Applied Time Series Analysis: Final Project Appendix

Figure 1

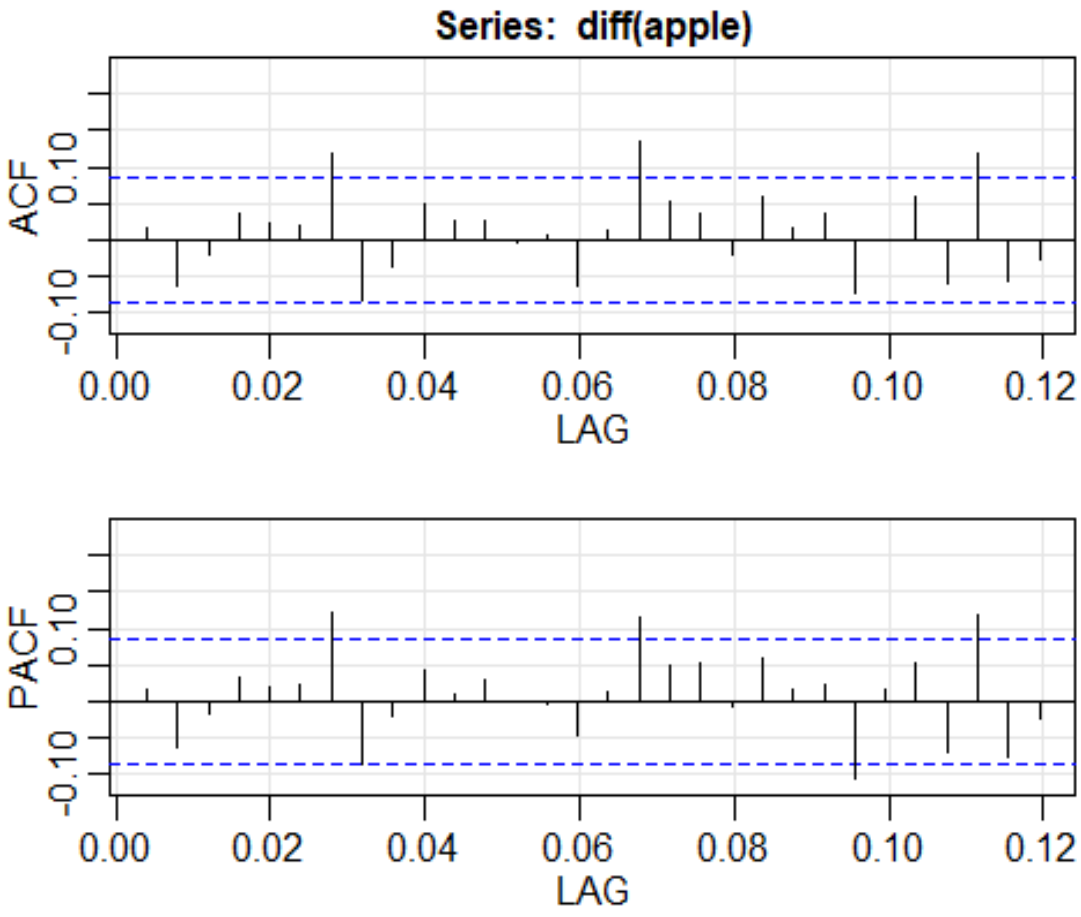

Figure 2

```
### AR Model - consider all orders p from 1 to 7 ###
p=7

#store information criteria values
ARaic = rep(NA,7)
ARaicc = rep(NA,7)
ARbic = rep(NA,7)

#append
for (p in 1:7) {
  fitAR = Arima(log(apple), order=c(p,1,0), method='ML')
  ARaic[p] = fitAR$aic
  ARaicc[p] = fitAR$aicc
  ARbic[p] = fitAR$bic
}


### MA Model - consider all orders q from 1 to 7 ###
q=7

#store information criteria values
MAaic = rep(NA,7)
MAaicc = rep(NA,7)
MAbic = rep(NA,7)

#append
for (q in 1:7) {
  fitMA = Arima(log(apple), order=c(0,1,q), method='ML')
  MAaic[q] = fitMA$aic
  MAaicc[q] = fitMA$aicc
  MAbic[q] = fitMA$bic
}


### ARMA(p,q) model ###
# I'm curious about ARMA Model - consider all orders p and q from 1 to 7 #
p=7
q=7

#store information criteria values
ARMAaic = matrix(0, nrow=p, ncol=q, byrow=TRUE) #row p represents ARMA(p,1,q)
ARMAaicc = matrix(0, nrow=p, ncol=q, byrow=TRUE)
ARMAbic = matrix(0, nrow=p, ncol=q, byrow=TRUE)
```

```
#append
for (p in 1:7) { #p

 for (q in 1:7) { #q

   fitARMA = Arima(log(apple), order=c(p,1,q), method='ML')

   ARMAaic[p,q] = fitARMA$aic

   ARMAaicc[p,q] = fitARMA$aicc

   ARMAbic[p,q] = fitARMA$bic

 }

}



### Model Choice - Choose model with lowest information criteria ###

min(ARaic) #highest
## [1] -3094.903
min(MAaic) #Second Lowest
## [1] -3094.91
min(ARMAaic) #Lowest value (most negative value)
## [1] -3097.772
min(ARaicc) #Highest
## [1] -3094.882
min(MAaicc) #Second Lowest
## [1] -3094.889
min(ARMAaicc) #Lowest value (most negative value)
## [1] -3097.665
min(ARbic) #Second lowest
## [1] -3086.223
min(MAbic) #Lowest value (most negative value)
## [1] -3086.23
min(ARMAbic) #Highest
## [1] -3080.174
### which orders for each model have lowest information criterion? ###
#AR(p)
which(min(ARaic)==ARaic) #1
## [1] 1
which(min(ARaicc)==ARaicc) #1
## [1] 1
which(min(ARbic)==ARbic) #1
## [1] 1
```

```
#AR(1)
AR1 = Arima(log(apple), order=c(0,1,1), method='ML')



#MA(q)
which(min(MAaic)==MAaic) #1
## [1] 1
which(min(min(MAaicc))==MAaicc) #1
## [1] 1
which(min(MAbic)==MAbic) #1
## [1] 1
#MA(1)
MA1 = Arima(log(apple), order=c(0,1,1), method='ML')



#ARMA(p)
which(min(ARMAaic)==ARMAaic) #9, corresponding to 9th entry, or (2nd row, 2nd col)
## [1] 9
which(min(ARMAaicc)==ARMAaicc) #9, corresponding to 9th entry, or (2nd row, 2nd col)
## [1] 9
which(min(ARMAbic)==ARMAbic) #1
## [1] 1
##ARMA(2,2)
ARMA22 = Arima(log(apple), order=c(2,1,2), method='ML')
ARMA22 #has lowest AIC and AICC values
## Series: log(apple)
## ARIMA(2,1,2)
##
## Coefficients:
##          ar1      ar2     ma1     ma2
##      -0.7865  -0.9559  0.8195  0.9544
## s.e.  0.0338   0.0480  0.0475  0.0376
##
## sigma^2 estimated as 0.0002455:  log likelihood=1553.89
## AIC=-3097.77   AICc=-3097.67   BIC=-3076.07
```

Figure 3

```
n = length(apple)

ARMA202 = Arima(diff((log(apple)))[1:(n-59)], order=c(2,0,2), method='ML',
include.constant=TRUE)
ARMA202
## Series: diff((log(apple)))[1:(n - 59)]
## ARIMA(2,0,2) with non-zero mean
##
## Coefficients:
##         ar1      ar2      ma1     ma2   mean
##       0.920  -0.9895  -0.9375  0.9861  5e-04
## s.e.  0.009   0.0119   0.0124  0.0166  7e-04
##
## sigma^2 estimated as 0.0002448:  log likelihood=1395.88
## AIC=-2779.77   AICc=-2779.6   BIC=-2754.37
```

Figure 4

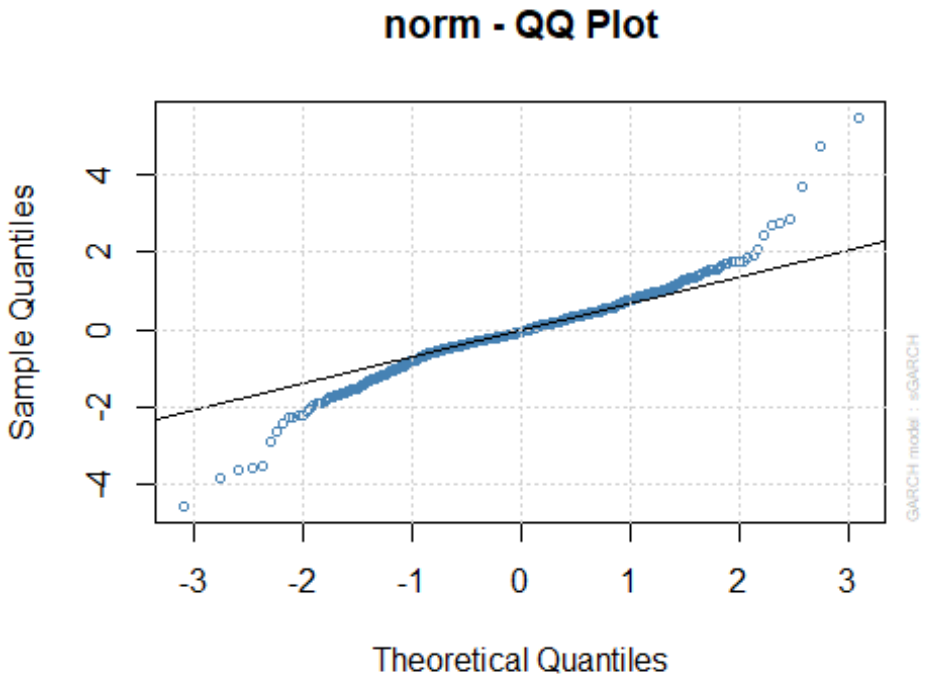

Figure 5

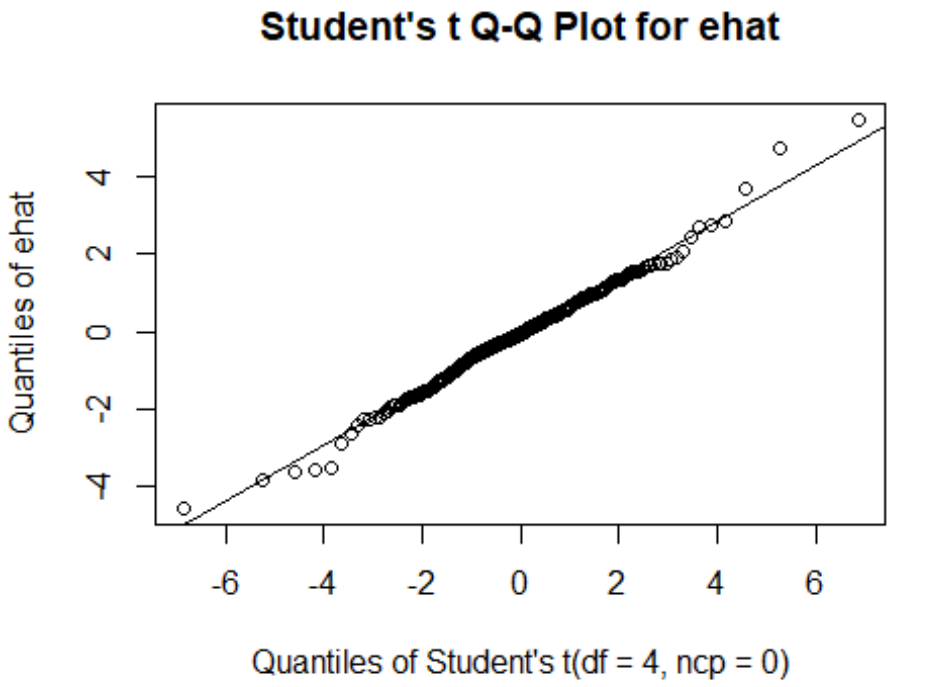

Figure 6

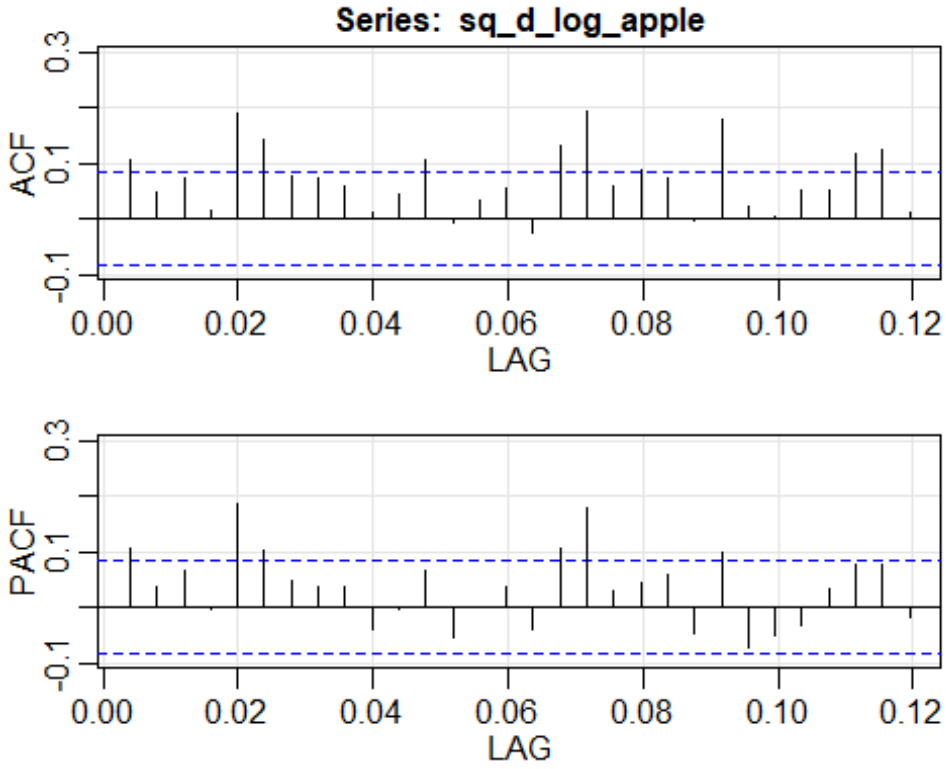
Series: sq_d_log_apple
ACF
PACF
LAG
0.3
0.1
-0.1
0.00
0.02
0.04
0.06
0.08
0.10
0.12

Figure 7.1

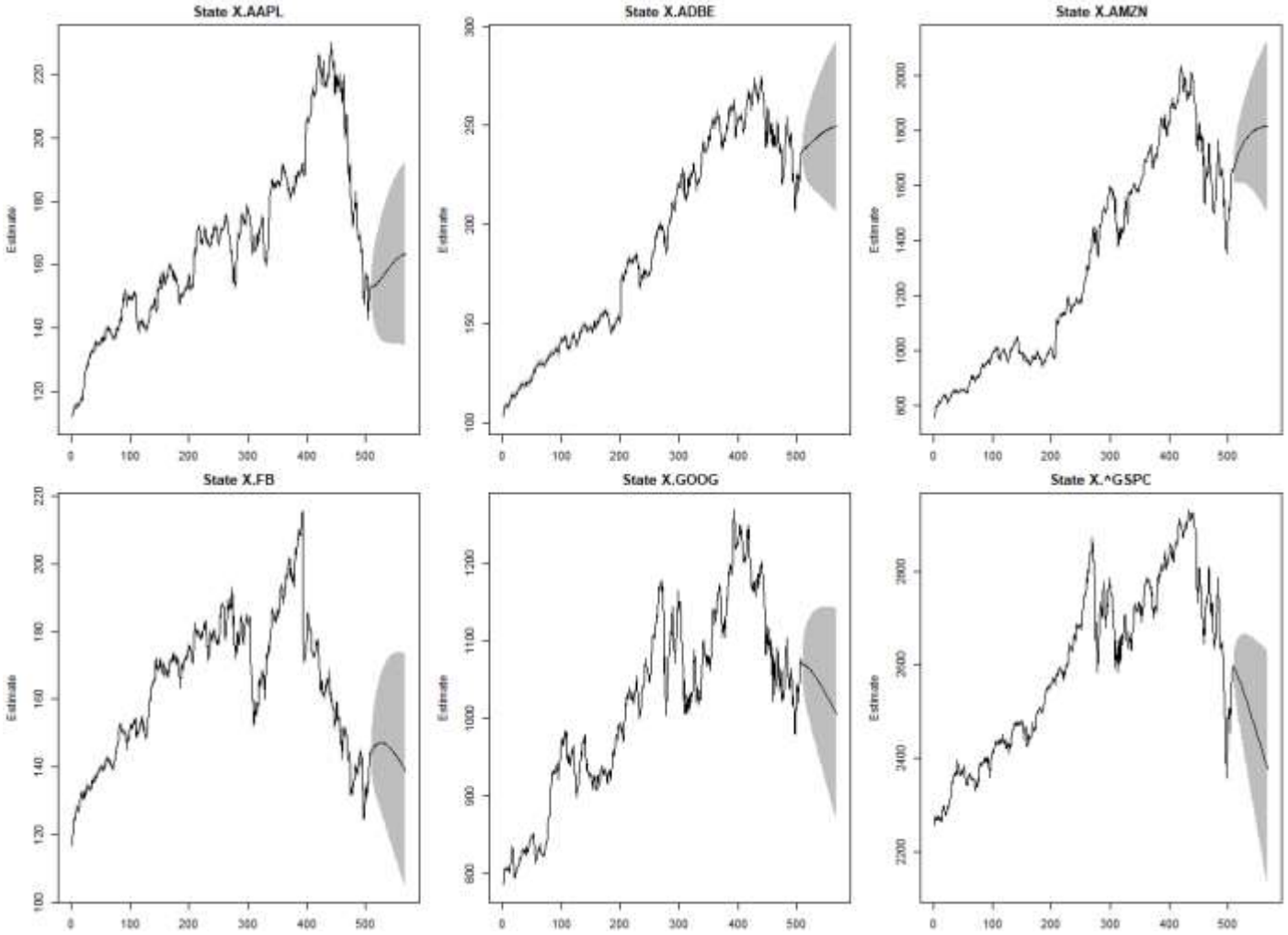
State X.AAPL
State X.ADBE
State X.AMZN
State X.FB
State X.GOOG
State X.^GSPC
Estimate

Figure 7.2

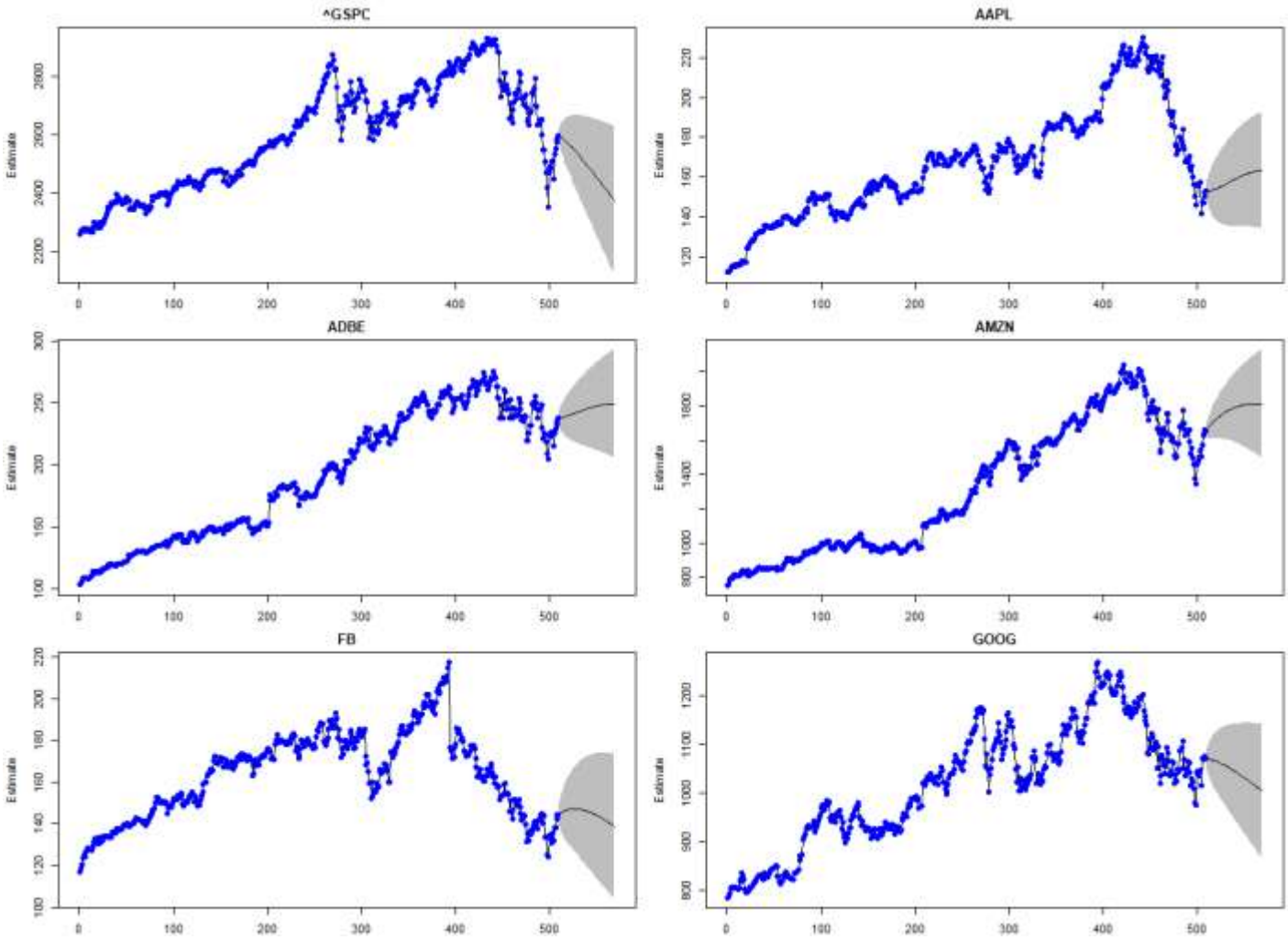

Figure 7.3

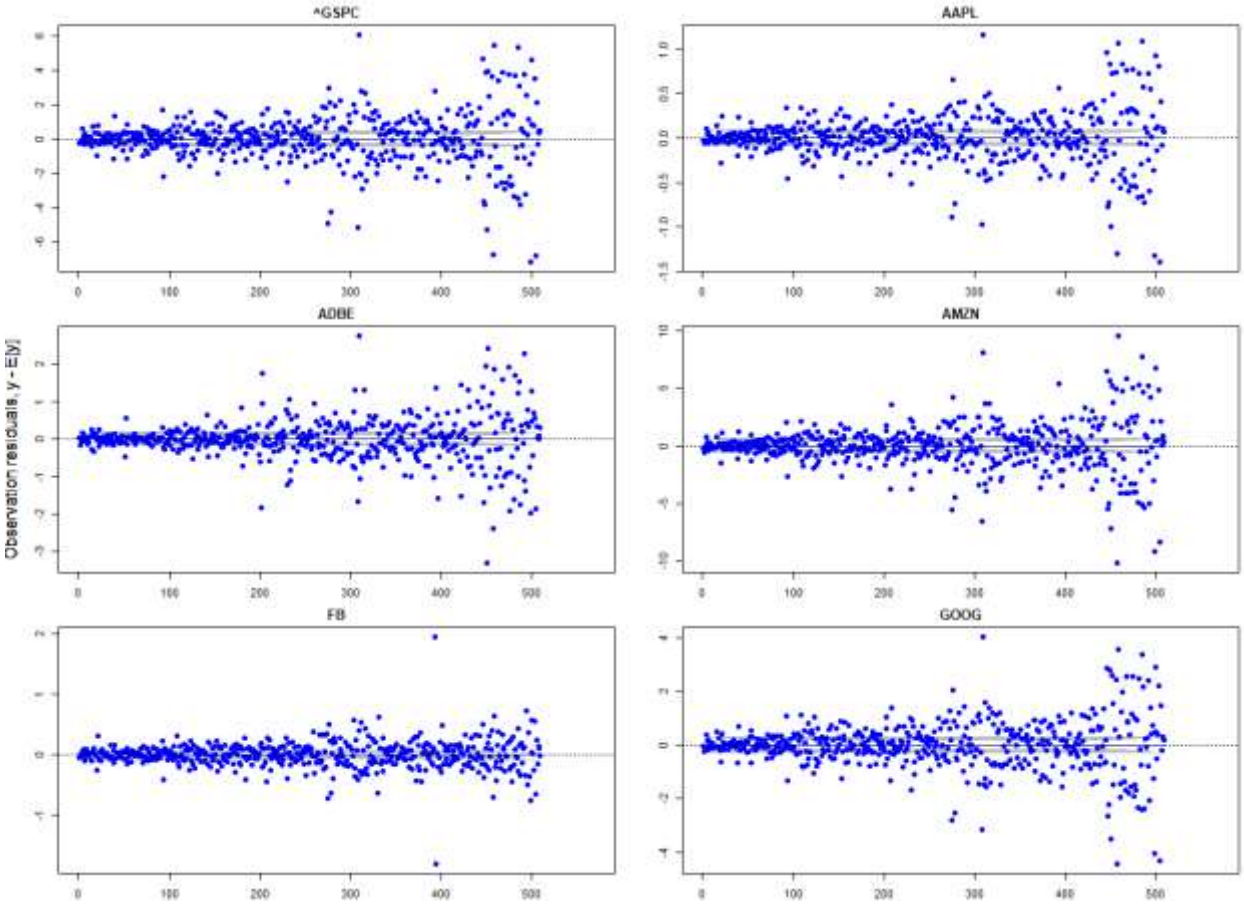

Figure 7.4

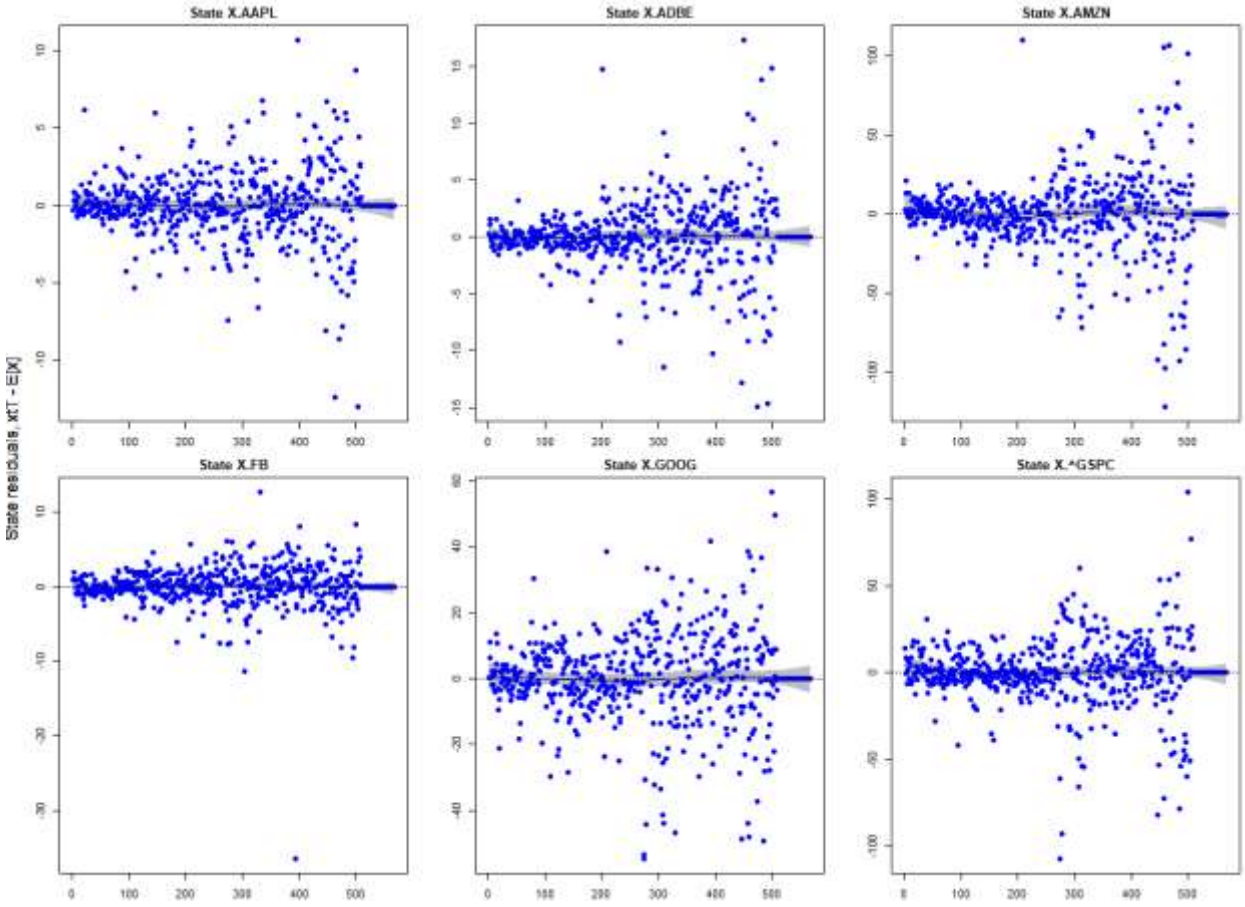
State X.AAPL
State X.ADBE
State X.AMZN
State X.FB
State X.GOOG
State X.^GSPC
State residuals, xtT - E[x]

Figure 7.5

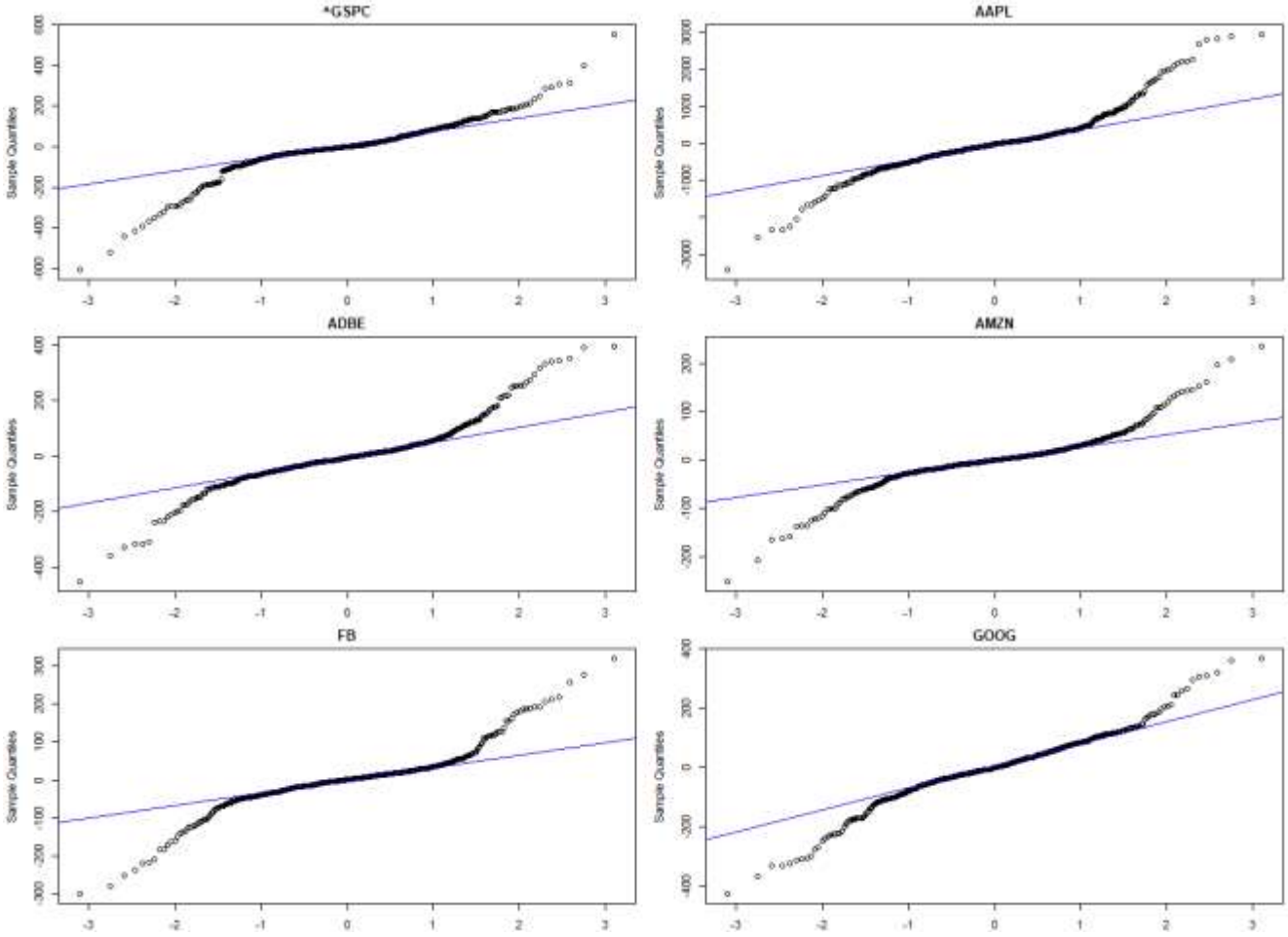

Figure 7.6

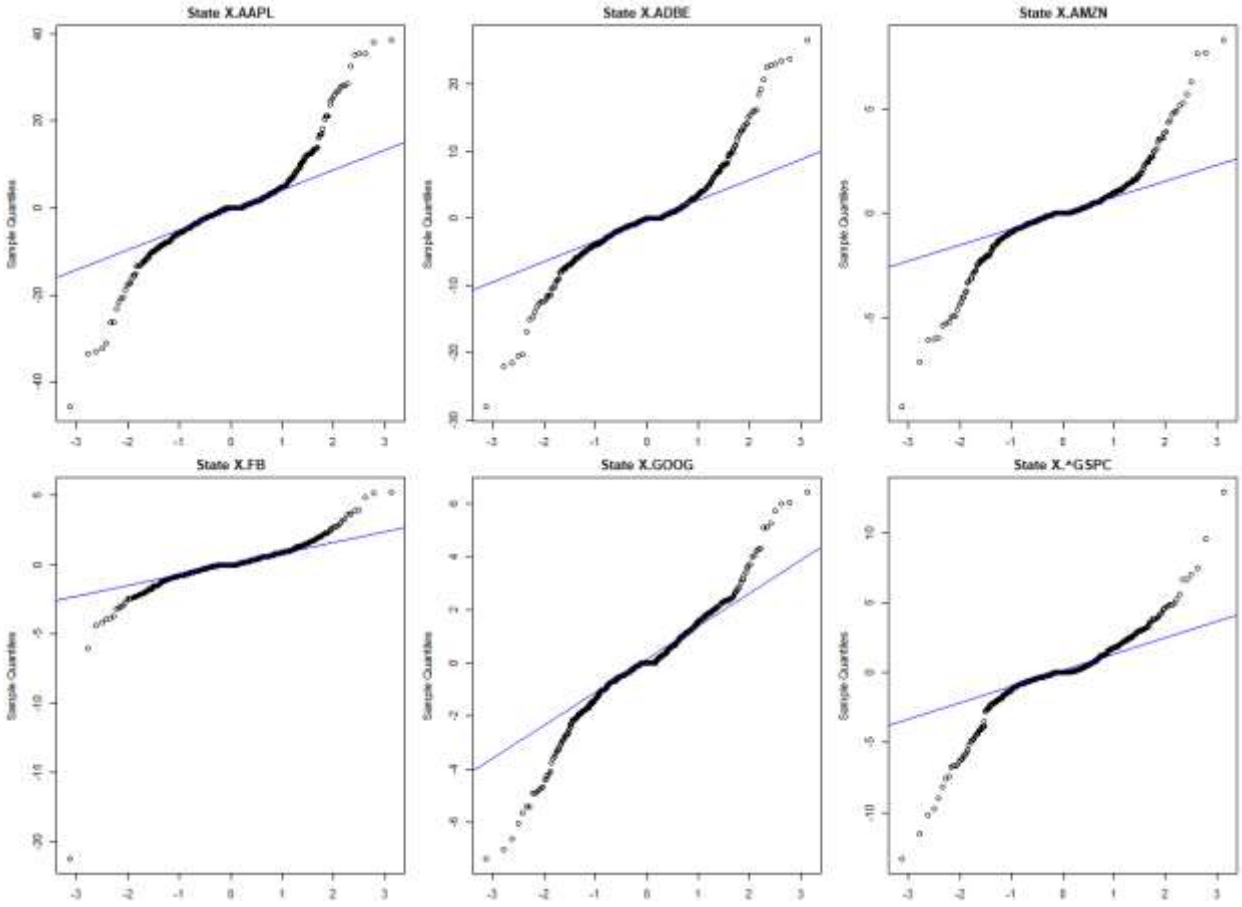
State X.AAPL
State X.ADBE
State X.AMZN
State X.FB
State X.GOOG
State X.^GSPC
Sample Quantiles

Figure 8

```
MARSS fit is
Estimation method: BFGS
Estimation converged in 412 iterations.
Log-likelihood: -9736.747
AIC: 19641.49   AICc: 19646.3

              ML.Est  Std.Err    low.CI    up.CI
R.r11       2.84e-01  0.32663 -3.57e-01 9.24e-01
R.r12       7.19e-01  0.39426 -5.33e-02 1.49e+00
R.r13       3.61e+00  2.76240 -1.80e+00 9.03e+00
R.r14       3.39e-01  0.30206 -2.53e-01 9.31e-01
R.r15       1.63e+00  1.54609 -1.40e+00 4.66e+00
R.r16       2.60e+00  2.25462 -1.81e+00 7.02e+00
R.r22       2.42e+00  0.71426  1.02e+00 3.82e+00
R.r23       9.36e+00  4.19148  1.14e+00 1.76e+01
R.r24       4.99e-01  0.44952 -3.82e-01 1.38e+00
R.r25       4.49e+00  2.32674 -7.12e-02 9.05e+00
R.r26       6.82e+00  3.32832  2.95e-01 1.33e+01
R.r33       4.63e+01 33.46542 -1.93e+01 1.12e+02
R.r34       4.34e+00  3.21935 -1.97e+00 1.06e+01
R.r35       2.08e+01 16.20847 -1.10e+01 5.25e+01
R.r36       3.33e+01 22.99801 -1.18e+01 7.84e+01
R.r44       7.15e-01  0.47487 -2.16e-01 1.65e+00
R.r45       1.68e+00  1.81237 -1.88e+00 5.23e+00
R.r46       3.01e+00  2.51040 -1.91e+00 7.94e+00
R.r55       9.60e+00 10.35560 -1.07e+01 2.99e+01
R.r56       1.51e+01 13.19337 -1.08e+01 4.09e+01
R.r66       2.40e+01 20.91870 -1.70e+01 6.50e+01
B.phi11     9.82e-01  0.01155  9.60e-01 1.01e+00
B.phi21    -1.44e-02  0.01497 -4.38e-02 1.49e-02
B.phi31    -2.13e-01  0.11353 -4.36e-01 9.45e-03
B.phi41    -1.57e-02  0.01329 -4.17e-02 1.04e-02
B.phi51    -5.16e-02  0.06386 -1.77e-01 7.35e-02
B.phi61     1.99e-02  0.09178 -1.60e-01 2.00e-01
B.phi12    -1.72e-02  0.01356 -4.38e-02 9.40e-03
B.phi22     9.90e-01  0.01775  9.55e-01 1.02e+00
B.phi32     2.99e-01  0.13448  3.57e-02 5.63e-01
B.phi42     2.80e-02  0.01570 -2.78e-03 5.88e-02
B.phi52     1.47e-01  0.07529 -1.36e-04 2.95e-01
B.phi62     1.35e-01  0.10822 -7.73e-02 3.47e-01
```

B.phi13	3.21e-03	0.00202	-7.55e-04	7.18e-03
B.phi23	1.81e-03	0.00265	-3.39e-03	7.00e-03
B.phi33	9.56e-01	0.02007	9.17e-01	9.95e-01
B.phi43	-3.25e-03	0.00234	-7.84e-03	1.35e-03
B.phi53	-1.50e-02	0.01125	-3.70e-02	7.08e-03
B.phi63	-2.59e-02	0.01615	-5.75e-02	5.79e-03
B.phi14	2.40e-02	0.00981	4.74e-03	4.32e-02
B.phi24	1.47e-02	0.01279	-1.03e-02	3.98e-02
B.phi34	-2.70e-02	0.09694	-2.17e-01	1.63e-01
B.phi44	9.90e-01	0.01140	9.68e-01	1.01e+00
B.phi54	6.95e-02	0.05452	-3.73e-02	1.76e-01
B.phi64	4.22e-02	0.07829	-1.11e-01	1.96e-01
B.phi15	-3.24e-03	0.00414	-1.14e-02	4.88e-03
B.phi25	-2.73e-03	0.00541	-1.33e-02	7.88e-03
B.phi35	6.34e-02	0.04087	-1.67e-02	1.44e-01
B.phi45	-5.59e-03	0.00479	-1.50e-02	3.79e-03
B.phi55	9.65e-01	0.02321	9.19e-01	1.01e+00
B.phi65	1.82e-02	0.03306	-4.66e-02	8.30e-02
B.phi16	5.56e-04	0.00122	-1.83e-03	2.94e-03
B.phi26	1.01e-03	0.00159	-2.10e-03	4.12e-03
B.phi36	-8.58e-03	0.01200	-3.21e-02	1.49e-02
B.phi46	3.43e-03	0.00141	6.80e-04	6.19e-03
B.phi56	9.62e-03	0.00681	-3.72e-03	2.30e-02
B.phi66	9.92e-01	0.00970	9.73e-01	1.01e+00
Q.q11	6.73e+00	0.75165	5.26e+00	8.20e+00
Q.q12	4.97e+00	0.82781	3.35e+00	6.59e+00
Q.q13	4.01e+01	6.20084	2.80e+01	5.23e+01
Q.q14	3.03e+00	0.67153	1.71e+00	4.34e+00
Q.q15	2.30e+01	3.49974	1.61e+01	2.99e+01
Q.q16	3.63e+01	5.13683	2.62e+01	4.63e+01
Q.q22	1.13e+01	1.37587	8.62e+00	1.40e+01
Q.q23	5.99e+01	8.69748	4.29e+01	7.70e+01
Q.q24	4.85e+00	0.93193	3.02e+00	6.67e+00
Q.q25	3.33e+01	4.88037	2.37e+01	4.29e+01
Q.q26	4.86e+01	6.99531	3.49e+01	6.23e+01
Q.q33	6.55e+02	74.37035	5.09e+02	8.01e+02
Q.q34	3.94e+01	7.00599	2.57e+01	5.31e+01
Q.q35	2.60e+02	36.21922	1.89e+02	3.31e+02
Q.q36	3.63e+02	51.33955	2.63e+02	4.64e+02
Q.q44	8.98e+00	1.03274	6.95e+00	1.10e+01
Q.q45	2.50e+01	4.01992	1.72e+01	3.29e+01
Q.q46	3.07e+01	5.56434	1.98e+01	4.16e+01
Q.q55	2.07e+02	23.45524	1.61e+02	2.53e+02

```
Q.q56       2.29e+02 29.93648  1.70e+02 2.88e+02
Q.q66       4.28e+02 47.87742  3.35e+02 5.22e+02
x0.X.AAPL   1.12e+02  2.68994  1.07e+02 1.18e+02
x0.X.ADBE   1.03e+02  3.70960  9.61e+01 1.11e+02
x0.X.AMZN   7.57e+02 26.89201  7.04e+02 8.10e+02
x0.X.FB     1.16e+02  3.19377  1.10e+02 1.23e+02
x0.X.GOOG   7.88e+02 15.06400  7.58e+02 8.17e+02
x0.X.^GSPC  2.26e+03 21.39016  2.22e+03 2.30e+03
Initial states (x0) defined at t=0

CIs calculated at alpha = 0.05 via method=hessian
```