0687628194  0.0002150934  0.0396991364 -0.0268152028  0.0002150934
##    [176] -0.0134839638  0.0396991364  0.0002150934  0.0193179644  0.0497940419
##    [181]  0.0523320104  0.0339293985  0.0002150934 -0.0227754260  0.0441854589
##    [186] -0.0108962458 -0.0225141252  0.0437072120 -0.0107741382 -0.0579567624
##    [191] -0.0235966671 -0.0498054999  0.0246077708 -0.0377686358 -0.0257618350
##    [196]  0.0002150934 -0.0129431798  0.0381989960 -0.0126057696  0.0128736603
##    [201] -0.0971571178 -0.0432767270 -0.0452549393  0.0836471678 -0.0432767270
##    [206]  0.0283878602 -0.0071629530 -0.0362635103 -0.0068939712  0.0216660225
##    [211]  0.0678350388 -0.0134839638 -0.0355472846  0.0075391026 -0.0140711051
##    [216] -0.0142781658 -0.0208975779 -0.0138698778  0.0002150934  0.0276158056
##    [221]  0.0002150934  0.0002150934 -0.0426550379 -0.0219829812 -0.0373694285
##    [226]  0.0573895349 -0.0219829812  0.0357155731 -0.0210753442  0.0210616815
##    [231]  0.0141044304 -0.0138698778  0.0782177629  0.0002150934  0.0130359585
##    [236] -0.0397954733  0.0386862114  0.0068376584  0.0426670016 -0.0441191848
##    [241] -0.0064516226  0.0128736603 -0.0392687471  0.0132024726 -0.0129431798
##    [246] -0.0268152028 -0.0134839638 -0.0426550379  0.0002150934  0.0413226782
##    [251]  0.0137290196 -0.0275662329 -0.0283601960  0.0413226782  0.0521868392
```

##	[256]	0.0130359585	-0.0397954733	0.0133733690	0.0002150934	-0.0201944796
##	[261]	-0.0200602613	-0.0426550379	0.0070255888	0.0347425600	0.0072880578
##	[266]	0.0131048177	-0.0062714385	-0.0134839638	0.0072880578	-0.0069082545
##	[271]	0.0002150934	-0.0279576210	-0.0140711051	-0.0292008821	-0.0300925412
##	[276]	-0.0151701266	0.0300703075	0.0149215078	-0.0147108319	-0.0149369994
##	[281]	-0.0233602785	-0.0232791187	-0.0325776204	0.0002150934	0.0002150934
##	[286]	0.1880333898	0.0967540581	0.0351059543	-0.0359372879	0.0181999764
##	[291]	0.0174252489	0.1406923361	-0.0098860881	-0.0310399551	-0.0210630994
##	[296]	0.0602516870	-0.0152201232	-0.0587432804	-0.0106546853	-0.0572873944
##	[301]	0.0335546538	0.0627564851	-0.0210630994	-0.0215257404	-0.0334991041
##	[306]	-0.0227754260	-0.0479961248	-0.0119803300	0.0002150934	-0.0121308983
##	[311]	0.0472915059	0.0232056360	-0.0479961248	0.0121201373	0.0002150934
##	[316]	-0.0241775546	0.0240268806	0.0456854823	0.0114512855	0.0221948948
##	[321]	0.0162192395	0.0058065204	-0.0331243641	-0.0463131237	-0.0424747451
##	[326]	0.0298665290	-0.0116899489	0.0207389296	-0.0271002110	-0.0304069393
##	[331]	-0.0122852312	0.0478523686	0.0063675222	0.0058621822	-0.0363783637
##	[336]	-0.0247874952	0.0807636583	0.0061566274	0.0056696659	0.0002150934
##	[341]	0.0002150934	-0.0474217526	-0.0060139838	-0.0055680714	0.0121201373
##	[346]	-0.0241775546	0.0002150934	0.0122635785	-0.0372936182	0.0125610870
##	[351]	-0.0183976463	0.0184877197	-0.0382558421	-0.0261037143	-0.0553686775
##	[356]	0.0651966128	-0.0546065031	-0.0279576210	0.0141044304	-0.2540752802
##	[361]	0.0725373099	0.0463855289	-0.0230867511	-0.0080389684	0.0002150934
##	[366]	0.0002150934	-0.0159146355	0.0002150934	-0.0161790806	-0.0164523418
##	[371]	0.0002150934	0.0478523686	-0.0498054999	0.0002150934	-0.0167348674
##	[376]	0.0168825349	0.0002150934	-0.0167348674	0.0168825349	0.1048886245
##	[381]	0.0430855062	-0.0142781658	-0.0779880138	0.0002150934	0.0727435670
##	[386]	0.0145012953	-0.0445758322	0.0292046901	-0.0296400546	-0.0149369994
##	[391]	-0.0077263461	0.0229036180	-0.0343810001	0.0266764097	0.0073793339
##	[396]	0.0002150934	0.0079165914	0.0216660225	-0.0370754880	0.0219815272
##	[401]	0.0424813294	0.0211763716	0.0067904833	-0.0136742406	0.0272454339
##	[406]	-0.0142781658	0.0145012953	0.0279964693	-0.0432767270	0.0002150934
##	[411]	0.0418939505	-0.0138698778	0.0002150934	-0.0106051628	-0.0032134848
##	[416]	0.0279964693	-0.0432767270	0.0145012953	-0.0604275599	0.0151410228
##	[421]	0.0002150934	0.0002150934	-0.0149369994	0.0002150934	0.0151410228
##	[426]	-0.0305589570	0.0002150934	-0.0154105400	0.0305227983	-0.0643451421
##	[431]	0.0314702214	0.0002150934	-0.0320485229	-0.0161790806	0.0898901120
##	[436]	0.0364716693	0.0210616815	0.0276158056	0.0268849425	-0.0271855719
##	[441]	-0.0279576210	0.0002150934	0.0108061503	0.1034027252	0.0807636583
##	[446]	-0.0355067207	-0.0118333900	-0.0435613085	0.0062151294	0.0246077708
##	[451]	-0.0121308983	-0.0122852312	-0.0254287247	-0.0127722835	0.0130359585
##	[456]	0.0252177145	0.0451205139	0.0030722401	-0.0302115476	-0.0449282688
##	[461]	-0.0261037143	0.0132024726	0.0197035124	0.0193309512	0.0062151294
##	[466]	-0.0387557124	0.0377239699	0.0002150934	-0.0387557124	-0.0403364468
##	[471]	-0.0134839638	-0.0136742406	-0.0283601960	0.0279964693	-0.0138698778
##	[476]	-0.0140711051	0.0002150934	0.0002150934	-0.0142781658	0.0803023621
##	[481]	0.0261920597	-0.0129431798	0.0002150934	-0.0131186338	0.0261920597
##	[486]	0.0002150934	-0.0471364471	-0.0208975779	0.0272454339	-0.0420508767
##	[491]	0.0211763716	-0.0211949842	-0.0140711051	-0.0292008821	0.0002150934
##	[496]	-0.0147108319	0.0218289347	-0.0068437887	0.0002150934	-0.0300925412
##	[501]	0.0151410228	0.0079165914	-0.0075461784	0.0292046901	-0.0452549393
##	[506]	0.0296311312	-0.0068939712	0.0216660225	-0.0073784374	-0.0080299940
##	[511]	0.0232320970	0.0210616815	-0.0071629530	0.0347425600	-0.0136742406
##	[516]	-0.0138698778	0.0211763716	0.0067904833	-0.0210511904	0.0210385238
##	[521]	-0.0279576210	0.0141044304	-0.0432767270	0.0002150934	0.0283878602

##	[526]	-0.0287744446	0.0145012953	-0.0066894493	-0.0221396992	0.0072244966
##	[531]	0.0077513967	0.0550374430	-0.0279576210	0.0002150934	0.0276158056
##	[536]	0.0643623369	0.0128736603	0.0127154199	-0.0591412654	-0.0269917221
##	[541]	0.0131048177	0.0071484823	-0.0199168364	0.0230772770	0.0356071618
##	[546]	0.0128736603	0.0002150934	0.0002150934	0.0424197992	-0.0502390483
##	[551]	-0.0195264423	0.0377239699	0.0363676170	0.0002150934	0.0059650053
##	[556]	-0.0304069393	0.0243138254	-0.0777844877	-0.1159804849	-0.0144913172
##	[561]	-0.0382793544	0.0229036180	-0.0149369994	0.0151410228	0.0002150934
##	[566]	0.0292046901	-0.0296400546	0.0292046901	-0.0370754880	-0.0156682841
##	[571]	-0.0431380441	0.0635416537	0.0002150934	-0.0466768863	0.0228193504
##	[576]	0.0372824827	-0.0147108319	0.0825015789	-0.0355472846	0.0213277812
##	[581]	-0.0283601960	0.0002150934	0.0512136146	0.0034583423	0.0002150934
##	[586]	-0.0275662329	0.0073855907	0.0202164336	-0.0420508767	0.0002150934
##	[591]	0.0002150934	0.0276158056	0.0137290196	-0.0275662329	0.0002150934
##	[596]	0.0002150934	0.0002150934	0.0073855907	0.0067904833	0.0002150934
##	[601]	0.1101987314	0.0440725881	-0.0207388129	-0.0147685488	0.0149775363
##	[606]	-0.1123035104	0.0320153669	-0.0261037143	-0.0131186338	-0.0199168364
##	[611]	-0.0069082545	0.0200875141	-0.0200602613	-0.0136742406	0.0002150934
##	[616]	-0.0070597329	0.0597244111	0.0132024726	-0.0193836128	0.0194370619
##	[621]	-0.0264547136	-0.0199168364	-0.0208975779	-0.0138698778	-0.0140711051
##	[626]	0.0413226782	-0.0064038187	-0.0070071915	-0.0283601960	0.0070255888
##	[631]	0.0002150934	0.0075391026	-0.0031766599	0.0035953815	-0.0210753442
##	[636]	0.0036554671	-0.0184775789	-0.0068437887	-0.0300925412	-0.0077263461
##	[641]	0.0304329966	-0.0075461784	0.0149215078	-0.0147108319	0.0149215078
##	[646]	0.0072244966	0.0621731404	-0.0426550379	0.0279964693	-0.0213529715
##	[651]	-0.0677150283	0.0296311312	0.0147083562	-0.0073784374	-0.0140033935
##	[656]	0.0216660225	-0.0144913172	0.0557996602	0.0272454339	-0.0420508767
##	[661]	0.0141044304	-0.0138698778	-0.0287744446	0.0002150934	0.0002150934
##	[666]	-0.0144913172	0.0072244966	-0.0068437887	-0.0033268267	-0.0264547136
##	[671]	0.0080323710	-0.0076637759	-0.0151701266	0.0002150934	0.0002150934
##	[676]	-0.0154105400	-0.0156585865	0.0002150934	-0.0159146355	-0.0331243641
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##	[1876]	-0.0107741382	0.0190841428	-0.0169207656	-0.0540018522	0.0794746516
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##	[1906]	-0.0066421032	-0.0527576015	0.0294248845	0.0151753773	-0.0861398420
##	[1911]	0.0375282837	0.0361857961	0.0002150934	-0.0814295379	-0.0035632532
##	[1916]	-0.0073991933	0.0002150934	0.0599169466	-0.0155431320	0.0157288445
##	[1921]	-0.0632786518	0.0297760804	0.0230811165	0.0505222886	-0.0604275599
##	[1926]	-0.0467562871	0.0225494667	0.0002150934	-0.0148988300	0.0307449023
##	[1931]	-0.0312762163	0.0077151638	0.0002150934	0.0234162100	0.0228900784
##	[1936]	-0.0082085921	0.0002150934	-0.0308072132	0.0002150934	0.0002150934
##	[1941]	-0.0575593551	0.0405283878	-0.0243034771	0.0241468623	-0.0164309987
##	[1946]	0.0090984592	-0.1067246447	0.0099509916	0.0002150934	-0.0859920273
##	[1951]	0.0545278647	0.0002150934	-0.0669076131	-0.0717412790	-0.0406124581
##	[1956]	0.0103162757	0.0002150934	-0.0918235236	0.1027091700	0.0002150934
##	[1961]	-0.0304018979	-0.0460645776	0.0002150934	-0.0827296184	-0.0377939703
##	[1966]	-0.0243775341	0.0002150934	0.0357957891	0.0597302914	0.0429328479
##	[1971]	-0.0216048104	-0.0595501926	-0.0134572061	0.0485612877	-0.0505877267
##	[1976]	-0.0642779407	-0.0124168205	0.0126894304	-0.0409219289	-0.2139259969
##	[1981]	0.1039350785	0.0002150934	-0.0313435013	0.0723508198	0.1016076062
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##	[1996]	-0.0229186306	0.0924326986	0.0913867517	0.0189481826	0.0172130825
##	[2001]	-0.0083564400	0.0279964693	0.0272454339	0.0515199345	-0.0356490988
##	[2006]	-0.0298851765	0.0255511543	-0.0487552841	0.0071595937	0.0337784940
##	[2011]	-0.0203342906	0.1101987314	-0.0059199144	-0.0582592902	0.0193245422
##	[2016]	0.0250623863	-0.0187733841	-0.0324704169	-0.0549849582	-0.0137713750
##	[2021]	0.0594607795	-0.0185527592	-0.0051757683	-0.0583056840	-0.0539463591
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##	[2081]	-0.0222306710	-0.0022849093	0.0409938946	-0.0294188410	-0.0122852312
##	[2086]	-0.0524404910	0.0454568289	-0.0073799162	-0.0392687471	-0.0268152028
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##	[2471]	-0.0020220450	-0.0226701880	-0.0020784866	0.0270040330	0.0112528457
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##	[2501]	-0.0244553253	0.0332486730	-0.0319873966	0.0039886872	0.0295233489
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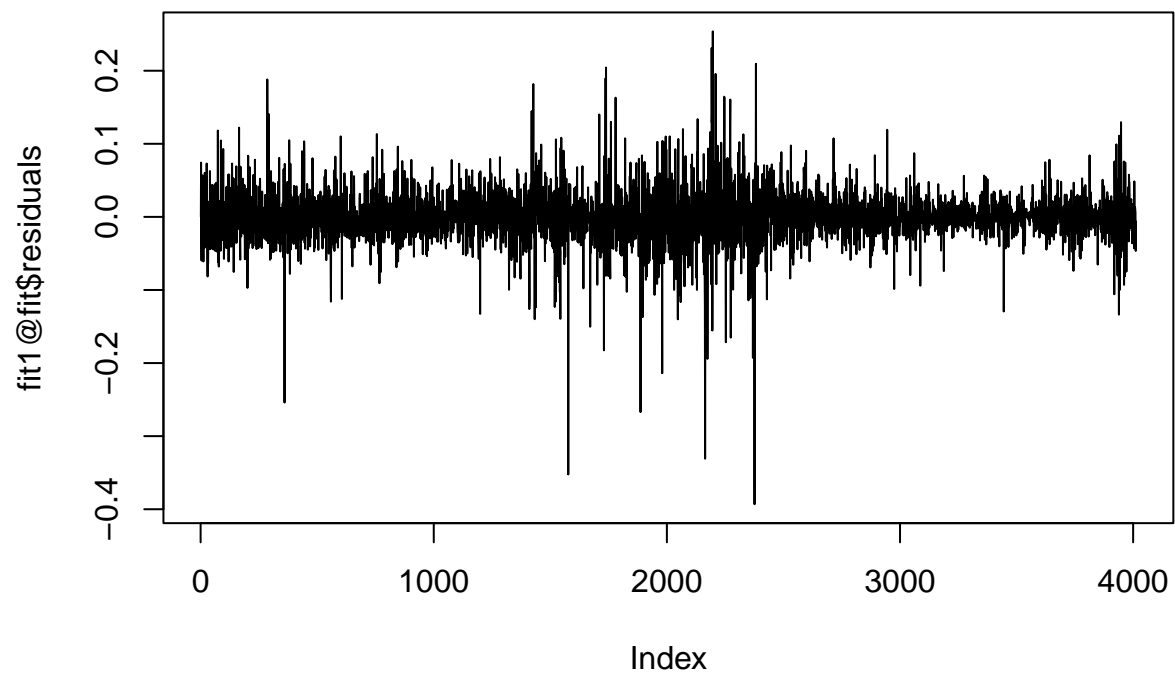
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##	[3386]	-0.0083515446	0.0030624776	-0.0284941528	-0.0009579274	0.0037218218
##	[3391]	-0.0068479435	-0.0015537755	0.0310771727	0.0131878216	-0.0037486769
##	[3396]	0.0080803431	0.0146120487	0.0073619382	-0.0222713328	0.0035764442
##	[3401]	-0.0280144357	0.0347047479	-0.0127430146	0.0063741469	0.0129296438
##	[3406]	0.0333585706	0.0149602320	-0.0045468294	-0.0056391178	0.0044546397
##	[3411]	-0.0067219953	0.0216266597	0.0002150934	0.0171563589	0.0002150934
##	[3416]	0.0027752600	-0.0023516446	0.0158802135	0.0072397373	-0.0218379663
##	[3421]	0.0043009066	-0.0276099942	0.0172437836	-0.0149766883	-0.0168342107
##	[3426]	-0.0402614775	0.0203142263	0.0056176048	0.0109047683	0.0123590041
##	[3431]	0.0363553461	-0.0054144143	-0.0111723156	0.0317993329	-0.0094004391
##	[3436]	0.0141876055	-0.0144689767	0.0052528981	-0.0172127455	-0.0117146494
##	[3441]	0.0043473365	-0.0013368990	0.0063847984	0.0277185844	-0.1294413273
##	[3446]	0.0047120169	0.0205909597	-0.0165830057	0.0041191747	0.0273481248
##	[3451]	0.0077542064	0.0113974357	-0.0431316647	0.0208912204	-0.0107862281
##	[3456]	0.0127086296	0.0130840824	0.0293707373	-0.0199668327	-0.0192772015
##	[3461]	0.0177691903	-0.0259887589	0.0136780755	0.0045046508	-0.0411142486
##	[3466]	0.0145248845	0.0105638624	-0.0130303258	0.0029668855	0.0045986691
##	[3471]	0.0346134689	0.0044300690	-0.0077510024	0.0148676342	0.0100598124
##	[3476]	-0.0044699836	0.0033287465	0.0033190818	0.0104559282	-0.0298526939
##	[3481]	-0.0191409481	-0.0008613331	0.0039684534	-0.0111734385	0.0023795972
##	[3486]	0.0007559263	0.0045231304	-0.0068348565	-0.0276591709	-0.0059543232
##	[3491]	-0.0128534592	0.0024826690	-0.0037689809	0.0036183898	0.0036068466

##	[3496]	0.0069529322	-0.0054314640	-0.0048927608	-0.0253988651	0.0013778843
##	[3501]	-0.0211641987	0.0279322925	0.0088013468	-0.0214240131	0.0019664077
##	[3506]	-0.0027123113	-0.0068604373	0.0060767917	0.0095067488	0.0306252210
##	[3511]	0.0108002498	0.0106893758	0.0191453802	-0.0063173428	-0.0058090394
##	[3516]	0.0110495421	0.0018375927	-0.0123810766	-0.0058455498	0.0056945729
##	[3521]	0.0211393749	0.0418725092	0.0053302052	-0.0008089724	0.0188091346
##	[3526]	-0.0161288387	0.0103264895	-0.0048662293	-0.0505271688	-0.0166152310
##	[3531]	0.0225099442	-0.0035142706	0.0044591379	-0.0061917844	0.0012817602
##	[3536]	-0.0391519578	0.0029790549	0.0002150934	0.0111502490	-0.0008795976
##	[3541]	0.0056587784	0.0109853614	-0.0003236998	0.0018288649	0.0039664419
##	[3546]	0.0018202305	0.0028831862	-0.0008532829	0.0012823294	0.0007484267
##	[3551]	-0.0035322388	0.0060693046	-0.0051353869	0.0044772267	0.0018108387
##	[3556]	-0.0116258714	0.0071633054	0.0071153605	0.0039168469	0.0012716176
##	[3561]	-0.0008425483	0.0023259129	0.0080685774	0.0202266973	0.0017519792
##	[3566]	0.0256796700	-0.0017859085	-0.0012879132	0.0438323297	0.0176359407
##	[3571]	0.0200595033	-0.0067552232	-0.0016471051	-0.0270479451	-0.0099300078
##	[3576]	0.0055010382	-0.0198842923	0.0113641374	-0.0036778605	-0.0186258772
##	[3581]	0.0017002424	-0.0194731991	0.0204934436	0.0026817954	0.0095016397
##	[3586]	0.0041099425	-0.0136056807	0.0133669594	0.0060262641	0.0045545477
##	[3591]	-0.0060925661	0.0021521406	-0.0017257133	-0.0175636168	0.0002150934
##	[3596]	-0.0112736701	0.0226779304	-0.0284176204	-0.0250192876	0.0208923181
##	[3601]	0.0097057457	0.0101064519	0.0085526105	0.0203990752	-0.0168922869
##	[3606]	-0.0106546853	-0.0057491567	-0.0205880228	0.0498982698	0.0163448278
##	[3611]	0.0188381487	-0.0221570622	0.0413039055	0.0020374178	-0.0048215580
##	[3616]	-0.0016197701	-0.0076444419	-0.0224818797	0.0246640383	0.0093559888
##	[3621]	-0.0108757064	-0.0239235356	0.0747487732	0.0365253807	0.0123088002
##	[3626]	-0.0236983591	0.0304474764	-0.0448021010	0.0134520311	-0.0397599213
##	[3631]	-0.0356711039	0.0029673904	-0.0285760191	-0.0030993067	-0.0098281167
##	[3636]	-0.0298386576	0.0075501226	0.0031404998	-0.0101299183	-0.0092330827
##	[3641]	0.0782416559	-0.0373769302	-0.0362820862	-0.0127722835	0.0217221366
##	[3646]	0.0521386284	0.0011410194	0.0089348002	0.0204502942	-0.0106942134
##	[3651]	0.0087776137	-0.0084213774	-0.0268656917	0.0216877435	-0.0155628209
##	[3656]	0.0188864929	0.0194212820	-0.0207622692	0.0033969169	-0.0312011914
##	[3661]	-0.0232995368	0.0030859107	-0.0158283729	-0.0012454719	0.0249089764
##	[3666]	-0.0050355274	0.0285120315	-0.0096211304	-0.0218067820	0.0148382579
##	[3671]	-0.0002568274	0.0077093088	0.0310870342	0.0193614156	-0.0096771539
##	[3676]	0.0502148230	0.0194873436	0.0056317865	0.0002150934	0.0206246807
##	[3681]	0.0018450859	0.0026541202	-0.0018215679	-0.0001924046	0.0256348457
##	[3686]	-0.0073880210	0.0006150934	0.0112912698	-0.0253454813	-0.0150243740
##	[3691]	0.0480767180	0.0017812647	0.0068273548	-0.0096043885	0.0033474399
##	[3696]	0.0021689828	-0.0060767295	0.0041320638	-0.0517238953	0.0039096830
##	[3701]	-0.0160559596	0.0146070393	-0.0316103461	0.0065389130	-0.0261834521
##	[3706]	0.0255235902	0.0304855994	0.0143284668	-0.0348504596	0.0190532316
##	[3711]	-0.0236865398	-0.0125241036	0.0078005013	0.0304608509	-0.0142961935
##	[3716]	0.0133087584	0.0131395254	-0.0187160732	-0.0097601340	0.0137456429
##	[3721]	-0.0263031454	0.0204226611	0.0156440473	0.0082699531	0.0211156765
##	[3726]	-0.0591341734	-0.0022974721	-0.0142289075	-0.0183926392	-0.0019531651
##	[3731]	0.0247522575	-0.0130729089	0.0203760628	0.0362553534	0.0323523306
##	[3736]	0.0152677674	-0.0475181383	0.0137775369	-0.0222174463	-0.0047029592
##	[3741]	-0.0030743863	-0.0281184802	0.0127415180	-0.0738423443	0.0468332835
##	[3746]	0.0211458887	-0.0322019465	-0.0015165092	0.0197409581	0.0144415164
##	[3751]	-0.0443799397	0.0236914407	-0.0057961064	0.0273696643	-0.0027174622
##	[3756]	-0.0224946453	-0.0032242943	0.0121100221	0.0023346371	-0.0122315789
##	[3761]	0.0301946382	-0.0010354280	-0.0374234664	0.0096411116	0.0116511756

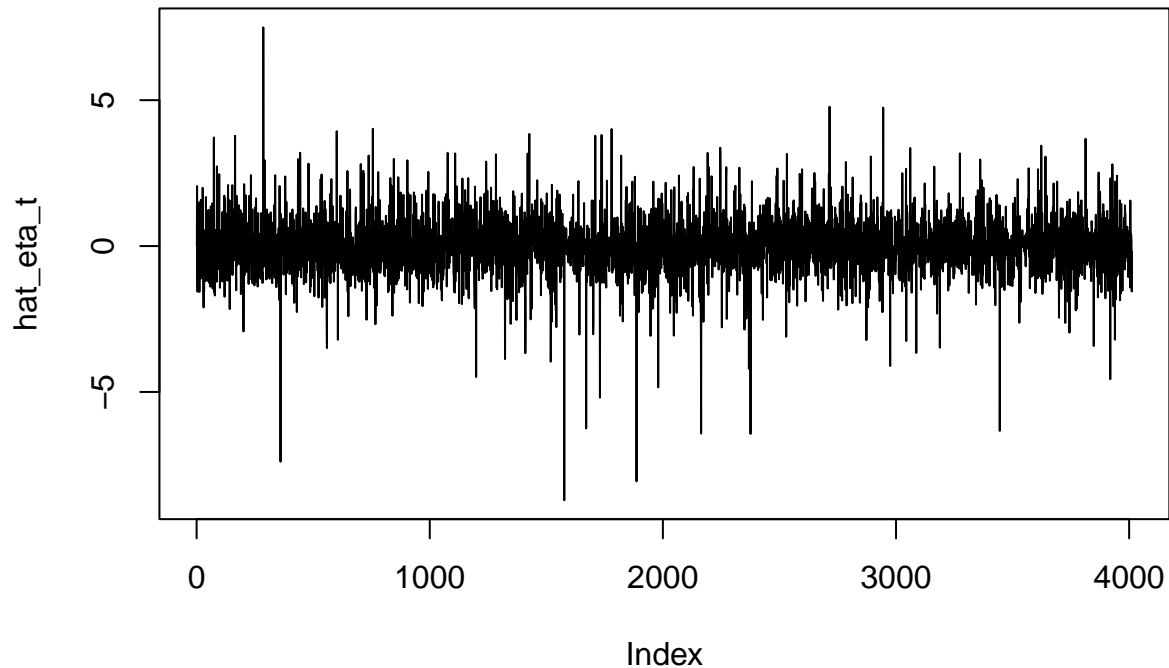
```
## [3766] 0.0056911106 0.0151534103 0.0264807593 0.0281056156 -0.0105036504
## [3771] -0.0546696973 -0.0039901335 0.0232245305 -0.0571573620 -0.0028350203
## [3776] -0.0090198661 0.0288392776 -0.0053691281 -0.0276030388 -0.0459905310
## [3781] 0.0527559889 -0.0086150432 0.0351604860 0.0027650324 -0.0304510863
## [3786] -0.0185276320 0.0400715073 0.0036309839 0.0190683311 -0.0190004301
## [3791] -0.0066637226 0.0390679370 -0.0265169616 -0.0092068873 0.0436537258
## [3796] 0.0087448477 -0.0104583436 -0.0276365834 0.0135377202 0.0035346015
## [3801] 0.0264807593 -0.0042492072 -0.0154491886 0.0144374356 0.0050675184
## [3806] 0.0002150934 -0.0108235603 0.0063102144 -0.0269167602 -0.0094774306
## [3811] -0.0061462726 0.0136046161 0.0842562337 0.0292478577 -0.0069064060
## [3816] -0.0005350943 0.0002150934 0.0009647186 0.0335546538 -0.0174849418
## [3821] -0.0124812885 0.0050460300 0.0155834284 -0.0131334664 0.0013262047
## [3826] -0.0072476624 -0.0080619009 -0.0046998602 -0.0024384352 0.0099750084
## [3831] -0.0092583333 0.0103427988 -0.0050639658 -0.0158775525 0.0066863986
## [3836] -0.0128975064 -0.0250940366 -0.0077562942 0.0178354296 0.0122076447
## [3841] -0.0087623884 0.0098789473 0.0036819724 -0.0126607978 -0.0092375875
## [3846] 0.0056988655 0.0079881994 -0.0652553245 -0.0022755692 -0.0179600363
## [3851] -0.0108962458 -0.0045079813 0.0091513828 0.0124053920 -0.0002054281
## [3856] -0.0091229028 0.0226236181 0.0022854882 0.0104611747 -0.0063856146
## [3861] 0.0079924949 -0.0206806942 -0.0031392106 -0.0120942148 0.0057026684
## [3866] -0.0342895101 -0.0153065918 -0.0020071307 0.0508699360 -0.0297763309
## [3871] 0.0268680160 0.0073550113 -0.0023112251 -0.0156110565 0.0420306833
## [3876] 0.0338848741 -0.0224680882 0.0157659618 0.0228203029 0.0071810941
## [3881] -0.0379620296 0.0085817250 -0.0009815563 0.0232101166 -0.0104192145
## [3886] -0.0149794115 0.0266876489 0.0174309436 0.0338629000 -0.0220845524
## [3891] -0.0051040806 0.0279246112 -0.0174549950 0.0032135986 0.0046927203
## [3896] 0.0178113133 0.0220884856 -0.0412455023 -0.0199767479 -0.0051468626
## [3901] -0.0229060769 0.0186776855 -0.0234091383 0.0145733688 0.0192493658
## [3906] 0.0283357324 -0.0221014233 0.0132800426 -0.0073066021 -0.0356320156
## [3911] 0.0056393742 0.0210815623 -0.0089733971 -0.0102299703 0.0158288300
## [3916] -0.0316173513 -0.0226968675 0.0156490286 -0.1058865903 0.0759360281
## [3921] 0.0192638698 -0.0402582707 -0.0089517014 -0.0432767270 0.0160480210
## [3926] -0.0288510565 -0.0511961463 0.0992544328 0.0051964340 -0.0085789896
## [3931] -0.0421370213 -0.0331694949 -0.0802793866 0.0016749479 -0.0729560220
## [3936] 0.0271492659 0.0522620120 0.0097572232 -0.1337573269 0.1110782923
## [3941] -0.0627091978 0.0456188612 -0.0997862281 -0.0172625812 0.0267998509
## [3946] -0.0226253803 -0.0554964389 0.1295869866 -0.0068343103 0.0087024646
## [3951] 0.0226669657 -0.0186820976 -0.0108459662 -0.0362702585 -0.0438686661
## [3956] 0.0318326257 -0.0290732278 -0.0191338140 -0.0478912991 0.0758106396
## [3961] -0.0930080120 0.0066142063 0.0048474203 -0.0812758366 -0.0395087903
## [3966] 0.0744254813 0.0356877139 -0.0365622580 0.0085833921 0.0275440996
## [3971] -0.0748540531 -0.0098860881 -0.0023165549 -0.0158627669 -0.0248369502
## [3976] -0.0064206553 0.0008782234 0.0235332809 -0.0102563017 0.0410300544
## [3981] -0.0335355814 0.0577396188 0.0474356422 0.0468989111 0.0214238695
## [3986] 0.0209833672 -0.0024544240 -0.0149616388 0.0039948000 0.0087805088
## [3991] 0.0201534619 0.0242829710 -0.0059673262 -0.0192188971 0.0177598570
## [3996] -0.0361564883 0.0102734952 -0.0286559906 -0.0169602627 -0.0070394344
## [4001] -0.0249591735 0.0143159571 0.0074939931 -0.0430225297 0.0485943896
## [4006] -0.0110274137 -0.0365063695 0.0134414722 0.0104600084 0.0058744332
## [4011] -0.0466027541 -0.0063442857
```

```
plot(fit1@fit$residuals, type='l')
```



Standardizing and plotting residuals

```
hat_u_t<-fit1@fit$residuals  
hat_sigma_t<-fit1@fit$sigma  
hat_eta_t<-hat_u_t/hat_sigma_t  
plot(hat_eta_t, type='l')
```



```
set.seed(123)
n<-length(fit1$fit$residuals)
```

Bootstrapping estimates of model parameters. De-meaning (centering) standardized residuals to obtain a new sequence.

```
hat_eta_t<-hat_eta_t-mean(hat_eta_t)
```

Sampling with replacement n times from the new residuals.

```
hat_eta_t_star<-sample(hat_eta_t, n, TRUE)
hat_eta_t_star
```

```
##      [1] -0.980211056 -0.236736572  1.146457042 -1.123350945 -0.702178823
##      [6] -1.068358354 -0.549610755  0.010842263  0.681931582  0.555361384
##     [11] -0.442785773  1.529706347  0.138638960  0.011212989  2.509888109
##     [16] -0.070418645  0.586705407 -0.289895477  0.583200295 -0.591005663
##     [21] -1.952793798  0.398490248 -0.834615443 -1.160060917 -0.103516905
##     [26] -0.097443559 -1.009780585 -1.706877921  0.010986333  0.383132980
##     [31] -0.810046389  0.956106754  1.741682708 -0.042104728  1.059078361
##     [36] -0.234510985  0.204707205 -0.187922859 -0.972375662  3.073504142
##     [41] -1.787522922 -0.128099364  1.314108280  0.295726844  0.708810570
##     [46]  0.010806419 -0.503529281 -0.921707230  0.356327596 -0.591615811
##     [51] -0.275343160  0.008624536 -0.562016928 -0.718752578  0.516654884
##     [56]  0.123282725  0.009088171 -0.558798498 -0.636788154  0.634570417
##     [61] -0.713052558  0.582146192 -0.545006734  1.574001932 -1.221892481
##     [66]  1.242220075 -0.108658947  2.091854113 -0.563947483  1.133399521
```

```

## [71] -0.033033754 -1.106199817 -0.267279287 0.201626427 -0.587237414
## [76] 0.176770677 -2.039944017 -3.479469157 0.226369995 -0.216504976
## [81] 0.277001279 0.119692553 0.195184453 -0.829018168 0.603592734
## [86] 0.184634328 0.011479325 -0.386822504 0.008138868 -0.549610755
## [91] -1.711667310 -0.037637928 -0.538527255 0.985075840 0.333134023
## [96] -0.868057987 -0.304501867 0.648327311 0.302809677 0.914909537
## [101] 0.240162265 -0.844105830 0.721379610 0.012148614 0.011615562
## [106] -0.688931241 1.195754468 -0.172827912 -0.334137345 0.999186652
## [111] 0.986837981 0.305411702 -0.189585376 0.012149510 0.123957238
## [116] 0.011976960 -1.391225629 0.573228419 -1.155631391 2.829856088
## [121] 1.192038563 0.907508679 1.314083595 -0.238973272 -1.550981443
## [126] -0.248423033 3.180383743 3.782409414 0.605832641 -0.693156777
## [131] -0.070957091 -0.954069568 -0.564096615 -1.542668981 -0.492339799
## [136] 0.717031715 -1.055633763 0.009886169 1.249109169 -0.997243179
## [141] 1.077640974 0.007152450 -1.173337525 0.078621095 0.293175442
## [146] -0.014781668 -1.161067969 -0.999727193 0.043968812 -1.600967995
## [151] -0.602989789 -0.368177867 -0.790866913 -0.543381899 0.476475751
## [156] 0.011016488 0.291942001 0.010290654 0.190459871 2.230814027
## [161] -0.437926191 -0.247724904 0.487396150 -0.086868435 0.772435727
## [166] -0.552768984 0.805258149 -0.423138954 -1.207970738 0.315345093
## [171] 0.962081330 -0.378766246 0.696612205 0.232160998 1.134387414
## [176] 0.483749736 1.717086799 -0.553222620 0.901715038 -0.510964902
## [181] 1.908491582 -0.491358726 -0.921795721 -0.103060320 0.153622356
## [186] -1.218417321 -0.218631018 1.073226355 -1.149167429 0.901715038
## [191] -0.575077700 -0.706438446 -1.430026397 0.999186652 -0.305530317
## [196] 0.915515953 -0.553222620 0.686420067 -0.161816843 0.078621095
## [201] -0.160648647 -0.365128842 0.562228507 1.675588227 -0.702178823
## [206] 0.010235328 -0.707481613 0.386279229 0.377960329 1.319579073
## [211] -0.334102223 0.010984042 0.327926193 2.717917842 1.905601741
## [216] 1.286694874 0.165827292 0.010397598 -0.530104941 -0.110683206
## [221] -1.076716029 0.012882818 -0.872884713 1.468162684 0.621694935
## [226] -0.227299364 -0.351639415 -0.396540065 -0.289459854 1.551661398
## [231] -2.580081475 -1.122986062 -0.854329738 -0.176212660 3.364839374
## [236] -0.259057085 -2.527239129 1.111659330 -0.142762090 0.008154347
## [241] 0.834632292 -0.891919226 -0.530778745 0.463785984 -0.854938881
## [246] 0.869189238 -0.694595113 0.584373283 0.476475751 0.219038098
## [251] 0.714871393 0.162988959 0.090381815 -1.521189791 2.335994778
## [256] 0.530112881 -0.421610048 0.088149425 -0.592593390 -0.347097776
## [261] 1.214633899 -1.197100873 0.010393005 -0.194712440 0.834632292
## [266] -1.820218600 -0.601882969 -2.784877098 -0.531618545 2.538027239
## [271] 1.244753273 0.394915826 -0.535205139 -0.763329094 0.302809677
## [276] 0.490021171 -1.208004023 1.257314252 0.538266015 0.093885795
## [281] -0.995569006 0.414947199 0.881903331 1.733720038 -1.596638452
## [286] -0.551199278 -0.242896840 -1.161067969 0.533821035 0.174130226
## [291] -0.865403436 0.869383213 0.368748024 -0.473338421 -0.464351597
## [296] 2.434416108 -1.941506803 -1.706877921 -2.085547532 0.534585257
## [301] -0.337263542 0.011765211 0.007923925 -1.358054275 0.449861830
## [306] -0.247025757 -0.913240506 -2.347339728 0.496779007 -0.757529842
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## [3456] 0.717031715 2.206572093 0.309972997 0.472804884 0.623540428
## [3461] -1.752908121 -1.118586721 -0.270189285 -0.601882969 -1.033312069
## [3466] 1.261316262 1.133399521 -0.326987882 0.291942001 0.476304153
## [3471] -1.468681232 -0.702178823 2.509888109 -0.188760607 0.008461915
## [3476] -0.046139650 -0.070957091 -1.162652317 0.820734601 -0.144177126
## [3481] -0.871779850 -0.982208769 0.744422220 0.188162711 -0.777164803
## [3486] -0.419711580 -0.193642023 1.394679605 -0.311228220 2.335994778
## [3491] 1.054896849 -0.544450330 0.805258149 0.045547394 -1.120498590
## [3496] 0.205833976 -0.234651123 1.314916400 0.142640718 0.199402795
## [3501] -0.246427754 -0.620096789 -0.897385356 -0.842728511 1.005355774
## [3506] 0.471242233 0.159507824 0.582070859 -0.611994314 0.438594705
## [3511] 0.012149510 -0.204418788 -1.390257351 -4.200637822 0.516654884
## [3516] 0.462298988 -0.048365238 -1.021928842 0.885941784 -0.582459660
## [3521] -1.032792674 0.010393005 -0.045235934 1.023156931 1.853083694
## [3526] 0.967746296 0.310105544 0.010235328 -1.101045001 0.141232396
## [3531] -2.507690091 0.040052632 0.190459871 -0.602528498 -0.201527290
## [3536] -1.083150216 0.604408130 0.557899560 0.580281402 -1.134068034
## [3541] 0.012913105 -0.242896840 0.210417356 -0.816451079 0.305543577
## [3546] -0.108658947 0.111268318 0.854011006 -0.628458215 1.077071931
## [3551] 0.456609878 1.205177811 -0.516673823 -0.543959782 0.371833407
## [3556] 1.385885748 0.319918852 0.619439310 -0.533511121 1.282143530
## [3561] -6.433685701 0.111268318 0.148059547 0.132942193 0.114411504
## [3566] -0.695708405 -2.259898653 0.011904934 -0.044693744 0.319363372
## [3571] 0.101579863 0.009064904 0.007104361 0.605562257 -0.090128013
## [3576] -0.364288806 -0.246891481 -1.358054275 0.803582145 1.059078361

```

```

## [3581] -1.175937791 -1.238433557 0.904915053 -0.077173445 0.008359736
## [3586] 0.010124434 -1.018627376 0.184392870 0.011535622 0.282081007
## [3591] 0.825362682 -0.799530042 0.327786591 0.323614466 -0.577436262
## [3596] 0.297558093 0.261281951 1.161552550 0.564397426 -8.062164647
## [3601] -0.035510960 0.220162845 1.076641918 1.080343861 0.008410162
## [3606] -0.689979501 1.380159662 0.007152450 0.274160815 0.672675648
## [3611] -0.816646087 1.032426830 -0.902161106 -0.253702548 0.350908998
## [3616] -0.574456032 -1.999243955 0.320275488 -0.480418858 1.490635063
## [3621] -0.278753613 1.564085620 -0.208304504 0.012533579 0.125785462
## [3626] 1.402752756 0.251984626 -0.552209270 -2.131744248 0.308651500
## [3631] -0.477286853 0.305411702 0.287674069 0.224026303 -0.355285214
## [3636] 0.118721548 -0.387778442 0.531045046 0.151594963 -0.659922024
## [3641] -0.771179033 0.117805614 -0.220977212 1.072808209 2.524084265
## [3646] -0.968582810 -0.049262533 1.364780464 -0.508817074 -0.365292242
## [3651] -0.211573339 -0.636760352 0.979932247 -0.005526125 0.293175442
## [3656] 0.421962815 -0.492799536 0.823060728 -0.936472982 0.749724573
## [3661] -0.786171087 -1.116250329 0.277001279 -0.468556342 -0.189574569
## [3666] -0.819946178 0.009637335 2.335994778 -0.388956215 2.006566672
## [3671] -0.004520468 -0.550767326 1.442919219 0.010339255 -0.305904136
## [3676] -1.022989177 0.564815591 -1.490657763 1.478471523 1.525059422
## [3681] 0.178901554 0.863559139 -1.596638452 -2.145371149 0.212549164
## [3686] 0.009751245 -0.305904136 0.613592405 0.053855010 0.933647284
## [3691] -0.361753811 1.427594967 0.432487312 -0.320099387 -0.889794623
## [3696] -0.540014925 0.012487575 0.666090385 -0.485326588 -0.204418788
## [3701] 0.477888568 -0.490228564 0.972327398 0.492163122 0.105272864
## [3706] -0.628564832 0.781827312 -1.105120924 -1.110868830 1.151949039
## [3711] 0.326816570 1.999614369 -0.871379682 0.474333669 0.170174640
## [3716] -0.261569462 0.529511992 0.362955060 -0.562861361 -0.360913991
## [3721] 2.243269889 1.259737068 -0.091631018 0.009545317 -0.500018713
## [3726] -1.568075243 -0.540393449 0.243765853 0.316123068 -0.710270704
## [3731] -0.056746942 -0.869701440 -0.661315885 -0.291312801 0.476475751
## [3736] -1.320060565 0.494176717 0.376418798 0.673790393 0.101579863
## [3741] -0.097341337 0.293175442 -0.973642040 0.191377205 -0.378025229
## [3746] -0.285873193 0.423067864 1.083713093 1.348121674 0.380367093
## [3751] 7.499308207 -1.157895510 -0.986216636 -0.568265026 -1.217058590
## [3756] -1.197100873 1.633022993 -1.268346681 0.008359736 -0.520964028
## [3761] -0.233629281 -0.861077360 0.887843794 -0.322293615 -0.608800607
## [3766] 1.398351407 -0.787601384 0.894890684 -3.479469157 0.012156152
## [3771] 0.297512698 0.130250716 1.628136082 0.710040596 -0.414707987
## [3776] -0.620096789 -0.160648647 -1.013303192 0.967682772 0.054332509
## [3781] -1.763536451 3.175108164 -0.844105830 -0.070418645 0.058960436
## [3786] -0.462408565 0.431505747 -0.295297894 -0.641836790 -1.171906960
## [3791] 1.942571218 -0.291171501 0.125043100 0.997016475 -0.028697782
## [3796] -2.131744248 -0.074350553 1.005843556 1.167488432 1.398351407
## [3801] -1.037684247 -0.410169647 -0.222998092 0.894890684 -0.636760352
## [3806] 0.410561448 -0.379071605 -0.492373911 -0.568265026 1.242220075
## [3811] 0.584014819 -0.174190411 -0.289459854 0.367671412 -0.412225564
## [3816] 0.074228739 1.256127616 0.182159390 0.011785210 -0.507149015
## [3821] -0.321203764 0.016264414 1.641933504 0.566321943 1.551661398
## [3826] -0.170042319 1.451261458 0.065122102 0.457040183 0.605583443
## [3831] 0.965113573 0.011327356 0.668859891 -0.530104941 0.562228507
## [3836] -0.952808493 0.748747517 -0.194712440 0.860751261 -0.243279798
## [3841] 1.086716348 -0.166520004 -0.922499071 0.982839348 1.028298491
## [3846] -0.101570714 0.381131168 -0.210815977 0.267800352 -0.305636412

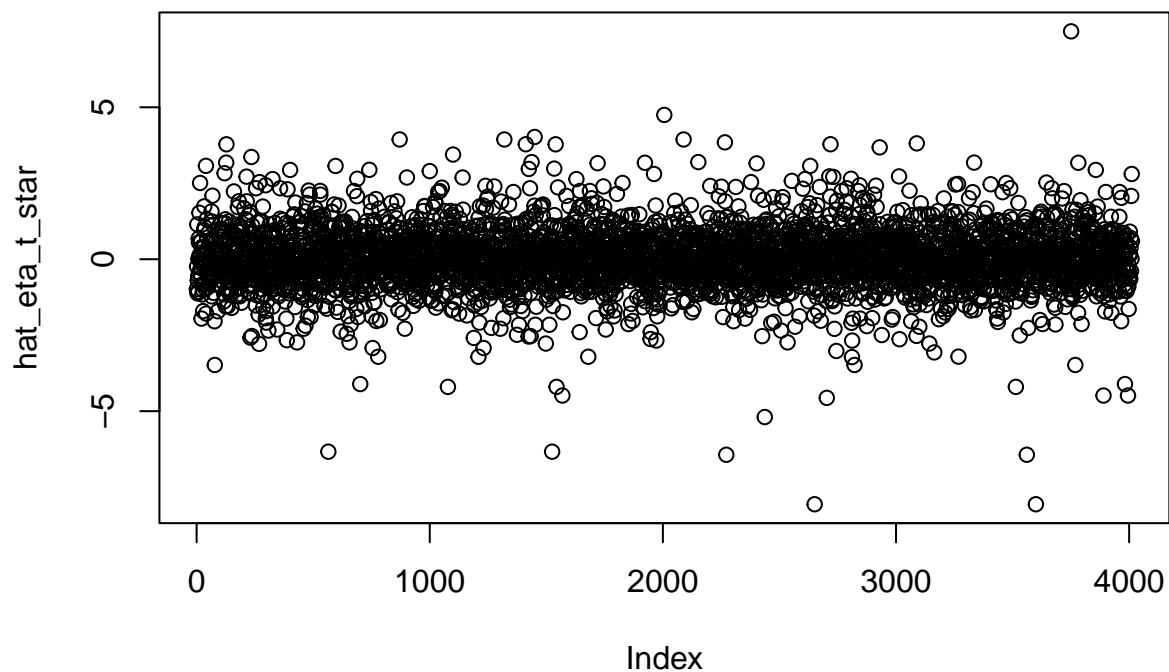
```

```

## [3851]  0.425450854 -0.571640450 -0.639661564  1.509143323  0.182673955
## [3856]  0.204036508  2.938946170  0.210442278  0.009036430 -1.220161556
## [3861] -0.311705752 -0.036739151 -0.982386058  0.011001753  1.733720038
## [3866] -1.002180463  0.009991447  0.619439310 -0.629866973 -0.241032416
## [3871]  0.009238198 -0.459546928 -0.426448058  0.492163122 -0.680567233
## [3876] -1.122346785  0.794045670 -0.046059758 -0.294916296  0.057359968
## [3881]  0.862603338  0.011381208 -0.205554989 -0.095135482  0.755628783
## [3886]  0.537261992 -0.645768775 -0.213405425 -1.062699779 -4.484949600
## [3891] -1.214026443  0.009840530 -0.499526090 -0.289533357  0.990409820
## [3896] -0.042104728 -1.717158955  0.011914942  0.074935727  2.212758805
## [3901]  0.463785984  0.009726174  0.119692553  0.182339717 -0.550767326
## [3906]  0.605562257 -0.982208769 -0.195447558  0.454415237 -0.746051167
## [3911]  0.935476668  0.914909537  0.041311369  0.670845605 -1.368183261
## [3916] -1.155193406  0.480328558 -0.676465368 -0.523475207  0.921721107
## [3921] -0.664845584  1.398472365  0.850991279 -1.763536451  0.990494018
## [3926] -0.187911366  0.451157968  0.319918852  0.302809677 -0.214601800
## [3931]  0.011327356  0.011976960  0.714871393 -1.058800750  0.968302159
## [3936] -0.470149210 -1.074158920 -0.464081868 -0.834615443 -0.343779458
## [3941]  0.561451639  0.132942193  0.169334844 -1.061957619  0.248239562
## [3946]  0.112057282  0.295990026  0.830400021  0.657958144  0.168742314
## [3951] -0.207488006  0.065205212 -0.231220461 -0.243279798 -0.305636412
## [3956] -0.196161443 -1.062699779  1.398472365  2.212758805 -0.366419486
## [3961]  0.010397598  0.559271061 -1.225888221 -0.522363427  0.774149013
## [3966] -2.039944017  2.021040456  0.359059303  0.391001556  0.871296856
## [3971] -0.672158334  0.680250615 -0.302118997  0.219038098  0.012241002
## [3976]  0.130380443 -0.663777478  0.856963118 -0.837034716 -0.551584079
## [3981] -1.029184726 -4.107354347  0.601307309  0.010086312 -0.245594743
## [3986]  0.247699877  0.477885421  0.766781643 -1.046696040  0.392050582
## [3991] -0.379071605 -0.351274437 -0.945164896 -0.326987882 -4.484949600
## [3996] -0.165286551 -0.883625595 -1.636447992 -0.412771876 -0.587037238
## [4001]  0.128669891  0.186852833  0.906627600  0.157348012 -0.645768775
## [4006]  0.387084508  0.697961593 -0.390547698  2.083701697  0.012553330
## [4011]  2.806131327  0.600713172

```

```
plot(hat_eta_t_star)
```



Using GARCH equations, estimating GARCH parameters and obtaining one bootstrap replicate of the model.

```
hat_u_t_star<-rep(NA,n)
hat_sigma_t_star<-rep(NA,n)
hat_sigma_t_star[1]<-hat_sigma_t[1]
hat_u_t_star<-hat_sigma_t_star[1]*hat_eta_t_star[1]
hat_sigma_t_star
```

```
##      [1] 0.03710785      NA      NA      NA      NA      NA
##      [7]      NA      NA      NA      NA      NA      NA
##     [13]      NA      NA      NA      NA      NA      NA
##     [19]      NA      NA      NA      NA      NA      NA
##     [25]      NA      NA      NA      NA      NA      NA
##     [31]      NA      NA      NA      NA      NA      NA
##     [37]      NA      NA      NA      NA      NA      NA
##     [43]      NA      NA      NA      NA      NA      NA
##     [49]      NA      NA      NA      NA      NA      NA
##     [55]      NA      NA      NA      NA      NA      NA
##     [61]      NA      NA      NA      NA      NA      NA
##     [67]      NA      NA      NA      NA      NA      NA
##     [73]      NA      NA      NA      NA      NA      NA
##     [79]      NA      NA      NA      NA      NA      NA
##     [85]      NA      NA      NA      NA      NA      NA
##     [91]      NA      NA      NA      NA      NA      NA
##     [97]      NA      NA      NA      NA      NA      NA
##    [103]      NA      NA      NA      NA      NA      NA
##    [109]      NA      NA      NA      NA      NA      NA
```

##	[115]	NA	NA	NA	NA	NA	NA
##	[121]	NA	NA	NA	NA	NA	NA
##	[127]	NA	NA	NA	NA	NA	NA
##	[133]	NA	NA	NA	NA	NA	NA
##	[139]	NA	NA	NA	NA	NA	NA
##	[145]	NA	NA	NA	NA	NA	NA
##	[151]	NA	NA	NA	NA	NA	NA
##	[157]	NA	NA	NA	NA	NA	NA
##	[163]	NA	NA	NA	NA	NA	NA
##	[169]	NA	NA	NA	NA	NA	NA
##	[175]	NA	NA	NA	NA	NA	NA
##	[181]	NA	NA	NA	NA	NA	NA
##	[187]	NA	NA	NA	NA	NA	NA
##	[193]	NA	NA	NA	NA	NA	NA
##	[199]	NA	NA	NA	NA	NA	NA
##	[205]	NA	NA	NA	NA	NA	NA
##	[211]	NA	NA	NA	NA	NA	NA
##	[217]	NA	NA	NA	NA	NA	NA
##	[223]	NA	NA	NA	NA	NA	NA
##	[229]	NA	NA	NA	NA	NA	NA
##	[235]	NA	NA	NA	NA	NA	NA
##	[241]	NA	NA	NA	NA	NA	NA
##	[247]	NA	NA	NA	NA	NA	NA
##	[253]	NA	NA	NA	NA	NA	NA
##	[259]	NA	NA	NA	NA	NA	NA
##	[265]	NA	NA	NA	NA	NA	NA
##	[271]	NA	NA	NA	NA	NA	NA
##	[277]	NA	NA	NA	NA	NA	NA
##	[283]	NA	NA	NA	NA	NA	NA
##	[289]	NA	NA	NA	NA	NA	NA
##	[295]	NA	NA	NA	NA	NA	NA
##	[301]	NA	NA	NA	NA	NA	NA
##	[307]	NA	NA	NA	NA	NA	NA
##	[313]	NA	NA	NA	NA	NA	NA
##	[319]	NA	NA	NA	NA	NA	NA
##	[325]	NA	NA	NA	NA	NA	NA
##	[331]	NA	NA	NA	NA	NA	NA
##	[337]	NA	NA	NA	NA	NA	NA
##	[343]	NA	NA	NA	NA	NA	NA
##	[349]	NA	NA	NA	NA	NA	NA
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##	[367]	NA	NA	NA	NA	NA	NA
##	[373]	NA	NA	NA	NA	NA	NA
##	[379]	NA	NA	NA	NA	NA	NA
##	[385]	NA	NA	NA	NA	NA	NA
##	[391]	NA	NA	NA	NA	NA	NA
##	[397]	NA	NA	NA	NA	NA	NA
##	[403]	NA	NA	NA	NA	NA	NA
##	[409]	NA	NA	NA	NA	NA	NA
##	[415]	NA	NA	NA	NA	NA	NA
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##	[427]	NA	NA	NA	NA	NA	NA
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##	[463]	NA	NA	NA	NA	NA	NA
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##	[487]	NA	NA	NA	NA	NA	NA
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##	[499]	NA	NA	NA	NA	NA	NA
##	[505]	NA	NA	NA	NA	NA	NA
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##	[517]	NA	NA	NA	NA	NA	NA
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##	[541]	NA	NA	NA	NA	NA	NA
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##	[559]	NA	NA	NA	NA	NA	NA
##	[565]	NA	NA	NA	NA	NA	NA
##	[571]	NA	NA	NA	NA	NA	NA
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## [3565]	NA	NA	NA	NA	NA	NA
## [3571]	NA	NA	NA	NA	NA	NA
## [3577]	NA	NA	NA	NA	NA	NA
## [3583]	NA	NA	NA	NA	NA	NA
## [3589]	NA	NA	NA	NA	NA	NA
## [3595]	NA	NA	NA	NA	NA	NA
## [3601]	NA	NA	NA	NA	NA	NA
## [3607]	NA	NA	NA	NA	NA	NA
## [3613]	NA	NA	NA	NA	NA	NA
## [3619]	NA	NA	NA	NA	NA	NA
## [3625]	NA	NA	NA	NA	NA	NA
## [3631]	NA	NA	NA	NA	NA	NA
## [3637]	NA	NA	NA	NA	NA	NA
## [3643]	NA	NA	NA	NA	NA	NA
## [3649]	NA	NA	NA	NA	NA	NA
## [3655]	NA	NA	NA	NA	NA	NA
## [3661]	NA	NA	NA	NA	NA	NA
## [3667]	NA	NA	NA	NA	NA	NA
## [3673]	NA	NA	NA	NA	NA	NA

## [3679]	NA	NA	NA	NA	NA	NA
## [3685]	NA	NA	NA	NA	NA	NA
## [3691]	NA	NA	NA	NA	NA	NA
## [3697]	NA	NA	NA	NA	NA	NA
## [3703]	NA	NA	NA	NA	NA	NA
## [3709]	NA	NA	NA	NA	NA	NA
## [3715]	NA	NA	NA	NA	NA	NA
## [3721]	NA	NA	NA	NA	NA	NA
## [3727]	NA	NA	NA	NA	NA	NA
## [3733]	NA	NA	NA	NA	NA	NA
## [3739]	NA	NA	NA	NA	NA	NA
## [3745]	NA	NA	NA	NA	NA	NA
## [3751]	NA	NA	NA	NA	NA	NA
## [3757]	NA	NA	NA	NA	NA	NA
## [3763]	NA	NA	NA	NA	NA	NA
## [3769]	NA	NA	NA	NA	NA	NA
## [3775]	NA	NA	NA	NA	NA	NA
## [3781]	NA	NA	NA	NA	NA	NA
## [3787]	NA	NA	NA	NA	NA	NA
## [3793]	NA	NA	NA	NA	NA	NA
## [3799]	NA	NA	NA	NA	NA	NA
## [3805]	NA	NA	NA	NA	NA	NA
## [3811]	NA	NA	NA	NA	NA	NA
## [3817]	NA	NA	NA	NA	NA	NA
## [3823]	NA	NA	NA	NA	NA	NA
## [3829]	NA	NA	NA	NA	NA	NA
## [3835]	NA	NA	NA	NA	NA	NA
## [3841]	NA	NA	NA	NA	NA	NA
## [3847]	NA	NA	NA	NA	NA	NA
## [3853]	NA	NA	NA	NA	NA	NA
## [3859]	NA	NA	NA	NA	NA	NA
## [3865]	NA	NA	NA	NA	NA	NA
## [3871]	NA	NA	NA	NA	NA	NA
## [3877]	NA	NA	NA	NA	NA	NA
## [3883]	NA	NA	NA	NA	NA	NA
## [3889]	NA	NA	NA	NA	NA	NA
## [3895]	NA	NA	NA	NA	NA	NA
## [3901]	NA	NA	NA	NA	NA	NA
## [3907]	NA	NA	NA	NA	NA	NA
## [3913]	NA	NA	NA	NA	NA	NA
## [3919]	NA	NA	NA	NA	NA	NA
## [3925]	NA	NA	NA	NA	NA	NA
## [3931]	NA	NA	NA	NA	NA	NA
## [3937]	NA	NA	NA	NA	NA	NA
## [3943]	NA	NA	NA	NA	NA	NA
## [3949]	NA	NA	NA	NA	NA	NA
## [3955]	NA	NA	NA	NA	NA	NA
## [3961]	NA	NA	NA	NA	NA	NA
## [3967]	NA	NA	NA	NA	NA	NA
## [3973]	NA	NA	NA	NA	NA	NA
## [3979]	NA	NA	NA	NA	NA	NA
## [3985]	NA	NA	NA	NA	NA	NA
## [3991]	NA	NA	NA	NA	NA	NA
## [3997]	NA	NA	NA	NA	NA	NA

```
## [4003]      NA      NA      NA      NA      NA      NA
## [4009]      NA      NA      NA      NA      NA
for (t in 2:n)
{
  hat_sigma_t_star[t]<-sqrt(fit1@fit$coef['omega']+
                           fit1@fit$coef['alpha1']*(hat_u_t_star[t-1])^2)+
                           fit1@fit$coef['beta1']*(hat_sigma_t_star[t-1])^2
  hat_u_t_star[t]<-hat_sigma_t_star[t]*hat_eta_t_star[t]
}
hat_u_t_star<-hat_u_t_star-mean(hat_u_t_star)
r_t_star<-fit1@fit$coef['mu']+hat_u_t_star
fitisar<-ugarchfit(data=r_t_star, spec=spec1)
fitisar@fit$matcoef
```

```
##           Estimate   Std. Error    t value    Pr(>|t|)
## mu      -2.316853e-04 4.066181e-05 -5.697860e+00 1.213203e-08
## alpha1  5.208600e-02 2.032059e-02  2.563213e+00 1.037084e-02
## beta1   6.663309e-06 1.228805e-01  5.422592e-05 9.999567e-01
## shape   4.043144e+00 1.617330e-01  2.499887e+01 0.000000e+00
## omega   9.030383e-06      NA      NA      NA
```

Estimating constant + EWMA model for log-returns.

```
spec2 = ugarchspec(variance.model=list(model="iGARCH", garchOrder=c(1,1),
                                       variance.targeting=TRUE),
                  mean.model=list(armaOrder=c(0,0), include.mean=TRUE),
                  distribution.model="norm", fixed.pars=list(omega=0))
#specifications for model (2)
fit2 = ugarchfit(data = x, spec = spec2)
```

Point Forecast and Density Forecast.

Using the previous model to obtain point volatility forecast.

```
fit1forecast<-ugarchforecast(fitORspec=fit1, data = NULL,
                             n.ahead = 10, n.roll = 0)
fit1forecast@forecast$sigmaFor
```

```
##      1980-12-26
## T+1  0.03032607
## T+2  0.03037400
## T+3  0.03042154
## T+4  0.03046872
## T+5  0.03051551
## T+6  0.03056194
## T+7  0.03060801
## T+8  0.03065371
## T+9  0.03069906
## T+10 0.03074405
```

```
fit1forecast@forecast$seriesFor
```

```
##      1980-12-26
## T+1  -0.0002150934
## T+2  -0.0002150934
## T+3  -0.0002150934
```

```
## T+4 -0.0002150934
## T+5 -0.0002150934
## T+6 -0.0002150934
## T+7 -0.0002150934
## T+8 -0.0002150934
## T+9 -0.0002150934
## T+10 -0.0002150934

fitlforecast@forecast$seriesFor
```

```
##          1980-12-26
## T+1 -0.0002150934
## T+2 -0.0002150934
## T+3 -0.0002150934
## T+4 -0.0002150934
## T+5 -0.0002150934
## T+6 -0.0002150934
## T+7 -0.0002150934
## T+8 -0.0002150934
## T+9 -0.0002150934
## T+10 -0.0002150934
```

Estimating the density of conditional volatility forecast and density of series forecast.

```
fitlboot<-ugarchboot(fitORspec=fit1, data = NULL, method = c('Full'),
                     sampling = c('raw'), n.ahead=10,
                     n.bootfit = 30, n.bootpred = 1000, out.sample = 0,
                     rseed=1:1030)
```

```
#matrix (n.bootfit x 5) with bootstrap parameter estimates
fitlboot@bcoef
```

```
##          mu          alpha1          beta1          shape          omega
## 1 -6.145276e-04 1.432949e-05 0.05096196 0.9300358 4.753350
## 2 -8.019613e-04 7.215842e-06 0.04322067 0.9499896 4.685451
## 3 -1.124743e-03 1.246952e-05 0.05231666 0.9403809 4.450850
## 4 -7.542813e-04 1.043591e-05 0.04305927 0.9502554 4.295209
## 5 -1.454117e-03 5.967508e-06 0.05141041 0.9475896 4.132920
## 6 4.522272e-04 1.661887e-05 0.05170688 0.9433845 3.958486
## 7 -9.141104e-04 8.426658e-06 0.04498842 0.9498556 4.055288
## 8 -1.188673e-03 1.263481e-05 0.04162337 0.9489461 4.294900
## 9 -1.263638e-04 1.028068e-05 0.05380999 0.9400768 4.296802
## 10 -8.894585e-04 3.179099e-06 0.03642447 0.9607267 4.780817
## 11 -7.501214e-05 1.256505e-05 0.04889350 0.9391120 4.828423
## 12 -6.044253e-04 1.015904e-05 0.04577539 0.9505525 3.891268
## 13 -2.137107e-04 1.226917e-05 0.06037533 0.9349375 4.236949
## 14 -9.420176e-04 1.138551e-05 0.04178266 0.9465418 4.575068
## 15 -2.101160e-03 1.029874e-05 0.04499349 0.9477325 4.074577
## 16 -3.117905e-05 7.900406e-06 0.03910365 0.9561271 4.186463
## 17 -3.627988e-04 1.288332e-05 0.04549201 0.9419496 4.865661
## 18 -2.103626e-04 6.699121e-06 0.05401910 0.9423173 4.754520
## 19 -4.700702e-04 1.097007e-05 0.04778601 0.9437337 4.496755
## 20 1.459569e-04 1.231386e-05 0.05459889 0.9363381 4.494024
## 21 -8.004753e-05 8.672111e-06 0.04880751 0.9448272 4.576799
## 22 -9.394385e-04 6.398983e-06 0.04581790 0.9509559 4.627815
## 23 -5.648969e-04 1.314311e-05 0.05455263 0.9311109 4.385136
```

```
## 24 -5.077290e-04 1.741225e-05 0.06136977 0.9312750 4.018254
## 25 -1.556842e-03 1.281845e-05 0.05057826 0.9397545 4.190464
## 26 -6.200271e-04 9.279981e-06 0.04322089 0.9479176 4.481595
## 27 -1.085537e-03 1.199982e-05 0.05325720 0.9415734 4.335733
## 28 -8.489005e-04 1.243571e-05 0.04630851 0.9467357 4.032873
## 29 -7.105183e-04 1.418315e-05 0.06850814 0.9304918 3.763539
## 30 -4.803321e-04 8.719836e-06 0.04906545 0.9455284 4.347962
```

```
boxplot(fitlboot@fsigma[1:1000,])#one set of bootstrap density estimates for sigma_{t+k}
```

