The R Companion for Econ 513: Economic Forecasting

Note: Having downloaded R from the R Project webpage, sections of this packet require the additional installation of the TimeSeries, lmtest, vars, and strucchange packages and uses comma separated value (.csv) files containing the data for each nation (Argentina, France, United States, South Korea, and Sierra Leone). Furthermore, to call the included functions, load each package at the start of each session. Bear in mind, R is case-sensitive.

Packages to be installed:

```
>install.packages("TimeSeries")
>install.packages("lmtest")
>install.packages("vars")
>install.packages("strucchange")
```

Loading packages before use:

```
>library("TimeSeries")
>library("lmtest")
>library("vars")
>library("strucchange")
>library("stats")
>library("forecast")
>library("tseries")
>library("pastecs")
```

Reading the .csv file into R:

```
> sierraleone.df = read.csv("C:/Your/File/Path/sierraleone.csv", header = TRUE)
```

Instantiating a time series object from a .df file:

```
>sierraleone.ts = ts(data=sierraleone.df, frequency =1, start=c(1965), end=c(2007))
```

Merging the time series into a single .ts file:

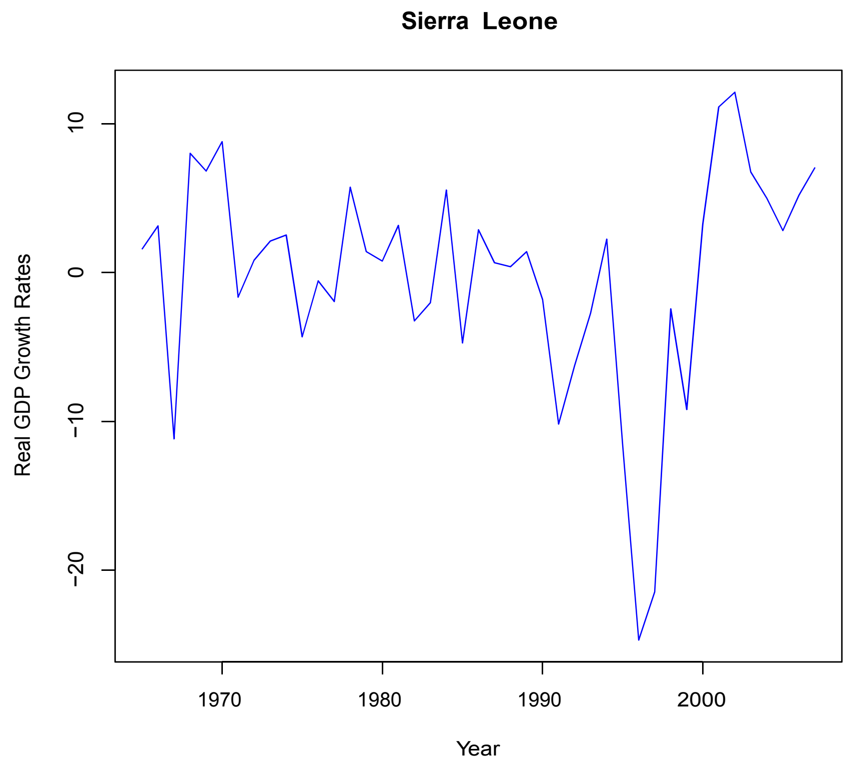
```
>nations.ts = cbind(argentina.ts, france.ts, unitedstates.ts, southkorea.ts, sierraleone.ts)
```

I. Time Series Plots

a. Individual Plots

Plotting individual .ts series

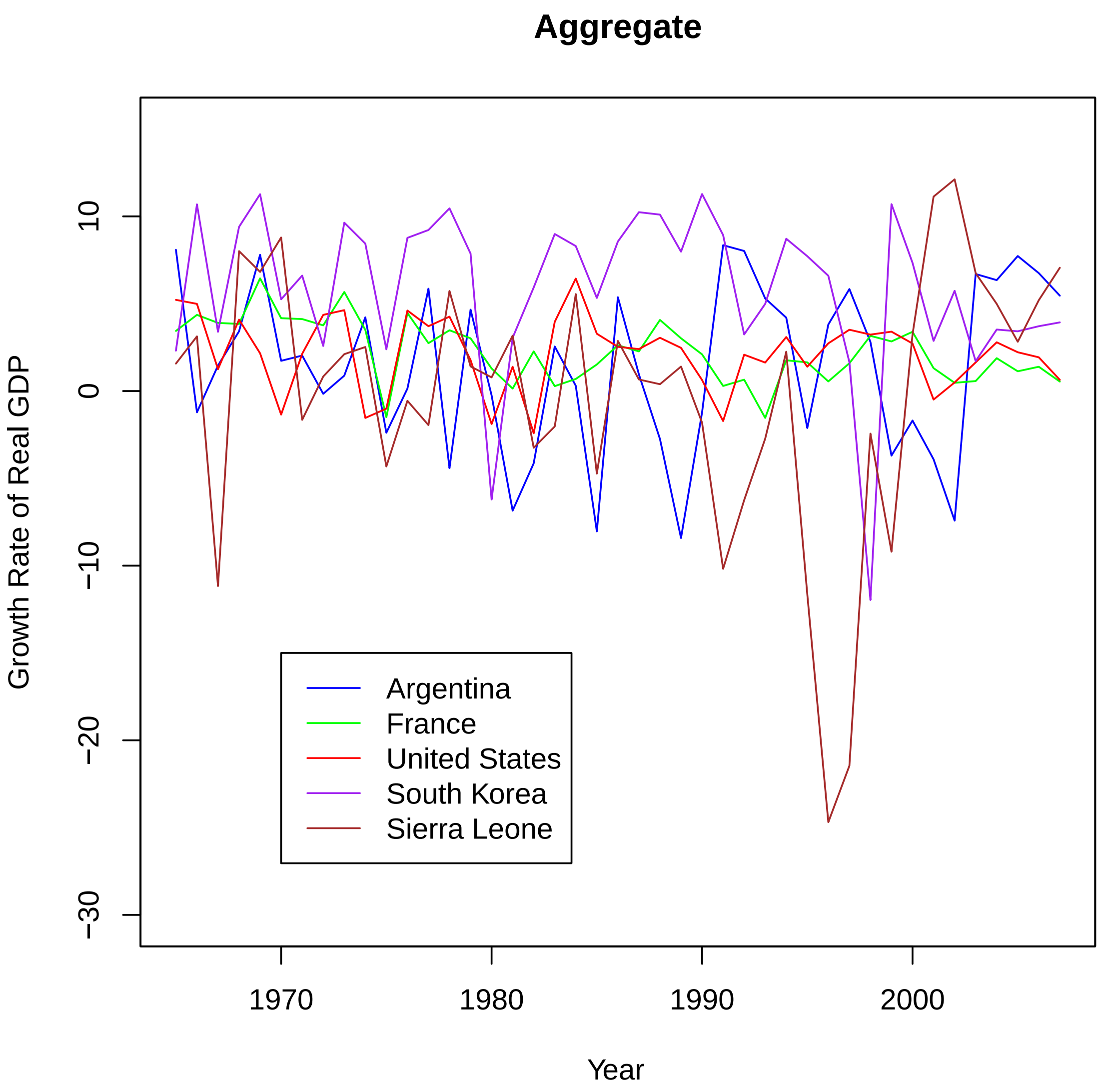
```
>plot(sierraleone.ts, col="blue", ylab="Real GDP Growth Rates",
+ main="Sierra Leone", xlab="Year")
```



b. Group Plot

Compiling each .ts series into an aggregate plot

```
>plot(argentina.ts, col="blue", ann=FALSE, ylim=range(-30, 15))
> lines(france.ts, col="green")
> lines(unitedstates.ts, col="red")
> lines(southkorea.ts, col="purple")
> lines(sierraleone.ts, col="brown")
>box()
>title(main="Aggregate")
>title(xlab="Year")
>title(ylab="Growth Rate of Real GDP")
>legend(1970, -15, legend=c("Argentina","France","United States",
+ "South Korea","Sierra Leone"), lty=c(1,1,1,1,1),
+ col=c("blue","green","red","purple","brown")
```



II. Descriptive Statistics

Sample Average

$$\bar{y} = \frac{1}{T}\sum_{t=1}^{T} y_t$$

Sample Standard Deviation

$$\hat{\sigma} = \sqrt{\hat{\sigma}^2} = \left(\frac{1}{T-1}\sum_{t=1}^{T}(y_t - \bar{y})^2\right)^{1/2}$$

Producing Descriptive Statistics

>stat.desc(nations.ts)

	argentina.ts	france.ts	unitedstates.ts	southkorea.ts	sierraleone.ts
nbr.val	43.000000	43.0000000	43.0000000	43.000000	43.0000000
nbr.null	0.000000	0.0000000	0.0000000	0.000000	0.0000000
nbr.na	0.000000	0.0000000	0.0000000	0.000000	0.0000000
min	-8.420000	-1.5400000	-2.4200000	-11.970000	-24.6900000
max	8.350000	6.4500000	6.4400000	11.280000	12.1200000
range	16.770000	7.9900000	8.8600000	23.250000	36.8100000
sum	62.070000	97.3100000	92.4000000	254.660000	-8.7600000
median	1.730000	2.2700000	2.4000000	6.610000	1.4000000
mean	1.443488	2.2630233	2.1488372	5.922326	-0.2037209
SE.mean	0.726091	0.2664374	0.3164770	0.689133	1.1468966
CI.mean.0.95	1.465311	0.5376924	0.6386765	1.390727	2.3145311
var	22.669947	3.0525216	4.3067819	20.420885	56.5609906
std.dev	4.761297	1.7471467	2.0752788	4.518947	7.5207041
coef.var	3.298466	0.7720410	0.9657683	0.763036	-36.9166983

Sample Covariance

$$\hat{\sigma}_{XY} = \frac{1}{T-1}\sum_{t=1}^{T}(x_i - \bar{x})(y_i - \bar{y})$$

Producing a Covariance Table

>cov(nations.ts)

	argentina.ts	france.ts	unitedstates.ts	southkorea.ts	sierraleone.ts
argentina.ts	22.6699471	-0.1061108	0.6071613	-2.283573	-3.6355224
france.ts	-0.1061108	3.0525216	1.1330346	2.262764	2.5490901
unitedstates.ts	0.6071613	1.1330346	4.3067819	2.090184	-0.2111306
southkorea.ts	-2.2835726	2.2627642	2.0901837	20.420885	1.9692017
sierraleone.ts	-3.6355224	2.5490901	-0.2111306	1.969202	56.5609906

Sample Correlation Coefficient

$$\hat{\rho}_{XY} = \frac{\hat{\sigma}_{XY}}{\hat{\sigma}_X\hat{\sigma}_Y} = \frac{\sum_{t=1}^{T}(x_i - \bar{x})(y_i - \bar{y})}{\left(\sum_{t=1}^{T}(x_i - \bar{x})^2\right)^{1/2}\left(\sum_{t=1}^{T}(y_i - \bar{y})^2\right)^{1/2}}$$

Both covariance and the correlation coefficient measure the *linear* dependence between the variables.

Notes: A correlation coefficient of 0 does not imply independence. Both covariance and correlation coefficient have the same sign.

Producing a Correlation Coefficient Table

>cor(nations.ts)

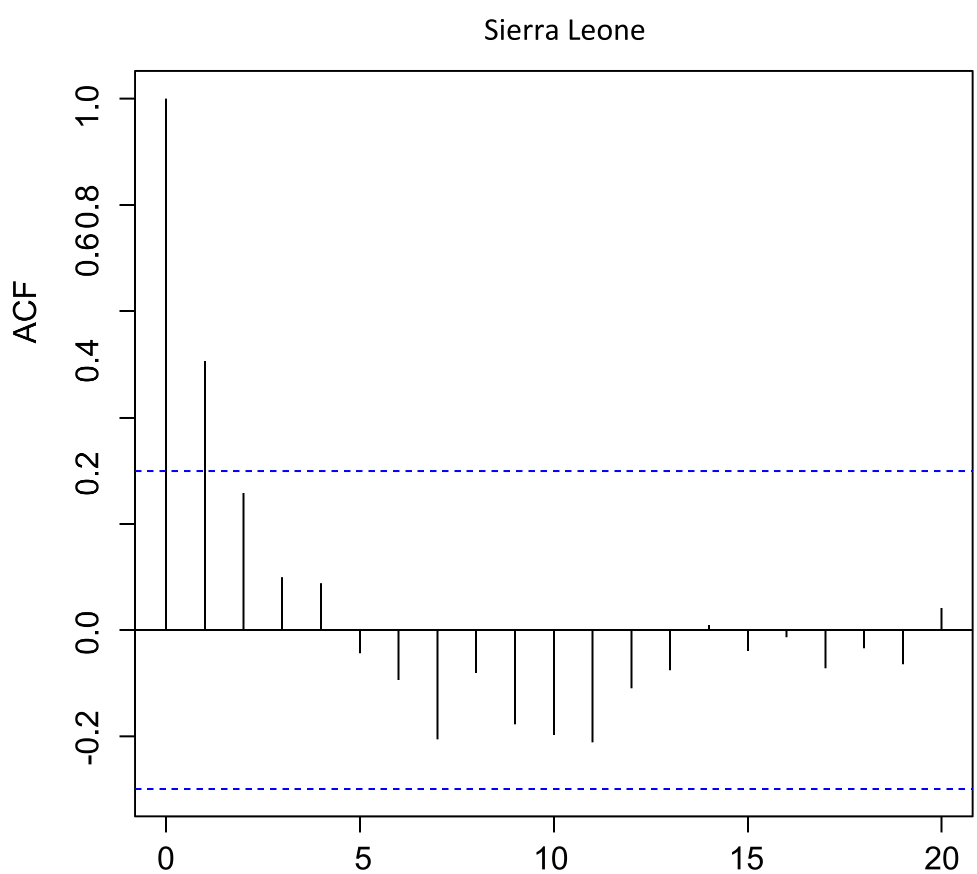
	argentina.ts	france.ts	unitedstates.ts	southkorea.ts	sierraleone.ts
argentina.ts	1.00000000	-0.01275572	0.06144724	-0.10613345	-0.10152735
france.ts	-0.01275572	1.00000000	0.31249087	0.28659767	0.19399802
unitedstates.ts	0.06144724	0.31249087	1.00000000	0.22287982	-0.01352746
southkorea.ts	-0.10613345	0.28659767	0.22287982	1.00000000	0.05794213
sierraleone.ts	-0.10152735	0.19399802	-0.01352746	0.05794213	1.00000000

III. Correlogram

$$\rho_j = \frac{\gamma_j}{\gamma_o} \quad \text{where } \gamma_j = cov(y_t, y_{t-j}), \ \ \gamma_o = V(y_y)$$

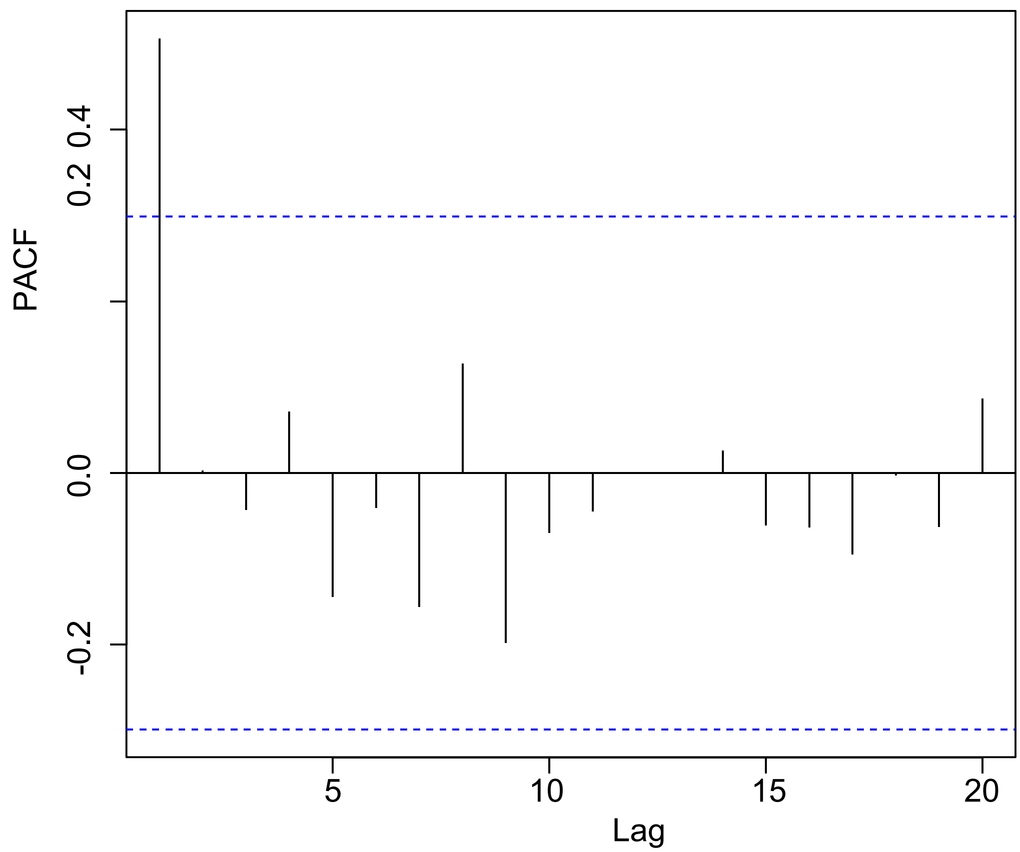
Creating a Correlogram (ACF and PACF)

>acf(sierraleone.ts, lag.max=20, main="Sierra Leone")
>pacf(sierraleone.ts, lag.max=20, main="Sierra Leone")



Lag

Sierra Leone



IV. Estimating Equations

ARMA Modeling

>summary(sierraleonearima <- arima(sierraleone.ts, order=c(0,0,0)))
>summary(sierraleonearima <- arima(sierraleone.ts, order=c(1,0,0)))
>summary(sierraleonearima <- arima(sierraleone.ts, order=c(0,0,1)))
>summary(sierraleonearima <- arima(sierraleone.ts, order=c(1,0,1)))
>summary(sierraleonearima <- arima(sierraleone.ts, order=c(1,0,2)))

Sample Output

```
> summary(sierraleonearima <- arima(sierraleone.ts, order=c(0,0,0)))
Series: sierraleone.ts
ARIMA(0,0,0) with non-zero mean

Coefficients:
      intercept
        -0.2037
s.e.     1.1335

sigma^2 estimated as 55.25:  log likelihood=-147.27
AIC=298.54   AICc=298.84   BIC=302.06

Training set error measures:
           ME         RMSE          MAE           MPE          MAPE
-2.546634e-12  7.432740e+00  5.423104e+00  1.033530e+02  1.033530e+02
         MASE
 9.850382e-01
```

```
> summary(sierraleonearima <- arima(sierraleone.ts, order=c(1,0,0)))
Series: sierraleone.ts
ARIMA(1,0,0) with non-zero mean

Coefficients:
         ar1  intercept
      0.5066     0.0023
s.e.  0.1300     1.9305

sigma^2 estimated as 40.76:  log likelihood=-140.88
AIC=287.75   AICc=288.37   BIC=293.04

Training set error measures:
          ME        RMSE         MAE         MPE         MAPE         MASE
 -0.02353238   6.38402178   4.74723215  65.71467312 106.57729532   0.86227458
```

```
> summary(sierraleonearima <- arima(sierraleone.ts, order=c(0,0,1)))
Series: sierraleone.ts
ARIMA(0,0,1) with non-zero mean

Coefficients:
         ma1  intercept
```

```
      0.3995    -0.1716
s.e.  0.1100     1.4055

sigma^2 estimated as 43.94:  log likelihood=-142.43
AIC=290.87   AICc=291.48   BIC=296.15

Training set error measures:
          ME         RMSE          MAE          MPE         MAPE         MASE
  0.01091142   6.62880467   5.09797176  87.33999462 121.10001912   0.92598198
```

```
> summary(sierraleonearima <- arima(sierraleone.ts, order=c(1,0,1)))
Series: sierraleone.ts
ARIMA(1,0,1) with non-zero mean

Coefficients:
         ar1      ma1  intercept
      0.5165  -0.0133     0.0074
s.e.  0.2400   0.2749     1.9454

sigma^2 estimated as 40.75:  log likelihood=-140.87
AIC=289.75   AICc=290.8   BIC=296.79

Training set error measures:
         ME        RMSE         MAE         MPE        MAPE        MASE
 -0.0241383   6.3838439   4.7414741  65.4265764 105.8771333   0.8612287
```

```
> summary(sierraleonearima <- arima(sierraleone.ts, order=c(1,0,2)))
Series: sierraleone.ts
ARIMA(1,0,2) with non-zero mean

Coefficients:
         ar1     ma1     ma2  intercept
      0.0488  0.4705  0.2496    -0.0190
s.e.  0.7467  0.7376  0.3428     1.7343

sigma^2 estimated as 40.51:  log likelihood=-140.76
AIC=291.53   AICc=293.15   BIC=300.33

Training set error measures:
          ME         RMSE          MAE          MPE         MAPE         MASE
 -0.04153261   6.36488293   4.74191312  62.54760186 110.25180694   0.86130844
```

Tables of Coefficients

Where Φ is the coefficient of AR and Θ_j is the coefficient of MA(j)

	Φ	θ_1	θ_2	θ_3
Argentina				
ARMA(0,0)	-	-	-	-
ARMA(1,0)	0.2492	-	-	-
ARMA(0,1)	-	0.3004	-	-
ARMA(1,1)	-0.1603	0.4477	-	-
France				
ARMA(0,0)	-	-	-	-
ARMA(1,0)	0.4477	-	-	-
ARMA(0,1)	-	0.3401	-	-
ARMA(1,1)	0.7882	-0.4424	-	-
ARMA(1,3)	0.6510	-0.3037	0.0333	0.0961
Sierra Leone				
ARMA(0,0)	-	-	-	-
ARMA(1,0)	0.5066	-	-	-
ARMA(0,1)	-	0.3995	-	-
ARMA(1,1)	0.5165	-0.0133	-	-
ARMA(1,2)	0.0488	0.4705	0.2496	-
South Korea				
ARMA(0,0)	-	-	-	-
ARMA(1,0)	0.0954	-	-	-
ARMA(0,1)	-	0.1198	-	-
ARMA(1,1)	-0.6879	0.8767	-	-
USA				
ARMA(0,0)	-	-	-	-
ARMA(1,0)	0.2110	-	-	-
ARMA(0,1)	-	0.3459	-	-
ARMA(1,1)	-0.4005	0.7049	-	-

Goodness of Fit Table

Where R^2 is the coefficient of determination, $\hat{\sigma}$ is the standard error of regression, the A.I.C. is the Akaike Info Criterion, and the B.I.C. is the Bayesian Info Criterion.

Country	R^2	$\hat{\sigma}$	A.I.C.	B.I.C.
Argentina				
ARMA(0,0)	0.4450	6.364747	291.53	300.33
ARMA(1,0)	0.0610	4.559605	258.58	263.87
ARMA(0,1)	0.0738	4.529901	258.03	263.32
ARMA(1,1)	0.0758	4.524378	259.94	266.98
France				
ARMA(0,0)	0.1367	1.726847	173	176.53
ARMA(1,0)	0.2031	1.541752	165.47	170.76
ARMA(0,1)	0.1537	1.594679	168.29	173.57
ARMA(1,1)	0.2377	1.508642	165.72	172.76
ARMA(1,3)	0.2396	1.505988	169.58	180.15
Sierra Leone				
ARMA(0,0)	0.1057	7.433034	298.54	302.06
ARMA(1,0)	0.2624	6.384356	287.75	293.04
ARMA(0,1)	0.2173	6.628725	290.87	296.15
ARMA(1,1)	0.2625	6.383573	289.75	296.79
ARMA(1,2)	0.2670	6.364747	291.53	300.33
South Korea				
ARMA(0,0)	0.5354	4.466542	254.73	258.25
ARMA(1,0)	0.0093	4.445222	256.34	261.62
ARMA(0,1)	0.0118	4.439595	256.24	261.52
ARMA(1,1)	0.0656	4.317407	256.08	263.12
USA				
ARMA(0,0)	0.0002	2.051097	187.81	191.33
ARMA(1,0)	0.0437	2.005742	187.93	193.21
ARMA(0,1)	0.0807	1.968756	186.41	191.7
ARMA(1,1)	0.1027	1.942936	187.35	194.4

Note: The R^2 presented here has not been adjusted and was hand calculated using the following formula:

$$R^2 = \frac{\sum_{t=1}^{T}(\hat{y}_t - \bar{y})^2}{\sum_{t=1}^{T}(y_t - \bar{y})^2} = 1 - \frac{\sum_{t=1}^{T}\hat{u}_t^{\,2}}{\sum_{t=1}^{T}(y_t - \bar{y})^2}$$

Accomplished in R using the following commands:

```
>y_fit<-(y-object$residuals)
>rsquared<-cor(y,y_fit)^2
```

Example:

```
>sierraleonearima <- arima(sierraleone.ts, order=c(1,0,2))
>sierraleonefit <- sierraleone.ts - sierraleonearima$residuals
>rsquared <- cor(sierraleone.ts, sierraleonefit)^2
>rsquared
```

V. Forecasting

In-Sample Forecast

Forecasting with ARMA(1,2)

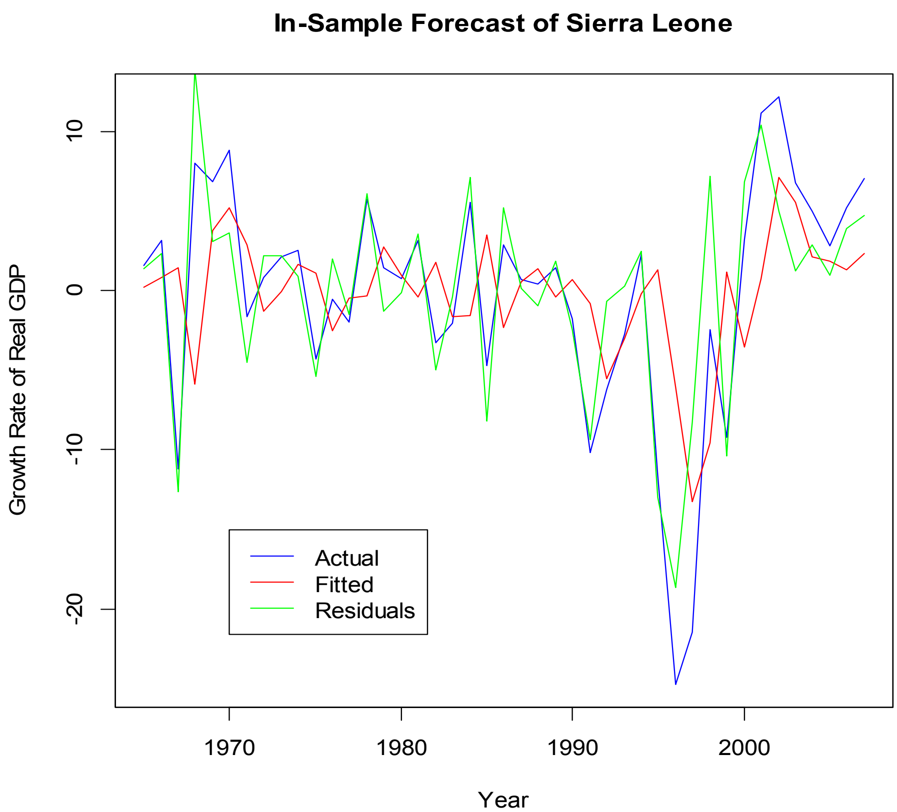
```
>sierraleonearima <- arima(sierraleone.ts, order=c(1,0,2))
>sierraleonefit <- sierraleone.ts - sierraleonearima$residuals
>cbind(sierraleone.ts,sierraleonefit,sierraleonearima$residuals)
```

Plot:

```
>plot(sierraleone.ts,col=c("blue"),ann=FALSE)
>lines(sierraleonefit,col=c("red"))
>lines(sierraleonearima$residuals,col=c("green"))
>box()
>title(main="In-Sample Forecast of Sierra Leone")
>title(xlab="Year")
>title(ylab="Growth Rate of Real GDP")
>legend(1970, -15, legend=c("Actual","Fitted","Residuals"),
>   lty=c(1,1,1),
>  col=c("blue","red","green"))
```

Sample Output

```
Time Series:
Start = 1965
End = 2007
Frequency = 1
     sierraleone.ts sierraleonefit sierraleonearima$residuals
1965           1.57     0.20013604                  1.3698640
1966           3.13     0.78600957                  2.3439904
1967         -11.17     1.45110307                -12.6211031
1968           8.01    -5.85936794                 13.8693679
1969           6.82     3.77868037                  3.0413196
1970           8.79     5.20208867                  3.5879113
1971          -1.65     2.85794534                 -4.5079453
1972           0.83    -1.32405799                  2.1540580
1973           2.11    -0.08934577                  2.1993458
1974           2.52     1.65745812                  0.8625419
1975          -4.32     1.05980484                 -5.3798048
1976          -0.56    -2.54477489                  1.9847749
1977          -1.95    -0.45451097                 -1.4954890
1978           5.73    -0.32137845                  6.0513784
1979           1.41     2.73547827                 -1.3254783
1980           0.78     0.93775884                 -0.1577588
1981           3.17    -0.38508375                  3.5550837
1982          -3.25     1.76996525                 -5.0199652
1983          -2.03    -1.65109914                 -0.3789009
1984           5.55    -1.54854263                  7.0985426
1985          -4.73     3.49812446                 -8.2281245
1986           2.87    -2.34821264                  5.2182126
1987           0.66     0.52319690                  0.1368031
1988           0.39     1.38117580                 -0.9911758
1989           1.40    -0.43120840                  1.8312084
1990          -1.81     0.66444295                 -2.4744430
1991         -10.18    -0.81348133                 -9.3665187
1992          -6.25    -5.53955743                 -0.7104426
1993          -2.73    -2.99553822                  0.2655382
1994           2.25    -0.20369528                  2.4536953
1995         -11.64     1.31252717                -12.9525272
1996         -24.69    -6.06781162                -18.6221884
1997         -21.46   -13.21822211                 -8.2417779
1998          -2.44    -9.59190746                  7.1519075
1999          -9.20     1.17043963                -10.3704396
2000           3.24    -3.56101646                  6.8010165
2001          11.13     0.75117471                 10.3788253
2002          12.12     7.10618813                  5.0138119
2003           6.75     5.52339370                  1.2266063
2004           4.99     2.14013135                  2.8498686
2005           2.82     1.87256960                  0.9474304
2006           5.20     1.27678010                  3.9232199
2007           7.06     2.31814165                  4.7418584
```



Out of Sample Forecast

Forecasting with ARMA(1,2)

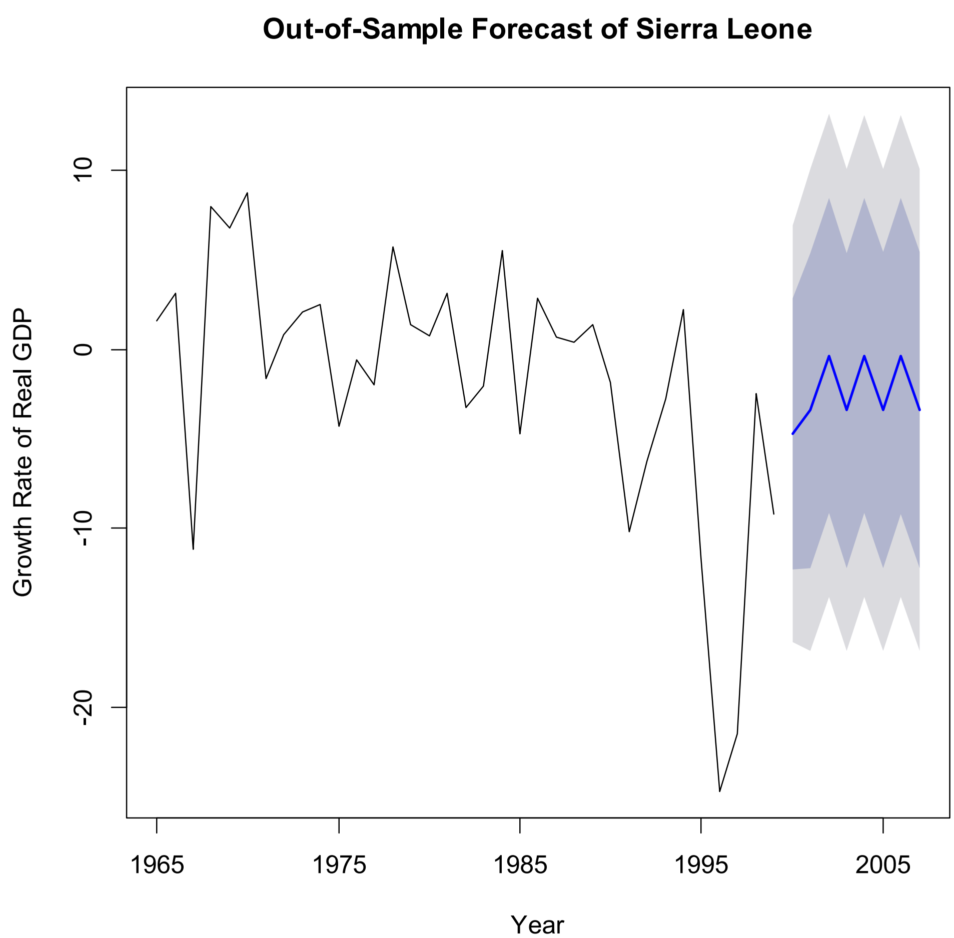
```
>sierraleonetrim <- sierraleone.df[1:35,]
>sierraleonearima <- arima(sierraleonetrim, order=c(1,0,2))
>sierraleoneforecasts <- forecast.Arima(sierraleonearima, h=8)
>sierraleoneforecasts
>error <- sierraleone.df[36:43,]-sierraleoneforecasts$mean
>year <- 2000:2007
>cbind(year,sierraleone.df[36:43,],sierraleoneforecasts$mean,error)
```

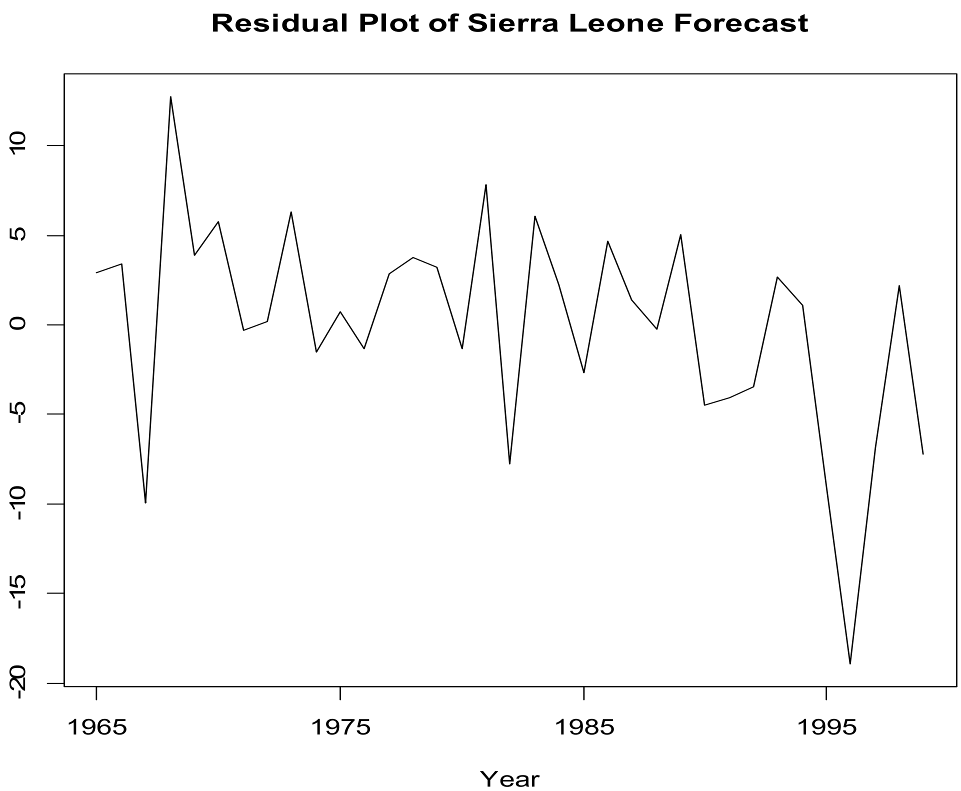
Plot:

```
>plot.forecast(sierraleoneforecasts,ylab="Growth Rate of Real GDP",
+       xlab="Year",main="Out-of-Sample Forecast of Sierra Leone",xaxt="n")
>axis(1,at=seq(1,43,by=10),labels=seq(1965,2007,by=10))
>dev.new()
>plot.ts(sierraleoneforecasts$residuals,ylab=NULL,xlab="Year",
+       main="Residual Plot of Sierra Leone Forecast",xaxt="n")
>axis(1,at=seq(1,43,by=10),labels=seq(1965,2007,by=10))
```

Sample Output

```
Time Series:
Start = 36
End = 43
Frequency = 1
   year sierraleone.df[36:43, ] sierraleoneforecasts$mean     error
36 2000                    3.24                -4.7143101  7.954310
37 2001                   11.13                -3.4023888 14.532389
38 2002                   12.12                -0.3372774 12.457277
39 2003                    6.75                -3.3971154 10.147115
40 2004                    4.99                -0.3425418  5.332542
41 2005                    2.82                -3.3918601  6.211860
42 2006                    5.20                -0.3477880  5.547788
43 2007                    7.06                -3.3866229 10.446623
```





Multivariate Time Series Models

ARMA(1,2) for Sierra Leone regressed on United States

```
>trimmedsierraleone<-ts(sierraleone.ts,start=1966, end=2007)
>summary(arima(sierraleone.ts, order=c(1,0,2), xreg=unitedstates.ts))
>summary(arima(trimmedsierraleone, order=c(1,0,2), xreg=unitedstates.ts[-1]))
```

Sample Output

```
Series: sierraleone.ts
ARIMA(1,0,2) with non-zero mean

Coefficients:
          ar1     ma1     ma2  intercept  United.States
      -0.6802  1.5806  1.0000    -3.1245         1.3747
s.e.   0.1229  0.1454  0.1755     1.8551         0.2038

sigma^2 estimated as 31.48:  log likelihood=-138.15
AIC=288.3   AICc=290.64   BIC=298.87

Training set error measures:
          ME         RMSE          MAE          MPE         MAPE         MASE
 -0.01782938   5.61108906   4.29355182  74.99712640 149.34162430   0.77986929
```

```
Series: trimmedsierraleone
ARIMA(1,0,2) with non-zero mean

Coefficients:
          ar1     ma1     ma2  intercept  unitedstates.ts[-1]
      -0.1080  0.6416  0.3300     2.2102              -1.1555
s.e.   2.5105  2.4783  0.8576     1.8538               0.4594

sigma^2 estimated as 35.12:  log likelihood=-134.51
AIC=281.03   AICc=283.43   BIC=291.45

Training set error measures:
         ME        RMSE         MAE         MPE        MAPE        MASE
 -0.0873143   5.9258982   4.3820440  34.4658616 120.4757561   0.7832925
```

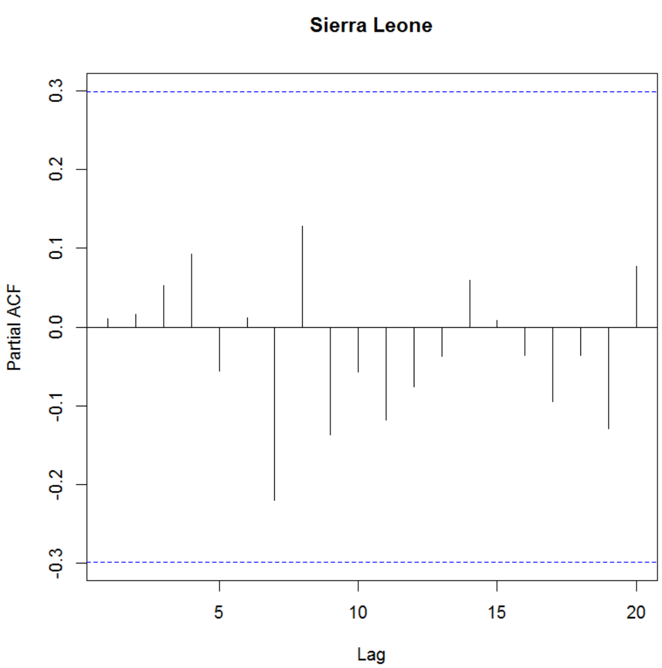
VI. Diagnostic Checking

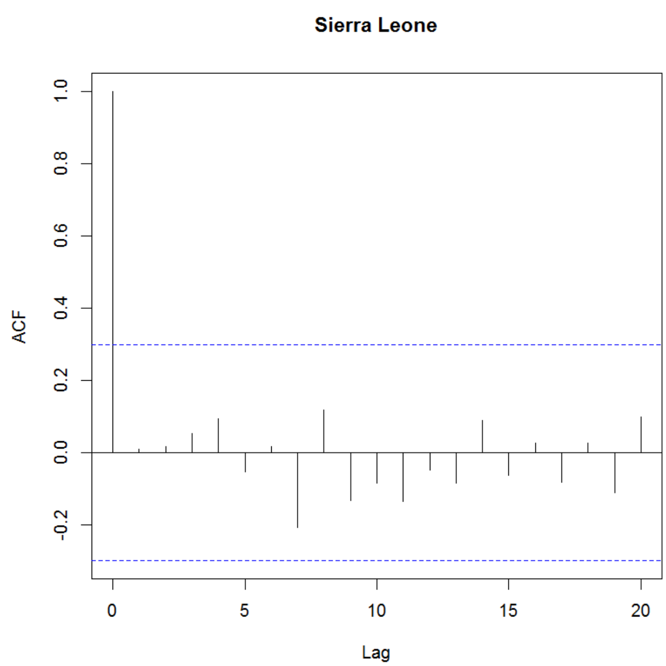
Residual Diagnostics

i. Correlogram of Residuals

Creating a Correlogram of the Residuals (ACF and PACF)

>acf(sierraleoneforecasts$residuals, lag.max=20, main="Sierra Leone")
>pacf(sierraleoneforecasts$residuals, lag.max=20, main="Sierra Leone")

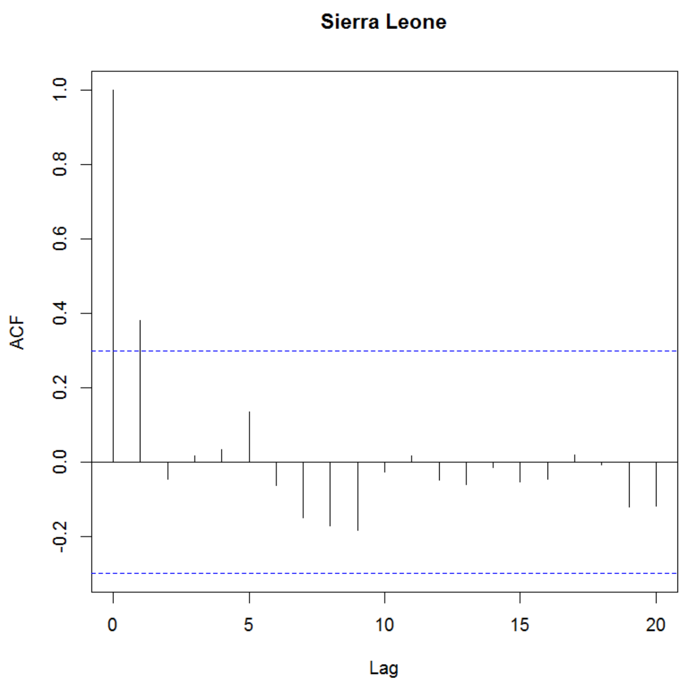


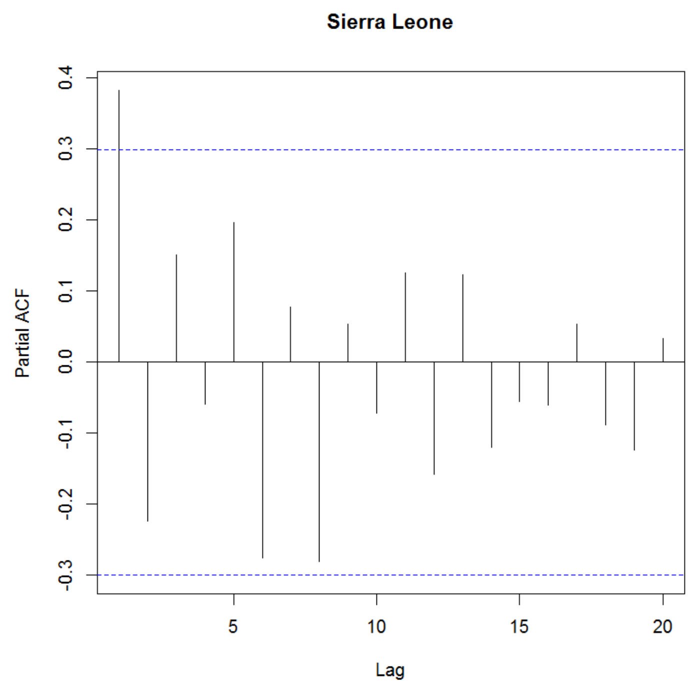


ii. Correlogram of Residuals Squared

Creating a Correlogram of the Residuals Squared (ACF and PACF)

>acf((sierraleoneforecasts$residuals)^2, lag.max=20, main="Sierra Leone")
>pacf((sierraleoneforecasts$residuals)^2, lag.max=20, main="Sierra Leone")

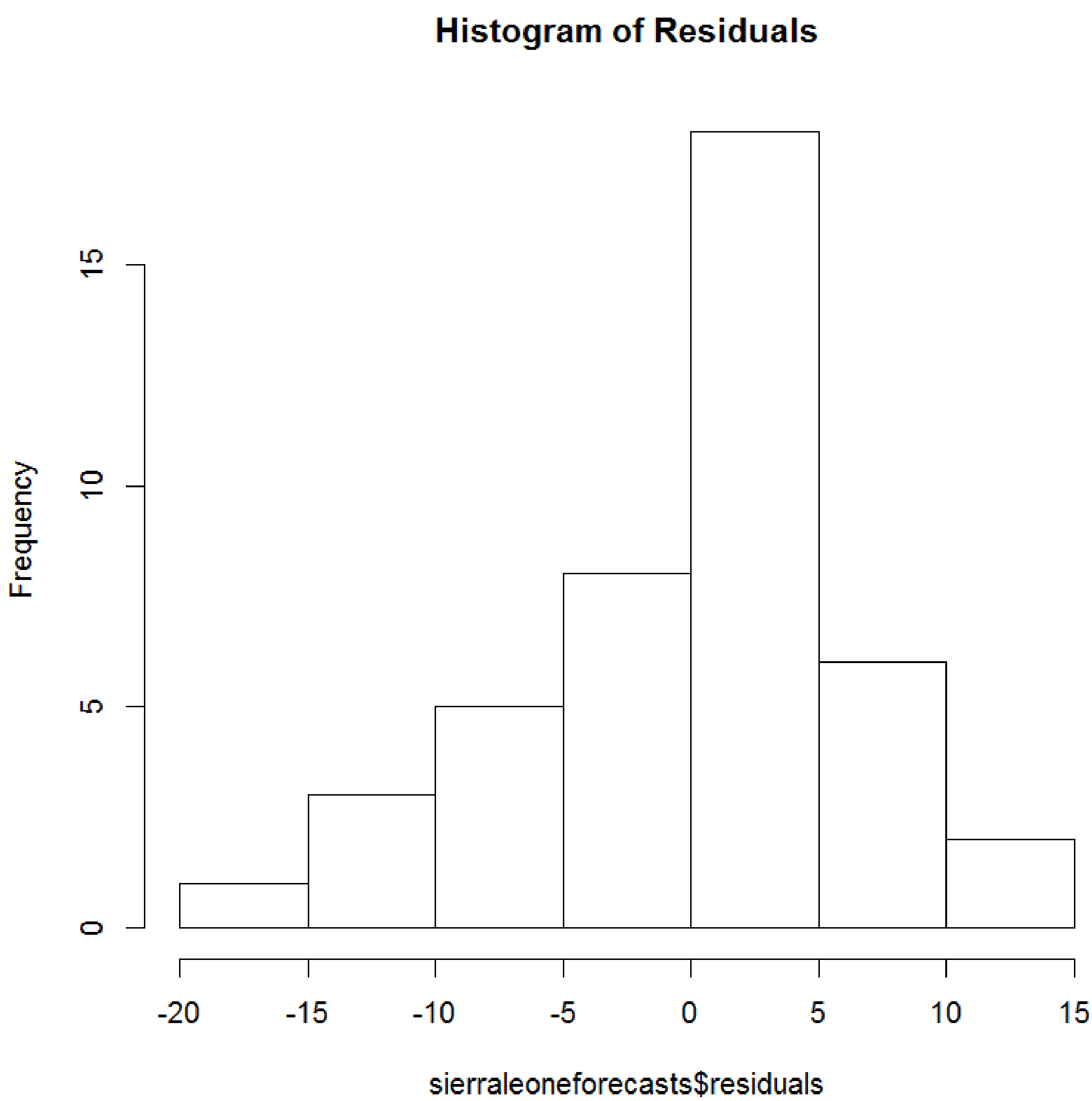




iii. Histogram

Creating a Histogram of the Residuals

>hist(sierraleoneforecasts$residuals, main = "Histogram of Residuals")



iv. Breusch-Godfrey Serial Correlation LM Test

Breusch-Godfrey Serial Correlation LM Test
>trimmedsierraleone<-ts(sierraleone.ts,start=1966, end=2007) *>bgtest(trimmedsierraleone~sierraleone.ts[-1])* Null: sierraleone.ts has no serial dependence

Sample Output

```
Breusch-Godfrey test for serial correlation of order up to 1

data:  trimmedsierraleone ~ sierraleone.ts[-1]
LM test = 0.0041, df = 1, p-value = 0.9489
```

Fail to reject null hypothesis

v. Heteroskedasticity Test

Breusch-Pagan Test Against Heteroskedasticity

>trimmedsierraleone<-ts(sierraleone.ts,start=1966, end=2007)
>waldtest(trimmedsierraleone~sierraleone.ts[-1])
Null: sierraleone.ts is homoskedastic

```
        studentized Breusch-Pagan test


data:  trimmedsierraleone ~ sierraleone.ts[-1]

BP = 1.0114, df = 1, p-value = 0.3146
```

Fail to reject null hypothesis

Coefficient Diagnostics

Wald Test

>trimmedsierraleone<-ts(sierraleone.ts,start=1966, end=2007)
>waldtest(trimmedsierraleone~sierraleone.ts[-1])
Null: all coefficients associated sierraleone.ts[-1] are zero

```
Wald test

Model 1: trimmedsierraleone ~ sierraleone.ts[-1]
Model 2: trimmedsierraleone ~ 1
  Res.Df Df      F    Pr(>F)
1     40
2     41 -1 14.217 0.0005271 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

Reject null hypothesis

VII. Nonstationary Models

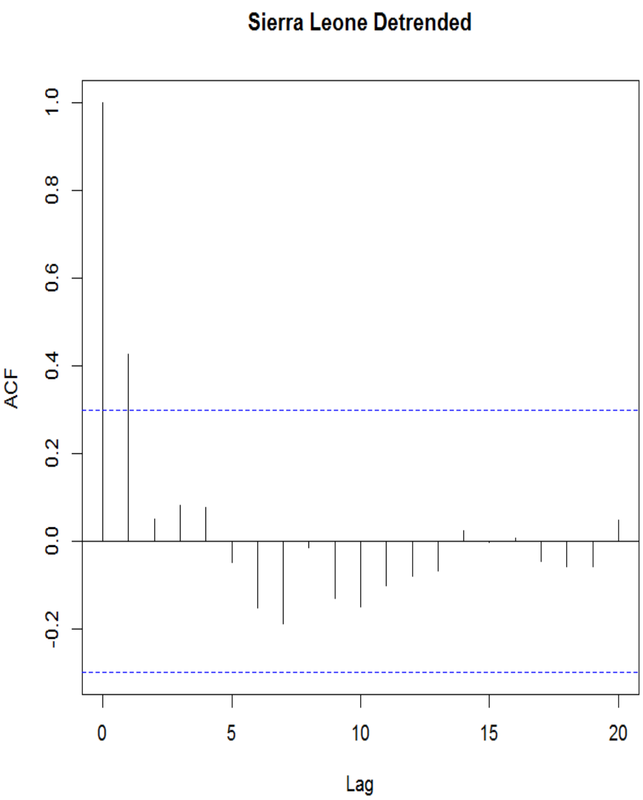
Detrending

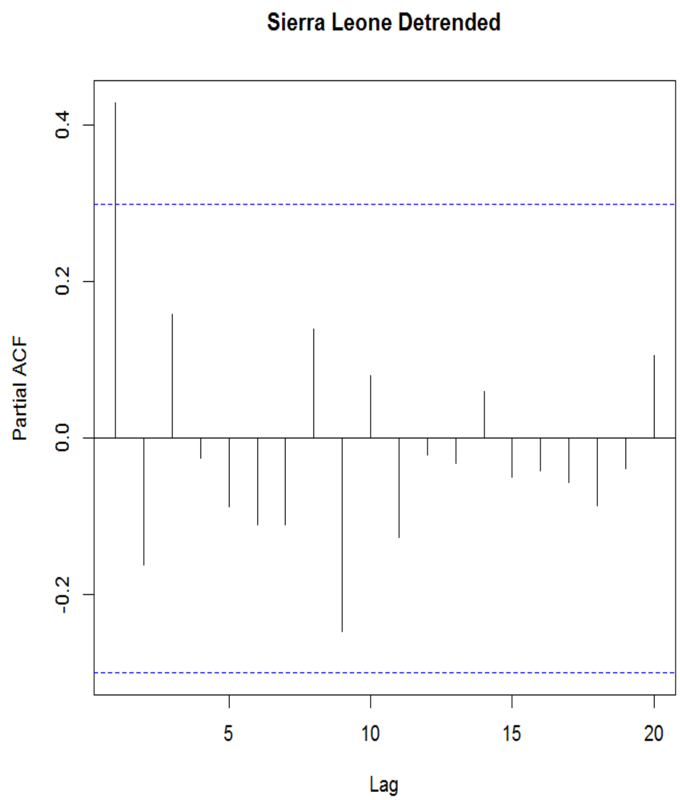
$$y_t = a_0 + a_1 t + a_2 t^2 + z_t$$

$$\hat{z}_t = y_t - \hat{a}_0 - \hat{a}_1 t - \hat{a}_2 t^2$$

Detrending Sierra Leone and Creating Correlograms of Detrended Series

```
>residuals<-sierraleoneforecasts$residuals
>detrendsierraleone<-sierraleone.ts-residuals
>acf(detrendsierraleone, lag.max=20, main="Sierra Leone Detrended")
>pacf(detrendsierraleone, lag.max=20, main="Sierra Leone Detrended")
```





Differencing

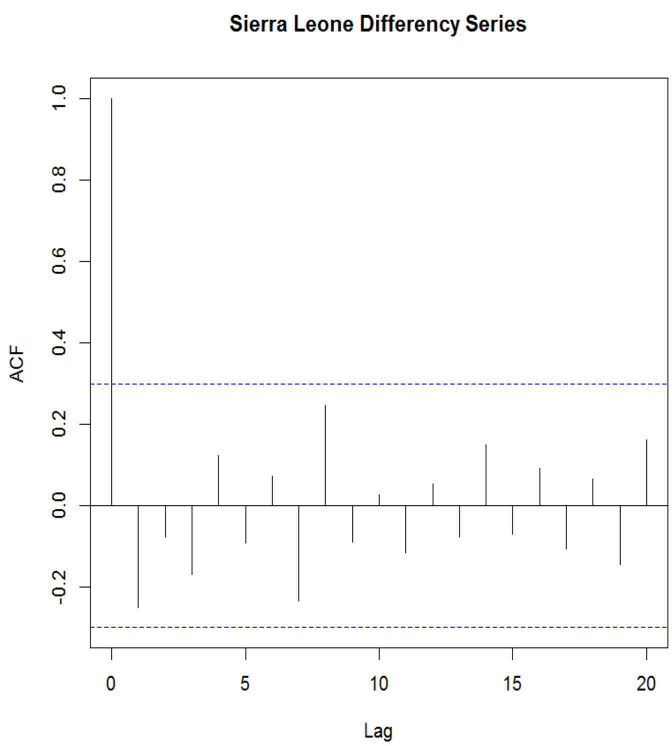
$$y_t = \propto + \beta x_t + \varepsilon_t$$

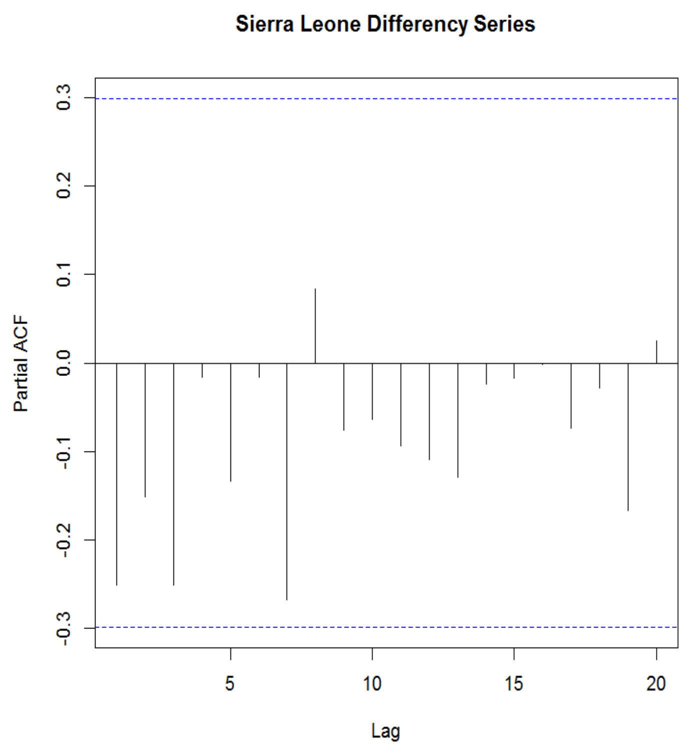
$$y_{t-1} = \propto + \beta x_{t-1} + \varepsilon_{t-1}$$

Differency Series = $y_t - y_{t-1}$

Differencing Sierra Leone and Creating Correlograms of the Differency Series

```
>sierraleonelag <- sierraleone.ts[-1]
>diffsierraleone <- sierraleone.ts - sierraleonelag
>acf(diffsierraleone, lag.max=20, main="Sierra Leone Differency Series")
>pacf(diffsierraleone, lag.max=20, main="Sierra Leone Differency Series")
```





Unit Root Test

Augmented Dickey-Fuller Test

Calling the Augmented Dickey-Fuller Test

```
>adf.test(sierraleone.ts)
```

Null: sierraleone.ts has a unit root

Sample Output

```
        Augmented Dickey-Fuller Test

data:  sierraleone.ts
Dickey-Fuller = -1.9723, Lag order = 3, p-value = 0.5847
alternative hypothesis: stationary
```

Fail to reject null hypothesis

Philips-Perron Test

Calling the Phillips-Perron Test

>PP.test(sierraleone.ts)

Null: sierraleone.ts has a unit root against a stationary alternative

Sample Output

```
        Phillips-Perron Unit Root Test

data:  sierraleone.ts
Dickey-Fuller = -3.4367, Truncation lag parameter = 3, p-value =
0.06432
```

Fail to reject null hypothesis

VIII. Structural Breaks

Dating Breaks

>trimmedsierraleone<-ts(sierraleone.ts,start=1966, end=2007)
>breakpoints(trimmedsierraleone~sierraleone.ts[-1])

```
         Optimal 1-segment partition:

Call:
breakpoints.formula(formula = trimmedsierraleone ~ sierraleone.ts[-1],
    breaks = 2)

Breakpoints at observation number:
NA
Corresponding to breakdates:
NA
```

IX. Vector Autoregression

Vector Autoregression

>VAR(nations.ts)

```
VAR Estimation Results:
=======================

Estimated coefficients for equation argentina.ts:
=================================================
Call:
argentina.ts = argentina.ts.l1 + france.ts.l1 + unitedstates.ts.l1 +
southkorea.ts.l1 + sierraleone.ts.l1 + const

   argentina.ts.l1       france.ts.l1 unitedstates.ts.l1   southkorea.ts.l1
         0.2561306         -0.2780129         -0.1904685          0.2411987
 sierraleone.ts.l1              const
        -0.0810553          0.5262640


Estimated coefficients for equation france.ts:
==============================================
Call:
france.ts = argentina.ts.l1 + france.ts.l1 + unitedstates.ts.l1 +
southkorea.ts.l1 + sierraleone.ts.l1 + const

   argentina.ts.l1       france.ts.l1 unitedstates.ts.l1   southkorea.ts.l1
      -0.032249135        0.383322493        0.303775131       -0.039270035
 sierraleone.ts.l1              const
      -0.009352738        0.962507511


Estimated coefficients for equation unitedstates.ts:
====================================================
Call:
unitedstates.ts = argentina.ts.l1 + france.ts.l1 + unitedstates.ts.l1 +
southkorea.ts.l1 + sierraleone.ts.l1 + const

   argentina.ts.l1       france.ts.l1 unitedstates.ts.l1   southkorea.ts.l1
        0.01948810        -0.22230931         0.29820739        -0.08290173
 sierraleone.ts.l1              const
       -0.07599102         2.37642651


Estimated coefficients for equation southkorea.ts:
==================================================
Call:
southkorea.ts = argentina.ts.l1 + france.ts.l1 + unitedstates.ts.l1 +
southkorea.ts.l1 + sierraleone.ts.l1 + const
```

```
   argentina.ts.l1       france.ts.l1 unitedstates.ts.l1   southkorea.ts.l1
       -0.20980242         0.14312304         0.29791879         0.01520925
 sierraleone.ts.l1              const
        0.12412291         5.26643049
```

```
Estimated coefficients for equation sierraleone.ts:
===================================================
Call:
sierraleone.ts = argentina.ts.l1 + france.ts.l1 + unitedstates.ts.l1 +
southkorea.ts.l1 + sierraleone.ts.l1 + const

   argentina.ts.l1       france.ts.l1 unitedstates.ts.l1   southkorea.ts.l1
       0.139471676        0.232069767        0.005235031       -0.146649737
 sierraleone.ts.l1              const
       0.522790367        0.092304352
```

Granger Causality/Instantaneous Causality Tests

Granger Causality/Instantaneous Causality Tests
>var.nations <- VAR(nations.ts)
>causality(var.nations, cause=”argentina.ts”)

```
Argentina:
$Granger

        Granger causality H0: argentina.ts do not Granger-cause france.ts
        unitedstates.ts southkorea.ts sierraleone.ts

data:  VAR object var.nations
F-Test = 0.8814, df1 = 4, df2 = 180, p-value = 0.4762


$Instant

        H0: No instantaneous causality between: argentina.ts and france.ts
        unitedstates.ts southkorea.ts sierraleone.ts

data:  VAR object var.nations
Chi-squared = 0.3541, df = 4, p-value = 0.9861


France:
$Granger

        Granger causality H0: france.ts do not Granger-cause argentina.ts
```

```
        unitedstates.ts southkorea.ts sierraleone.ts

data:  VAR object var.nations
F-Test = 0.7864, df1 = 4, df2 = 180, p-value = 0.5354


$Instant

        H0: No instantaneous causality between: france.ts and argentina.ts
        unitedstates.ts southkorea.ts sierraleone.ts

data:  VAR object var.nations
Chi-squared = 6.8768, df = 4, p-value = 0.1425


Sierra Leone:
$Granger

        Granger causality H0: sierraleone.ts do not Granger-cause
argentina.ts
        france.ts unitedstates.ts southkorea.ts

data:  VAR object var.nations
F-Test = 2.405, df1 = 4, df2 = 180, p-value = 0.05134


$Instant

        H0: No instantaneous causality between: sierraleone.ts and
        argentina.ts france.ts unitedstates.ts southkorea.ts

data:  VAR object var.nations
Chi-squared = 3.3919, df = 4, p-value = 0.4945


South Korea:
$Granger

        Granger causality H0: southkorea.ts do not Granger-cause
argentina.ts
        france.ts unitedstates.ts sierraleone.ts

data:  VAR object var.nations
F-Test = 0.8958, df1 = 4, df2 = 180, p-value = 0.4676


$Instant

        H0: No instantaneous causality between: southkorea.ts and
argentina.ts
        france.ts unitedstates.ts sierraleone.ts

data:  VAR object var.nations
Chi-squared = 7.3588, df = 4, p-value = 0.1181
```

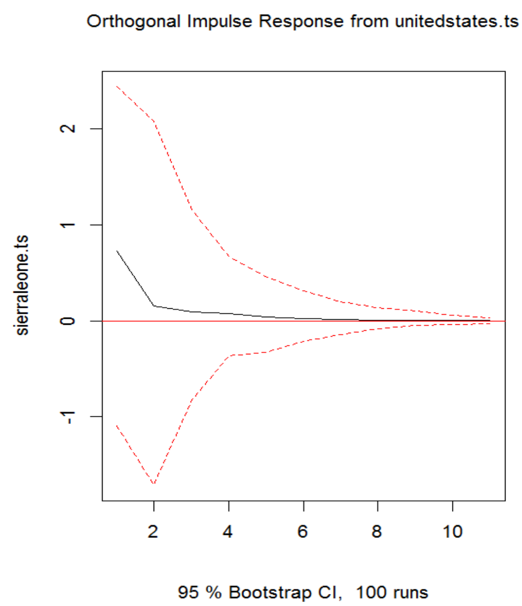
```
United States:
$Granger

        Granger causality H0: unitedstates.ts do not Granger-cause
        argentina.ts france.ts southkorea.ts sierraleone.ts

data:  VAR object var.nations
F-Test = 1.7188, df1 = 4, df2 = 180, p-value = 0.1477


$Instant

        H0: No instantaneous causality between: unitedstates.ts and
        argentina.ts france.ts southkorea.ts sierraleone.ts

data:  VAR object var.nations
Chi-squared = 9.3437, df = 4, p-value = 0.05306
```

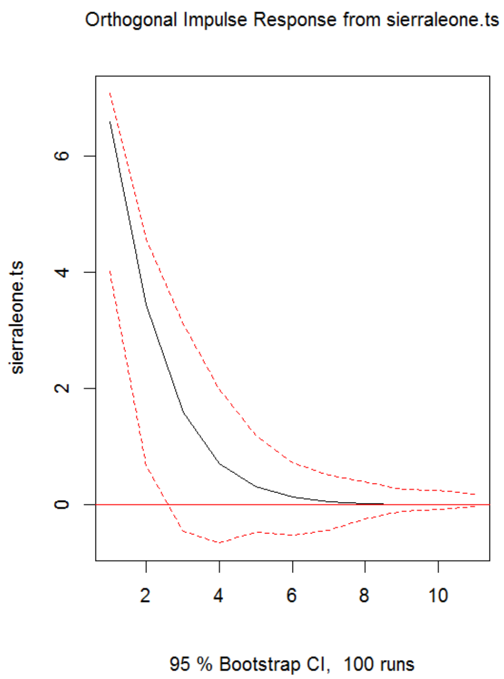
Impulse Graphs

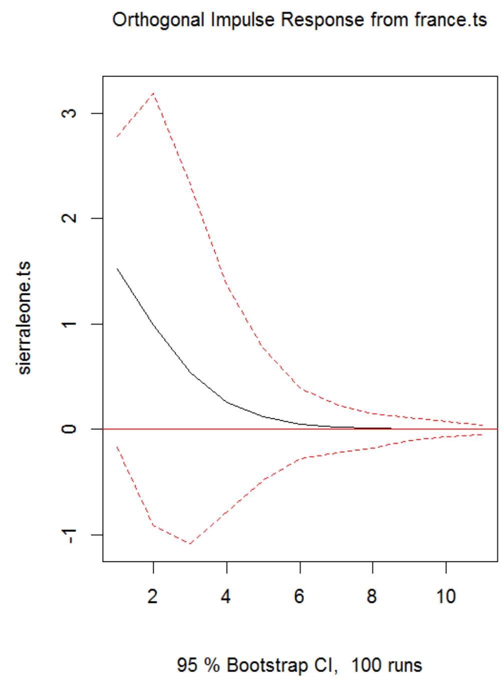
Creating and Graphing Impulse Response Functions

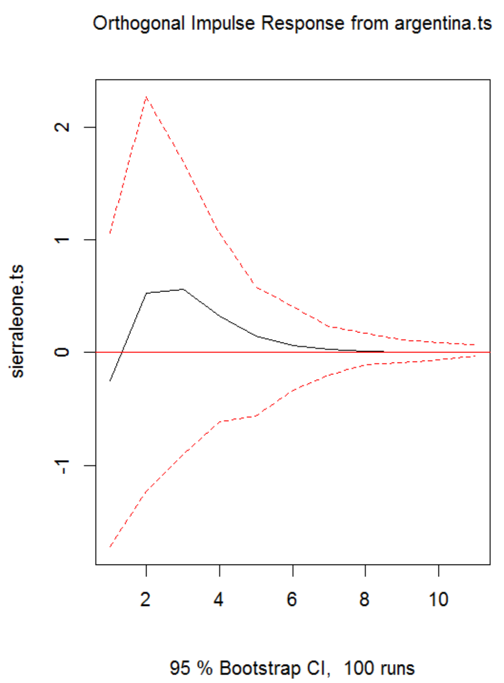
>irf.sierraleone <- irf(var.nations, impulse="unitedstates.ts",
+ response="sierraleone.ts")
>plot(irf.sierraleone)

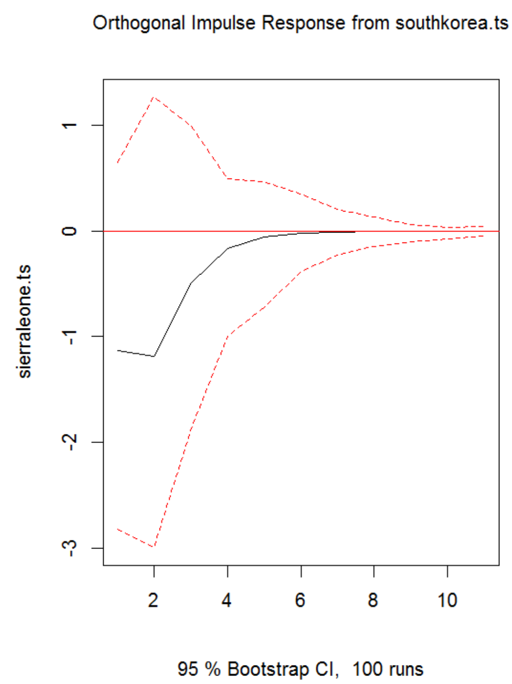
Response of Sierra Leone to each nation:




Orthogonal Impulse Response from sierraleone.ts
sierraleone.ts
95 % Bootstrap CI, 100 runs


Orthogonal Impulse Response from france.ts
sierraleone.ts
95 % Bootstrap CI, 100 runs


Orthogonal Impulse Response from argentina.ts
sierraleone.ts
95 % Bootstrap CI, 100 runs


Orthogonal Impulse Response from southkorea.ts
sierraleone.ts
95 % Bootstrap CI, 100 runs