ARMA-X Models

Contents

	Model 1
ar1	0.0300
	(0.0510)
ar2	0.7229***
	(0.0397)
ar3	0.2110***
	(0.0287)
ma1	0.2751***
	(0.0496)
ma2	−0.6445***
	(0.0284)
ma3	−0.3527***
	(0.0256)
intercept	0.0202***
	(0.0042)
dummy_lag_0	0.0014***
	(0.0002)
dummy_lag_1	0.0008***
	(0.0002)
AIC	−45761.2161
AICc	−45761.2051
BIC	−45682.1963
Log Likelihood	22890.6081
Num. obs.	19970

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table 1: ARMAX selected by AIC

Full Timeframe

SPY Models

```r
#dummy
dummy_fit = auto.armax.r(data$SPY_vol, x=data$dummy,
                max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)


#count
count_fit = auto.armax.r(data$SPY_vol, x=data$N,
                max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)


#tariffs
tariff_fit = auto.armax.r(data$SPY_vol, x=data$tariff,
                max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)


#trade
trade_fit = auto.armax.r(data$SPY_vol, x=data$trade,
                max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```

	Model 1
ar1	0.0278
	(0.0510)
ar2	0.7210***
	(0.0399)
ar3	0.2148***
	(0.0284)
ma1	0.2779***
	(0.0496)
ma2	−0.6430***
	(0.0285)
ma3	−0.3563***
	(0.0253)
intercept	0.0211***
	(0.0042)
N_lag_0	0.0004***
	(0.0001)
N_lag_1	0.0002**
	(0.0001)
AIC	−45737.6695
AICc	−45737.6585
BIC	−45658.6497
Log Likelihood	22878.8348
Num. obs.	19970

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table 2: ARMAX selected by AIC

	Model 1
ar1	0.2200***
	(0.0084)
ar2	0.9388***
	(0.0037)
ar3	−0.1837***
	(0.0079)
ma1	0.0870***
	(0.0042)
ma2	−0.8960***
	(0.0042)
intercept	0.0219***
	(0.0042)
tariff_lag_0	0.0035*
	(0.0014)
tariff_lag_1	0.0191***
	(0.0015)
tariff_lag_2	0.0103***
	(0.0015)
tariff_lag_3	−0.0045**
	(0.0014)
AIC	−46020.9547
AICc	−46020.9415
BIC	−45934.0340
Log Likelihood	23021.4774
Num. obs.	19968

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

Table 3: ARMAX selected by AIC

	Model 1
ar1	2.1903***
	(0.0096)
ar2	−1.4727***
	(0.0173)
ar3	0.2784***
	(0.0082)
ma1	−1.8955***
	(0.0062)
ma2	0.9165***
	(0.0063)
intercept	0.0225***
	(0.0028)
trade_lag_0	0.0032
	(0.0018)
trade_lag_1	0.0016
	(0.0018)
AIC	−45816.1540
AICc	−45816.1449
BIC	−45745.0361
Log Likelihood	22917.0770
Num. obs.	19970

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

Table 4: ARMAX selected by AIC

```
#china
china_fit = auto.armax.r(data$SPY_vol, x=data$china,
               max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```

```
#proportion of positive
positive_fit = auto.armax.r(data$SPY_vol, x=data$prop_positive,
               max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```

```
#proportion of negative
negative_fit = auto.armax.r(data$SPY_vol, x=data$prop_negative,
               max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```

SPY IRFs

```
#we want to plot the IRFs of these models
nb.periods = 7 * 15

irf.plot(dummy_fit$model,nb.periods)
```

	Model 1
ar1	0.2209***
	(0.0084)
ar2	0.9382***
	(0.0037)
ar3	−0.1837***
	(0.0079)
ma1	0.0878***
	(0.0042)
ma2	−0.8950***
	(0.0042)
intercept	0.0225***
	(0.0042)
china_lag_0	0.0026*
	(0.0012)
AIC	−45840.5349
AICc	−45840.5277
BIC	−45777.3186
Log Likelihood	22928.2675
Num. obs.	19971

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table 5: ARMAX selected by AIC

	Model 1
ar1	0.0262
	(0.0503)
ar2	0.7230***
	(0.0390)
ar3	0.2146***
	(0.0283)
ma1	0.2800***
	(0.0489)
ma2	−0.6451***
	(0.0277)
ma3	−0.3571***
	(0.0252)
intercept	0.0212***
	(0.0042)
prop_positive_lag_0	0.0063***
	(0.0016)
AIC	−45722.7625
AICc	−45722.7534
BIC	−45651.6441
Log Likelihood	22870.3812
Num. obs.	19971

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table 6: ARMAX selected by AIC

	Model 1
ar1	0.0237
	(0.0495)
ar2	0.7250***
	(0.0379)
ar3	0.2150***
	(0.0283)
ma1	0.2824***
	(0.0481)
ma2	−0.6460***
	(0.0270)
ma3	−0.3581***
	(0.0251)
intercept	0.0216***
	(0.0042)
prop_negative_lag_0	0.0070**
	(0.0022)
AIC	−45716.8054
AICc	−45716.7964
BIC	−45645.6871
Log Likelihood	22867.4027
Num. obs.	19971

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table 7: ARMAX selected by AIC
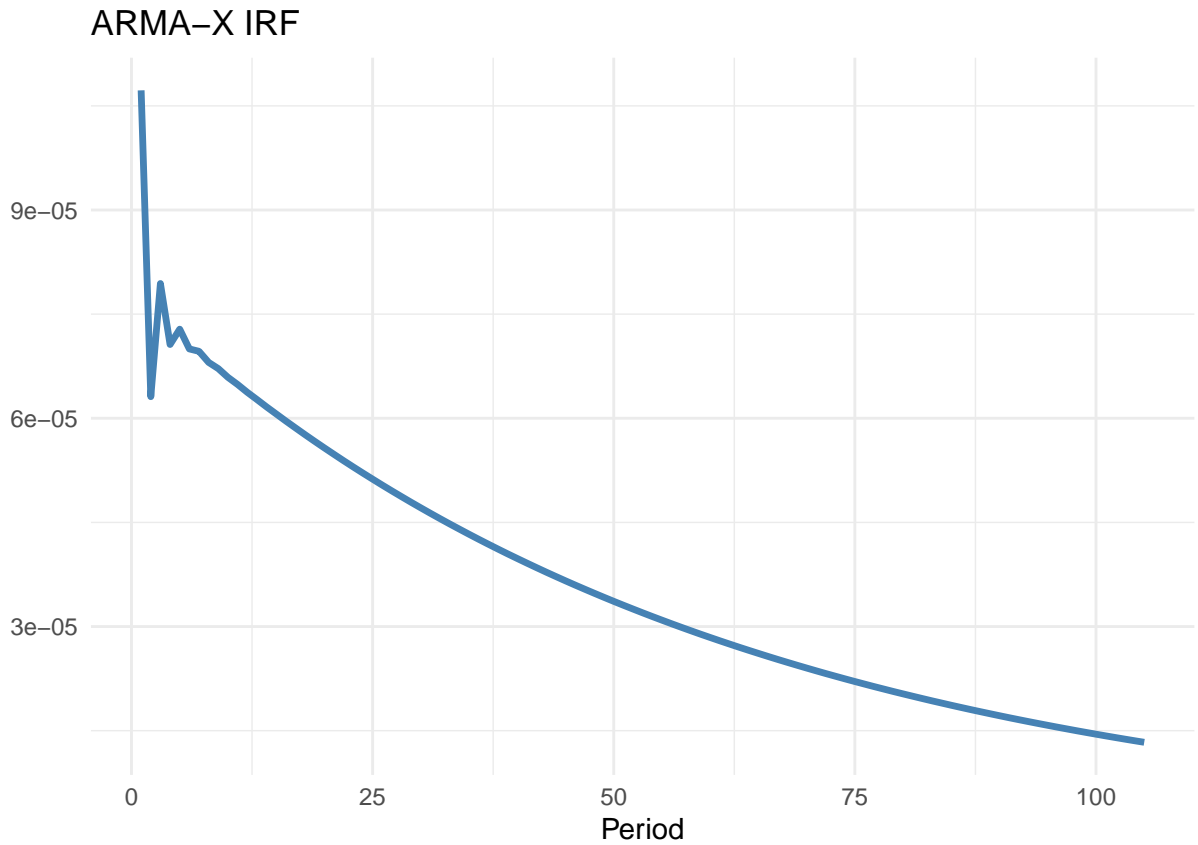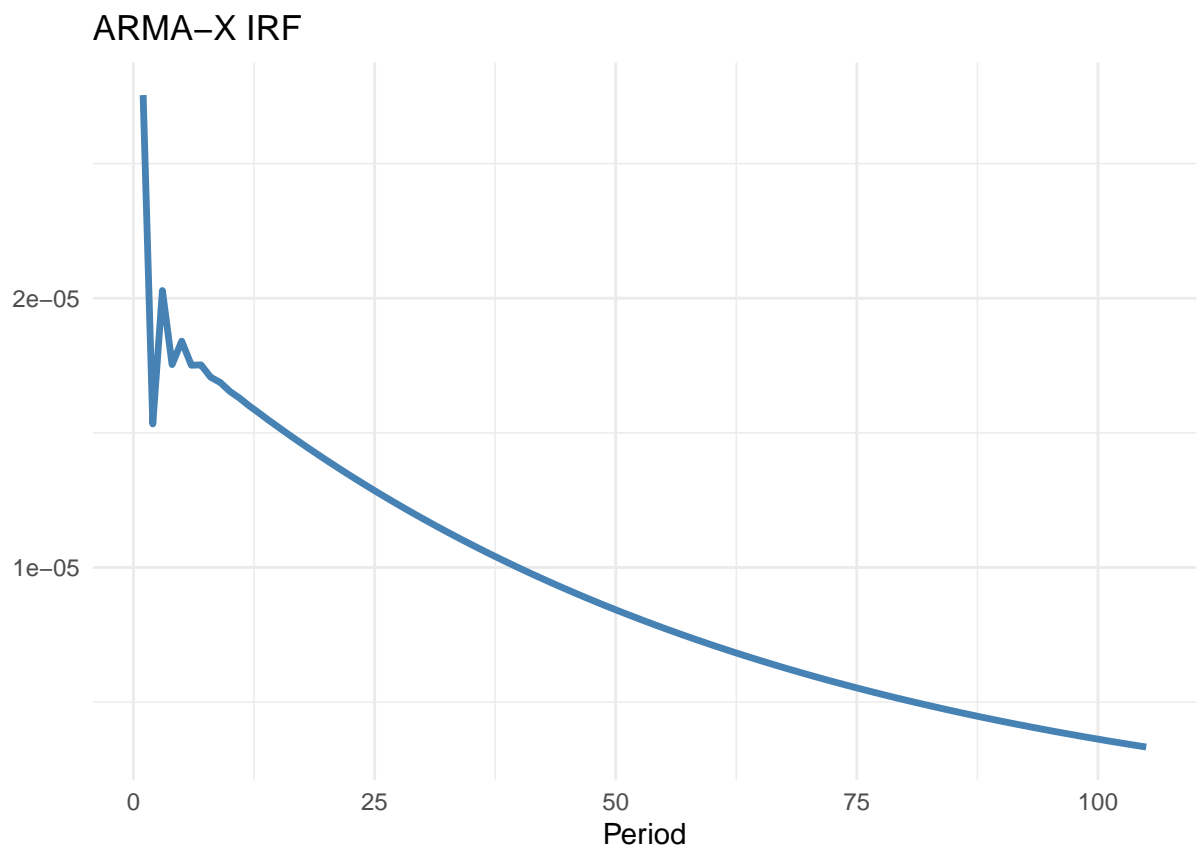
ARMA−X IRF

```
irf.plot(count_fit$model,nb.periods)
```

ARMA−X IRF


```
irf.plot(tariff_fit$model,nb.periods)
```

ARMA–X IRF


```
irf.plot(trade_fit$model,nb.periods)
```
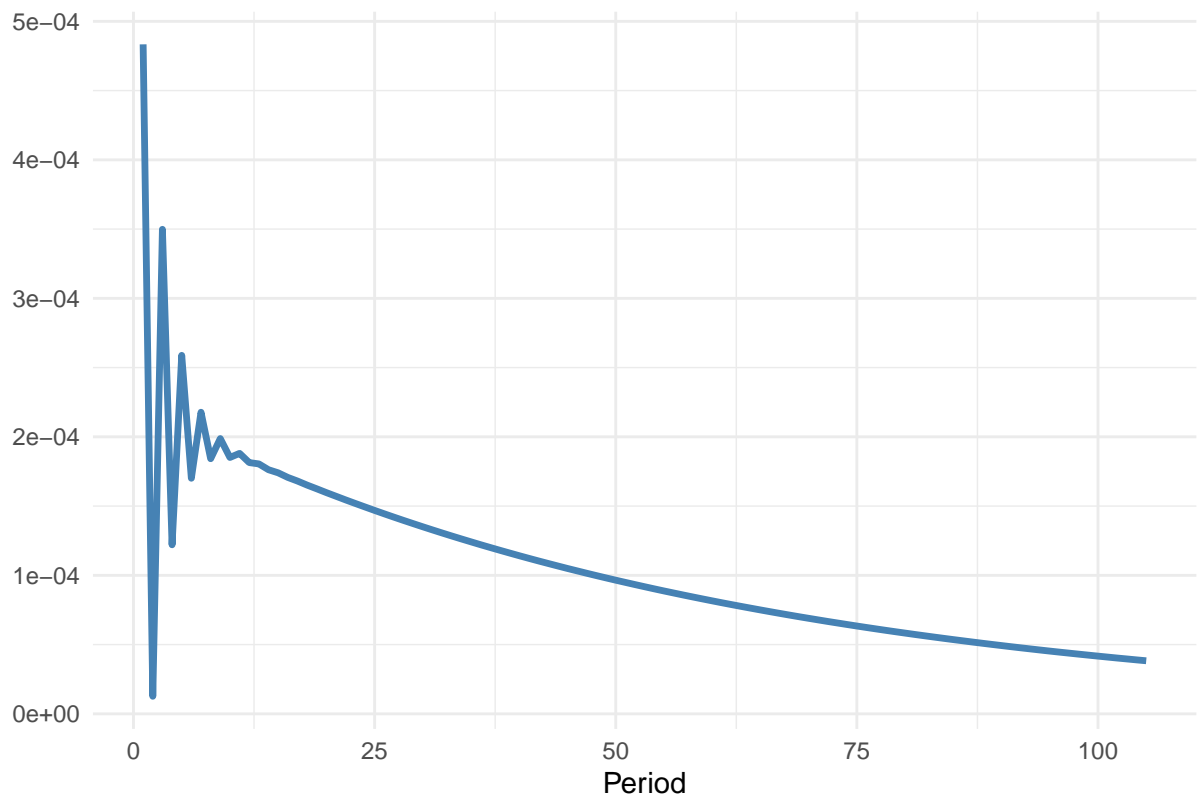
ARMA–X IRF
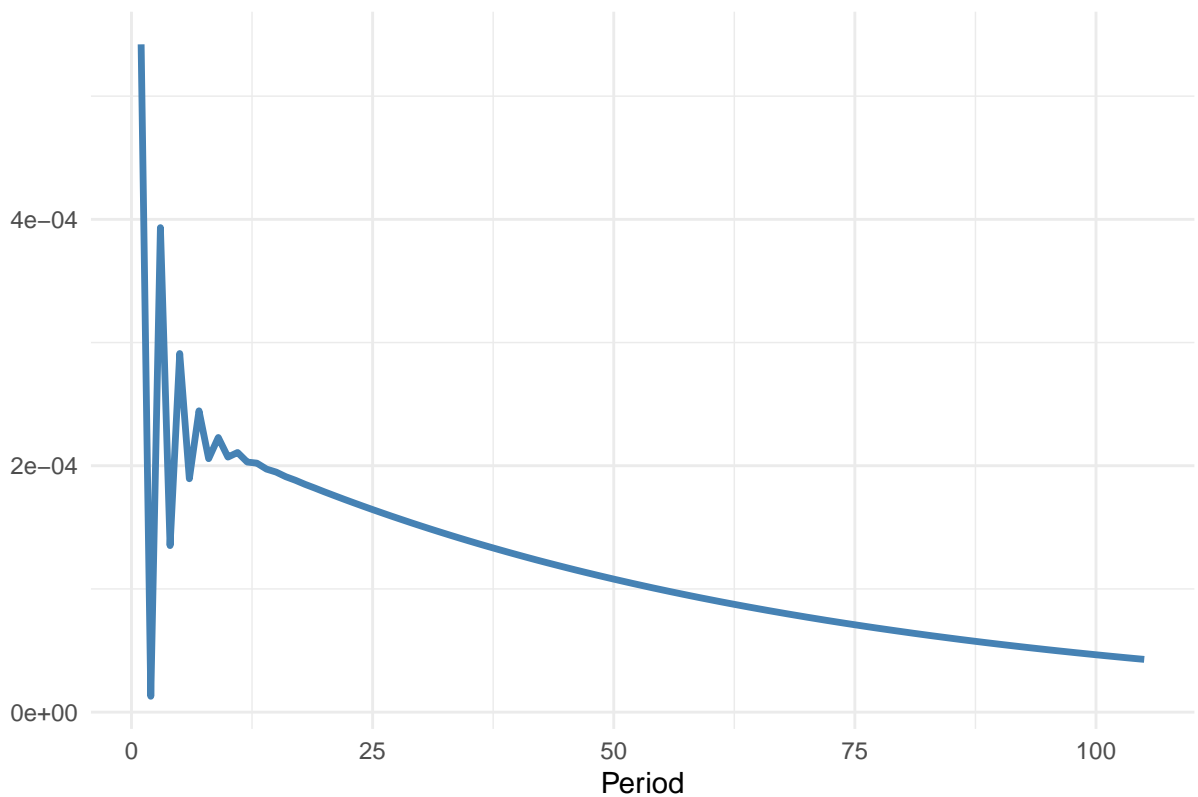
```
irf.plot(china_fit$model,nb.periods)
```

ARMA–X IRF


```r
irf.plot(positive_fit$model,nb.periods)
```

ARMA–X IRF


```
irf.plot(negative_fit$model,nb.periods)
```

ARMA−X IRF

SPY Residuals

```
res = checkresiduals(dummy_fit$model, plot = FALSE)
```
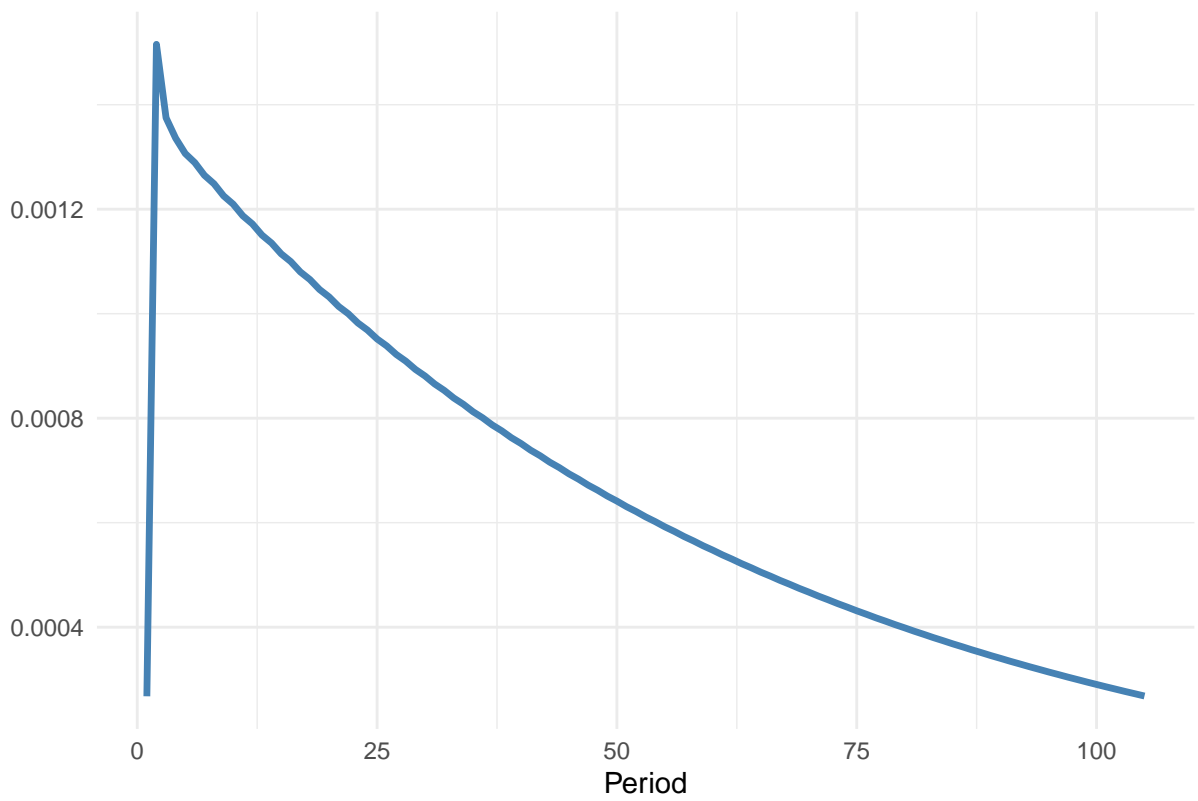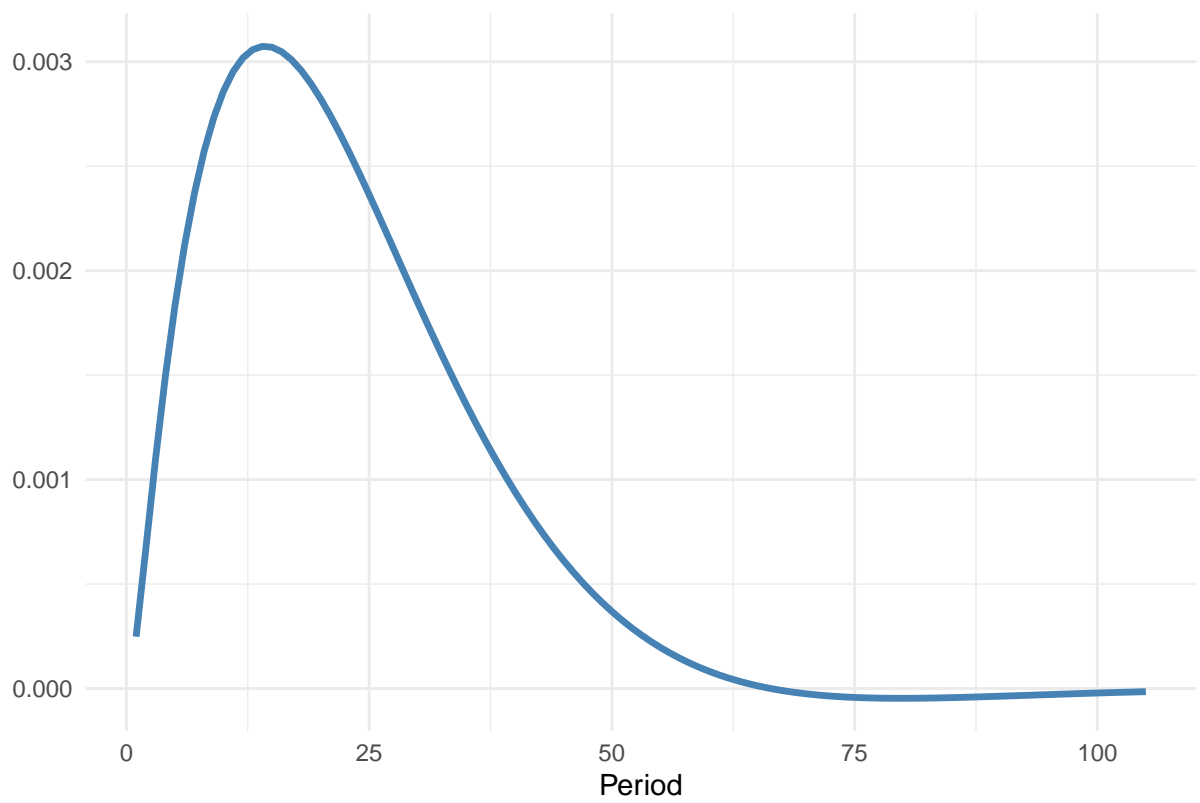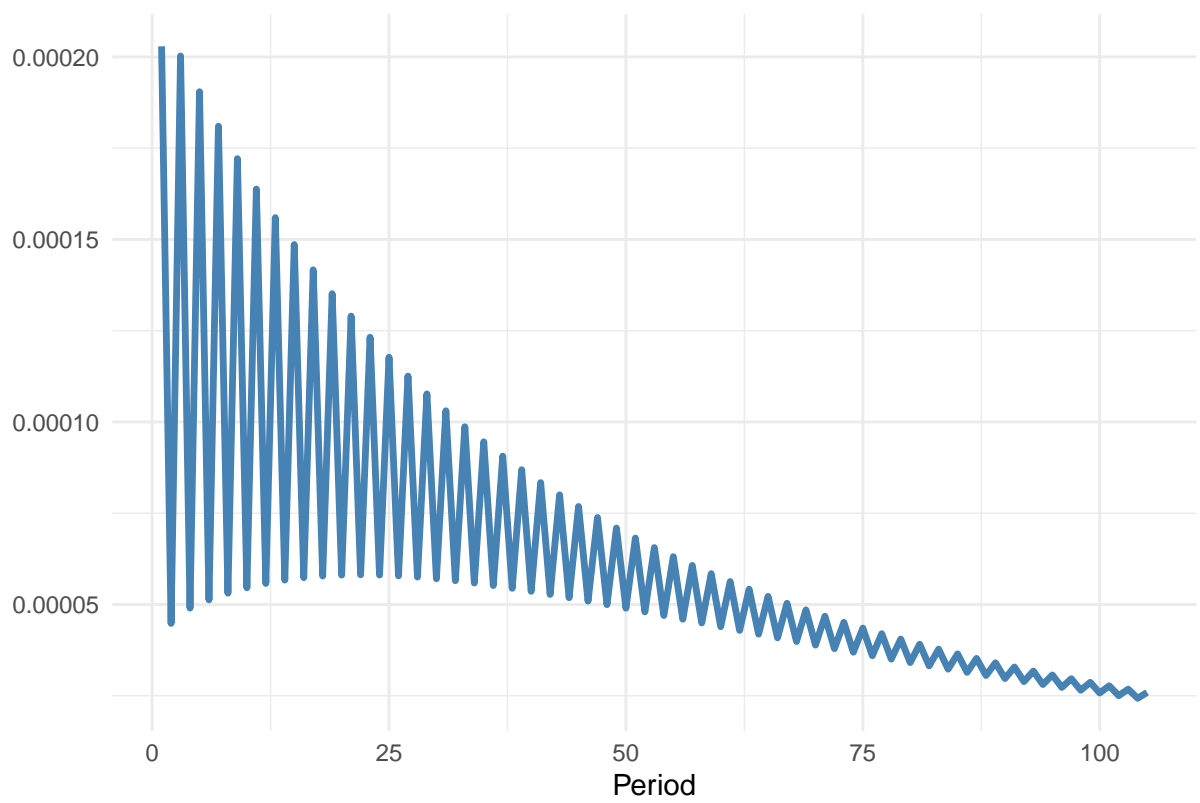
```
##
##  Ljung-Box test
##
## data:  Residuals from Regression with ARIMA(3,0,3) errors
## Q* = 125.17, df = 4, p-value < 2.2e-16
##
## Model df: 6.   Total lags used: 10
```

```
res = checkresiduals(count_fit$model, plot = FALSE)
```

```
##
##  Ljung-Box test
##
## data:  Residuals from Regression with ARIMA(3,0,3) errors
## Q* = 130.09, df = 4, p-value < 2.2e-16
##
## Model df: 6.   Total lags used: 10
```

```r
res = checkresiduals(tariff_fit$model, plot = FALSE)
```

```
##
##  Ljung-Box test
##
## data:  Residuals from Regression with ARIMA(3,0,2) errors
## Q* = 304.53, df = 5, p-value < 2.2e-16
##
## Model df: 5.   Total lags used: 10
```

```r
res = checkresiduals(trade_fit$model, plot = FALSE)
```

```
##
##  Ljung-Box test
##
## data:  Residuals from Regression with ARIMA(3,0,2) errors
## Q* = 260.68, df = 5, p-value < 2.2e-16
##
## Model df: 5.   Total lags used: 10
```

```r
res = checkresiduals(china_fit$model, plot = FALSE)
```

```
##
##  Ljung-Box test
##
## data:  Residuals from Regression with ARIMA(3,0,2) errors
## Q* = 303.32, df = 5, p-value < 2.2e-16
##
## Model df: 5.   Total lags used: 10
```

```r
res = checkresiduals(positive_fit$model, plot = FALSE)
```

```
##
##  Ljung-Box test
##
## data:  Residuals from Regression with ARIMA(3,0,3) errors
## Q* = 138.01, df = 4, p-value < 2.2e-16
##
## Model df: 6.   Total lags used: 10
```

```r
res = checkresiduals(negative_fit$model, plot = FALSE)
```

```
##
##  Ljung-Box test
##
## data:  Residuals from Regression with ARIMA(3,0,3) errors
## Q* = 139.51, df = 4, p-value < 2.2e-16
##
## Model df: 6.   Total lags used: 10
```

	Model 1
ar1	0.9843***
	(0.0025)
ma1	−0.7428***
	(0.0075)
ma2	−0.1703***
	(0.0087)
ma3	−0.0265***
	(0.0072)
intercept	0.0004
dummy_lag_0	0.0000
AIC	−200279.9599
AICc	−200279.9543
BIC	−200224.6457
Log Likelihood	100146.9800
Num. obs.	19971

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

Table 8: ARMAX selected by AIC

VGK Models

```r
#dummy
dummy_fit = auto.armax.r(data$VGK_vol, x=data$dummy,
                max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```

```r
#count
count_fit = auto.armax.r(data$VGK_vol, x=data$N,
                max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```

```r
#tariffs
tariff_fit = auto.armax.r(data$VGK_vol, x=data$tariff,
                max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```

```r
#trade
trade_fit = auto.armax.r(data$VGK_vol, x=data$trade,
                max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```

```r
#china
china_fit = auto.armax.r(data$VGK_vol, x=data$china,
                max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```

```r
#proportion of positive
positive_fit = auto.armax.r(data$VGK_vol, x=data$prop_positive,
                max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```

	Model 1
ar1	0.9843***
	(0.0025)
ma1	−0.7427***
	(0.0075)
ma2	−0.1708***
	(0.0087)
ma3	−0.0260***
	(0.0072)
intercept	0.0004
N_lag_0	0.0000
AIC	−200269.0091
AICc	−200269.0035
BIC	−200213.6949
Log Likelihood	100141.5046
Num. obs.	19971

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

Table 9: ARMAX selected by AIC

	Model 1
ar1	0.9844***
	(0.0025)
ma1	−0.7432***
	(0.0075)
ma2	−0.1701***
	(0.0087)
ma3	−0.0270***
	(0.0073)
intercept	0.0004***
	(0.0000)
tariff_lag_0	0.0000
	(0.0000)
tariff_lag_1	0.0001***
	(0.0000)
AIC	−200253.6847
AICc	−200253.6775
BIC	−200190.4688
Log Likelihood	100134.8424
Num. obs.	19970

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

Table 10: ARMAX selected by AIC

	Model 1
ar1	0.9843***
	(0.0025)
ma1	−0.7424***
	(0.0075)
ma2	−0.1706***
	(0.0087)
ma3	−0.0267***
	(0.0072)
intercept	0.0004***
	(0.0000)
trade_lag_0	−0.0000
	(0.0000)
AIC	−200248.5095
AICc	−200248.5039
BIC	−200193.1952
Log Likelihood	100131.2548
Num. obs.	19971

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table 11: ARMAX selected by AIC

	Model 1
ar1	0.9843***
	(0.0025)
ma1	−0.7427***
	(0.0075)
ma2	−0.1708***
	(0.0087)
ma3	−0.0261***
	(0.0072)
intercept	0.0004***
	(0.0000)
china_lag_0	0.0000
	(0.0000)
AIC	−200251.1835
AICc	−200251.1779
BIC	−200195.8692
Log Likelihood	100132.5917
Num. obs.	19971

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table 12: ARMAX selected by AIC

	Model 1
ar1	0.9843***
	(0.0025)
ma1	−0.7426***
	(0.0075)
ma2	−0.1708***
	(0.0087)
ma3	−0.0262***
	(0.0072)
intercept	0.0004***
	(0.0000)
prop_positive_lag_0	0.0001**
	(0.0000)
AIC	−200258.3763
AICc	−200258.3707
BIC	−200203.0620
Log Likelihood	100136.1881
Num. obs.	19971

$^{***}p < 0.001;\ ^{**}p < 0.01;\ ^{*}p < 0.05$

Table 13: ARMAX selected by AIC

```r
#proportion of negative
negative_fit = auto.armax.r(data$VGK_vol, x=data$prop_negative,
                max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```

VGK IRFs

```r
#we want to plot the IRFs of these models
nb.periods = 7 * 15

irf.plot(dummy_fit$model,nb.periods)
```
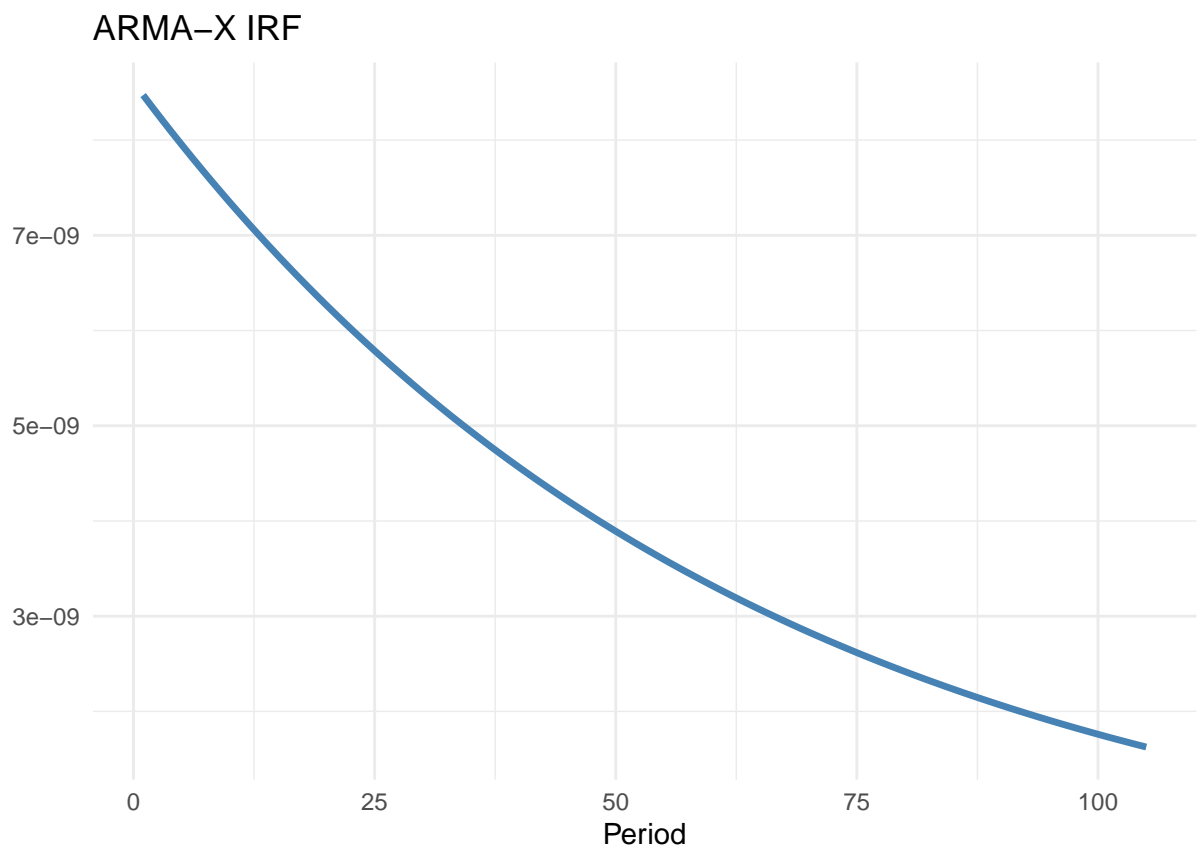
	Model 1
ar1	0.9843***
	(0.0025)
ma1	−0.7425***
	(0.0075)
ma2	−0.1707***
	(0.0087)
ma3	−0.0265***
	(0.0072)
intercept	0.0004***
	(0.0000)
prop_negative_lag_0	0.0001
	(0.0000)
AIC	−200250.1442
AICc	−200250.1386
BIC	−200194.8300
Log Likelihood	100132.0721
Num. obs.	19971

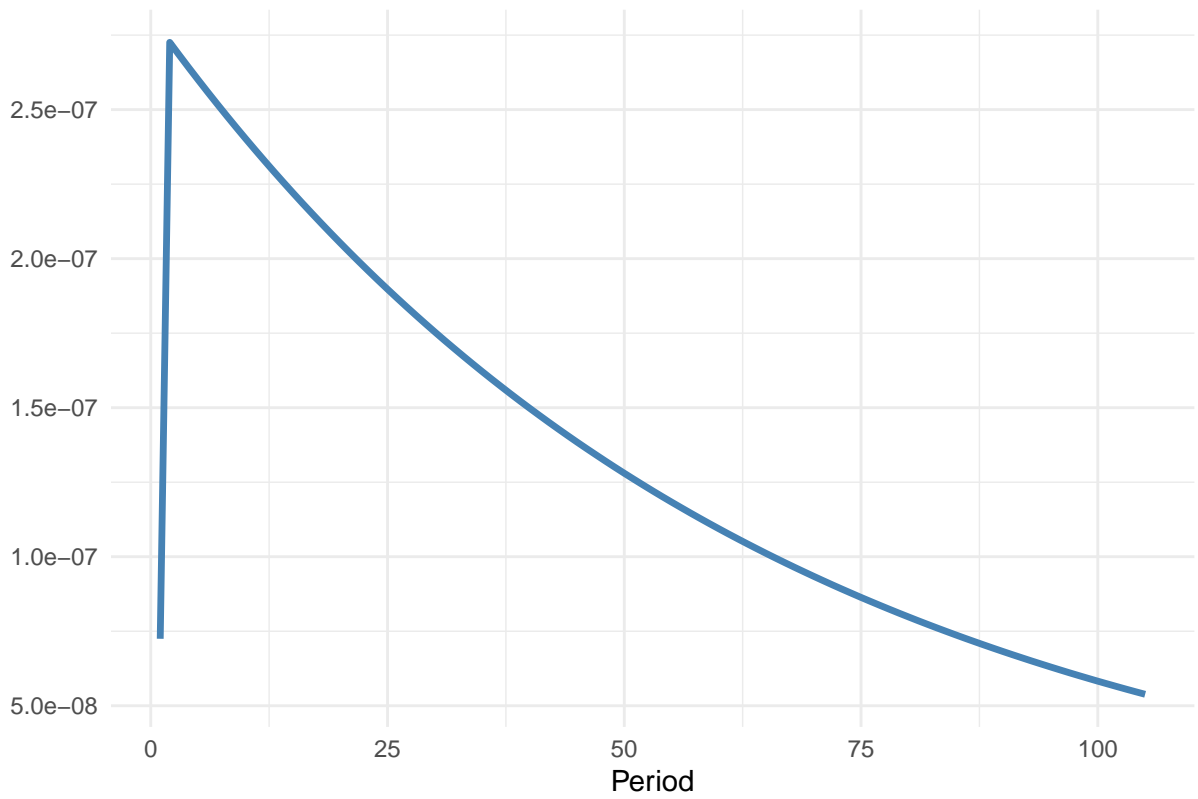***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

Table 14: ARMAX selected by AIC
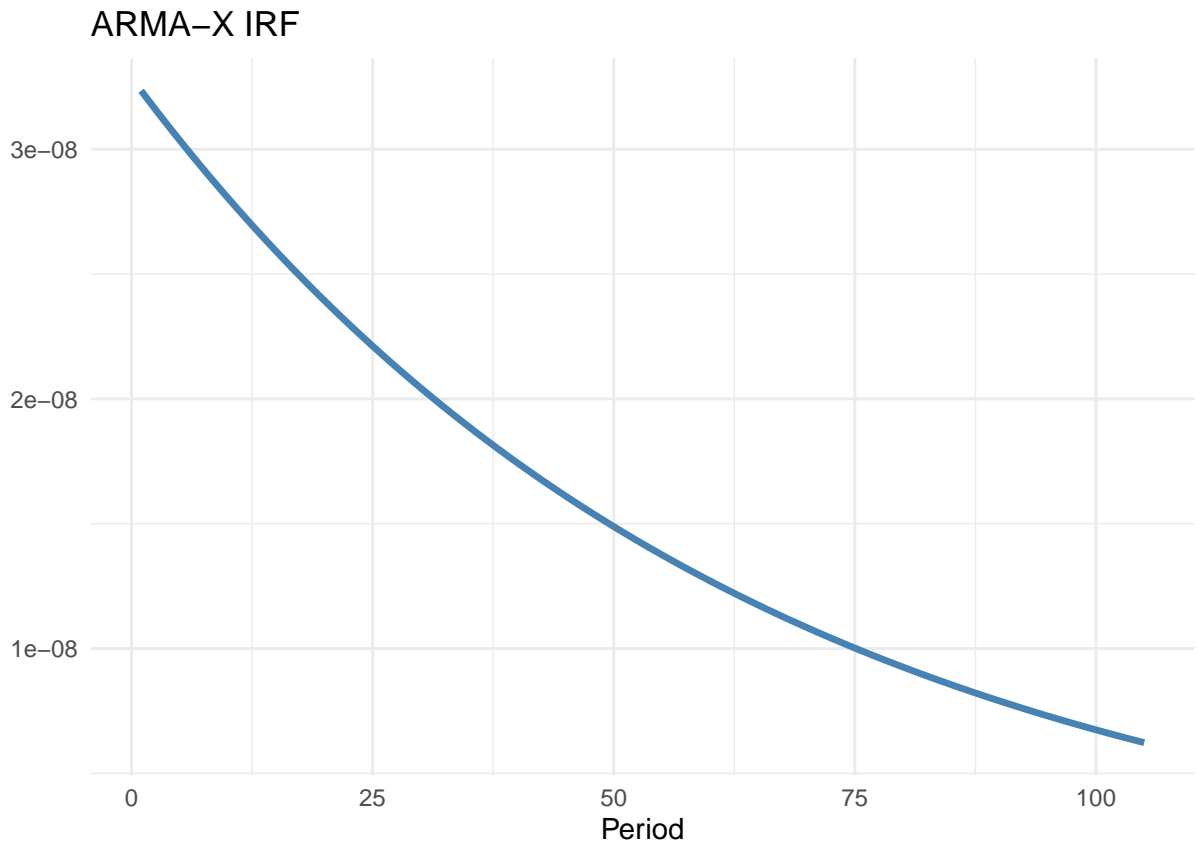
```
irf.plot(count_fit$model,nb.periods)
```
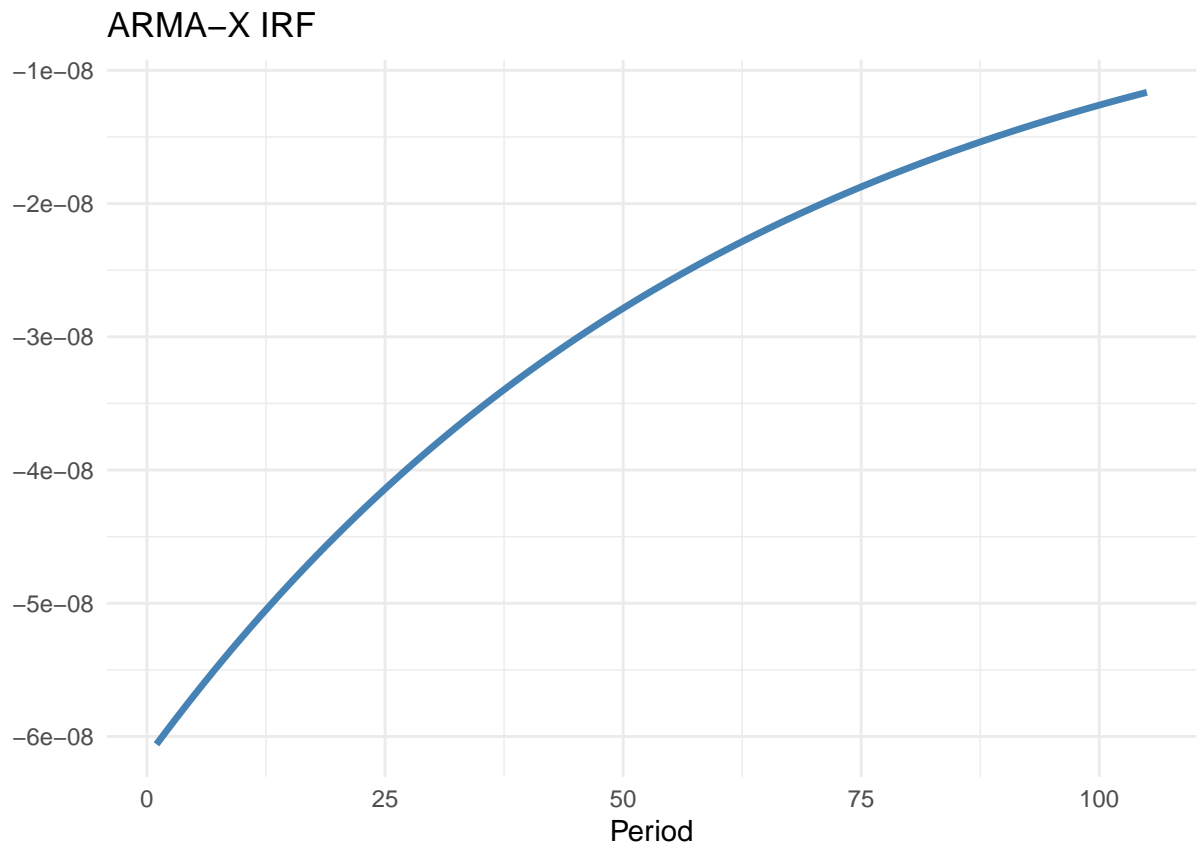
ARMA−X IRF


```
irf.plot(tariff_fit$model,nb.periods)
```
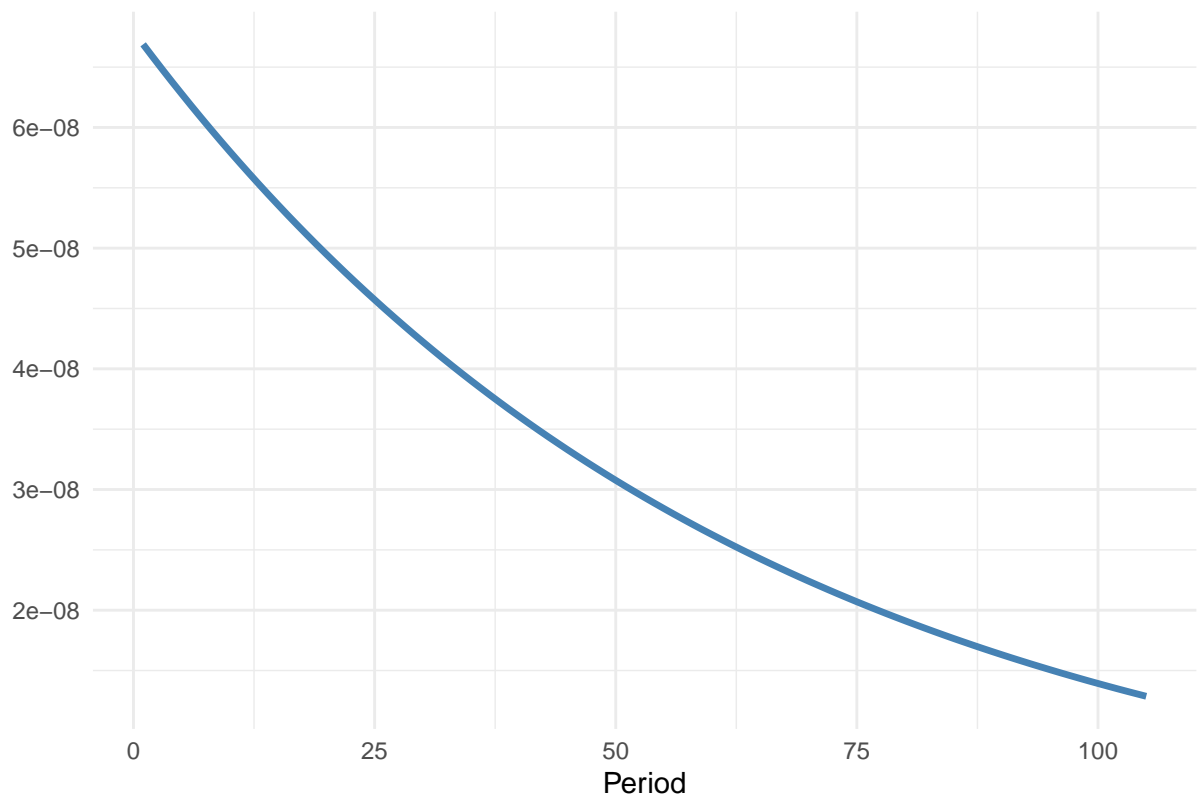
ARMA–X IRF


```
irf.plot(trade_fit$model,nb.periods)
```
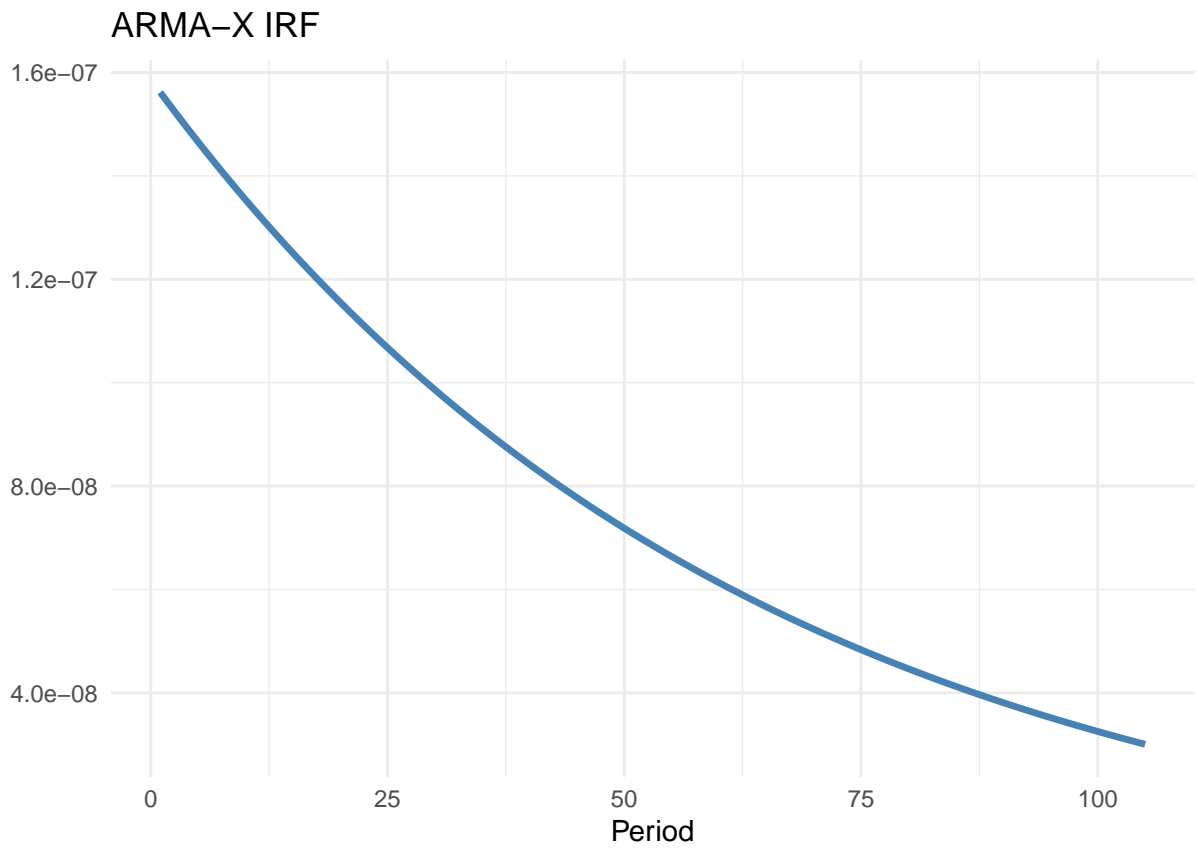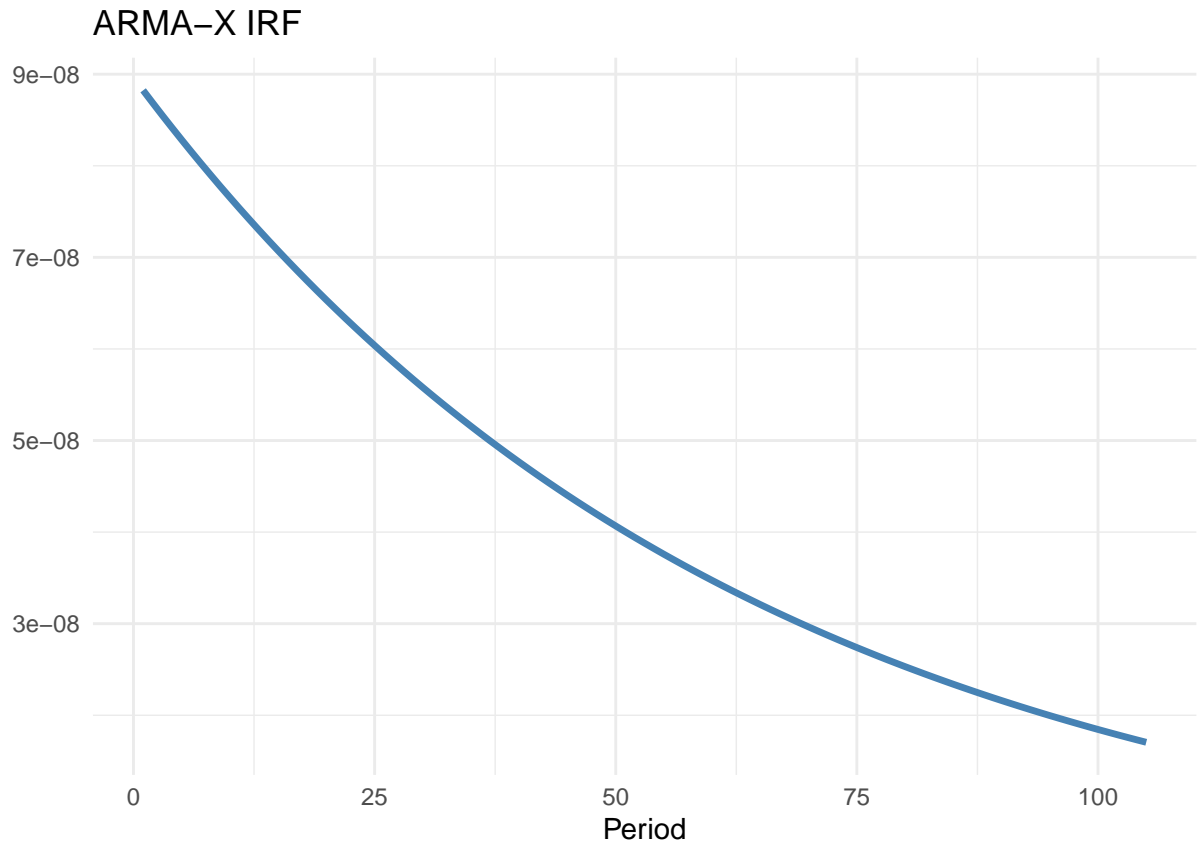
ARMA−X IRF


```
irf.plot(china_fit$model,nb.periods)
```

ARMA−X IRF

```r
irf.plot(positive_fit$model,nb.periods)
```

ARMA–X IRF


```
irf.plot(negative_fit$model,nb.periods)
```

ARMA−X IRF

VGK Residuals

```
res = checkresiduals(dummy_fit$model, plot = FALSE)
```

```
##
##  Ljung-Box test
##
## data:  Residuals from Regression with ARIMA(1,0,3) errors
## Q* = 7.0043, df = 6, p-value = 0.3204
##
## Model df: 4.    Total lags used: 10
```

```
res = checkresiduals(count_fit$model, plot = FALSE)
```

```
##
##  Ljung-Box test
##
## data:  Residuals from Regression with ARIMA(1,0,3) errors
## Q* = 7.2173, df = 6, p-value = 0.3012
##
## Model df: 4.    Total lags used: 10
```

```
res = checkresiduals(tariff_fit$model, plot = FALSE)
```

```
##
##  Ljung-Box test
##
## data:  Residuals from Regression with ARIMA(1,0,3) errors
## Q* = 8.6899, df = 6, p-value = 0.1918
##
## Model df: 4.   Total lags used: 10
```

```
res = checkresiduals(trade_fit$model, plot = FALSE)
```

```
##
##  Ljung-Box test
##
## data:  Residuals from Regression with ARIMA(1,0,3) errors
## Q* = 8.4517, df = 6, p-value = 0.2068
##
## Model df: 4.   Total lags used: 10
```

```
res = checkresiduals(china_fit$model, plot = FALSE)
```

```
##
##  Ljung-Box test
##
## data:  Residuals from Regression with ARIMA(1,0,3) errors
## Q* = 8.274, df = 6, p-value = 0.2187
##
## Model df: 4.   Total lags used: 10
```

```
res = checkresiduals(positive_fit$model, plot = FALSE)
```

```
##
##  Ljung-Box test
##
## data:  Residuals from Regression with ARIMA(1,0,3) errors
## Q* = 7.942, df = 6, p-value = 0.2424
##
## Model df: 4.   Total lags used: 10
```

```
res = checkresiduals(negative_fit$model, plot = FALSE)
```

```
##
##  Ljung-Box test
##
## data:  Residuals from Regression with ARIMA(1,0,3) errors
## Q* = 8.3531, df = 6, p-value = 0.2134
##
## Model df: 4.   Total lags used: 10
```

	Model 1
ar1	0.9910***
	(0.0014)
ma1	−0.7445***
	(0.0072)
ma2	−0.1387***
	(0.0088)
ma3	−0.0470***
	(0.0072)
intercept	0.0001
dummy_lag_0	0.0000
AIC	−256599.7623
AICc	−256599.7567
BIC	−256544.4480
Log Likelihood	128306.8811
Num. obs.	19971

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

Table 15: ARMAX selected by AIC

ASHR Models

```r
#dummy
dummy_fit = auto.armax.r(data$ASHR_vol, x=data$dummy,
                max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```

```r
#count
count_fit = auto.armax.r(data$ASHR_vol, x=data$N,
                max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```

```r
#tariffs
tariff_fit = auto.armax.r(data$ASHR_vol, x=data$tariff,
                max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```

```r
#trade
trade_fit = auto.armax.r(data$ASHR_vol, x=data$trade,
                max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```

```r
#china
china_fit = auto.armax.r(data$ASHR_vol, x=data$china,
                max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```

```r
#proportion of positive
positive_fit = auto.armax.r(data$ASHR_vol, x=data$prop_positive,
                max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```

	Model 1
ar1	0.9909***
	(0.0014)
ma1	−0.7439***
	(0.0072)
ma2	−0.1410***
	(0.0087)
ma3	−0.0452***
	(0.0072)
intercept	0.0001
N_lag_0	0.0000
AIC	−256508.5319
AICc	−256508.5263
BIC	−256453.2176
Log Likelihood	128261.2659
Num. obs.	19971

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table 16: ARMAX selected by AIC

	Model 1
ar1	0.9913***
	(0.0013)
ma1	−0.7508***
	(0.0072)
ma2	−0.1387***
	(0.0088)
ma3	−0.0429***
	(0.0073)
intercept	0.0002***
	(0.0000)
tariff_lag_0	0.0000
	(0.0000)
AIC	−255990.0623
AICc	−255990.0567
BIC	−255934.7481
Log Likelihood	128002.0312
Num. obs.	19971

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table 17: ARMAX selected by AIC

	Model 1
ar1	0.9914***
	(0.0013)
ma1	−0.7494***
	(0.0072)
ma2	−0.1406***
	(0.0087)
ma3	−0.0427***
	(0.0073)
intercept	0.0002***
	(0.0000)
trade_lag_0	0.0000**
	(0.0000)
AIC	−256004.3080
AICc	−256004.3024
BIC	−255948.9937
Log Likelihood	128009.1540
Num. obs.	19971

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table 18: ARMAX selected by AIC

	Model 1
ar1	0.9915***
	(0.0013)
ma1	−0.7509***
	(0.0072)
ma2	−0.1383***
	(0.0088)
ma3	−0.0434***
	(0.0073)
intercept	0.0002***
	(0.0000)
china_lag_0	0.0000**
	(0.0000)
AIC	−256010.2273
AICc	−256010.2217
BIC	−255954.9130
Log Likelihood	128012.1137
Num. obs.	19971

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table 19: ARMAX selected by AIC

	Model 1
ar1	0.9910***
	(0.0014)
ma1	−0.7463***
	(0.0072)
ma2	−0.1410***
	(0.0087)
ma3	−0.0438***
	(0.0073)
intercept	0.0001***
	(0.0000)
prop_positive_lag_0	0.0001***
	(0.0000)
AIC	−256208.9107
AICc	−256208.9050
BIC	−256153.5964
Log Likelihood	128111.4553
Num. obs.	19971

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

Table 20: ARMAX selected by AIC

```
#proportion of negative
negative_fit = auto.armax.r(data$ASHR_vol, x=data$prop_negative,
                max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```

ASHR IRFs

```
#we want to plot the IRFs of these models
nb.periods = 7 * 15

irf.plot(dummy_fit$model,nb.periods)
```
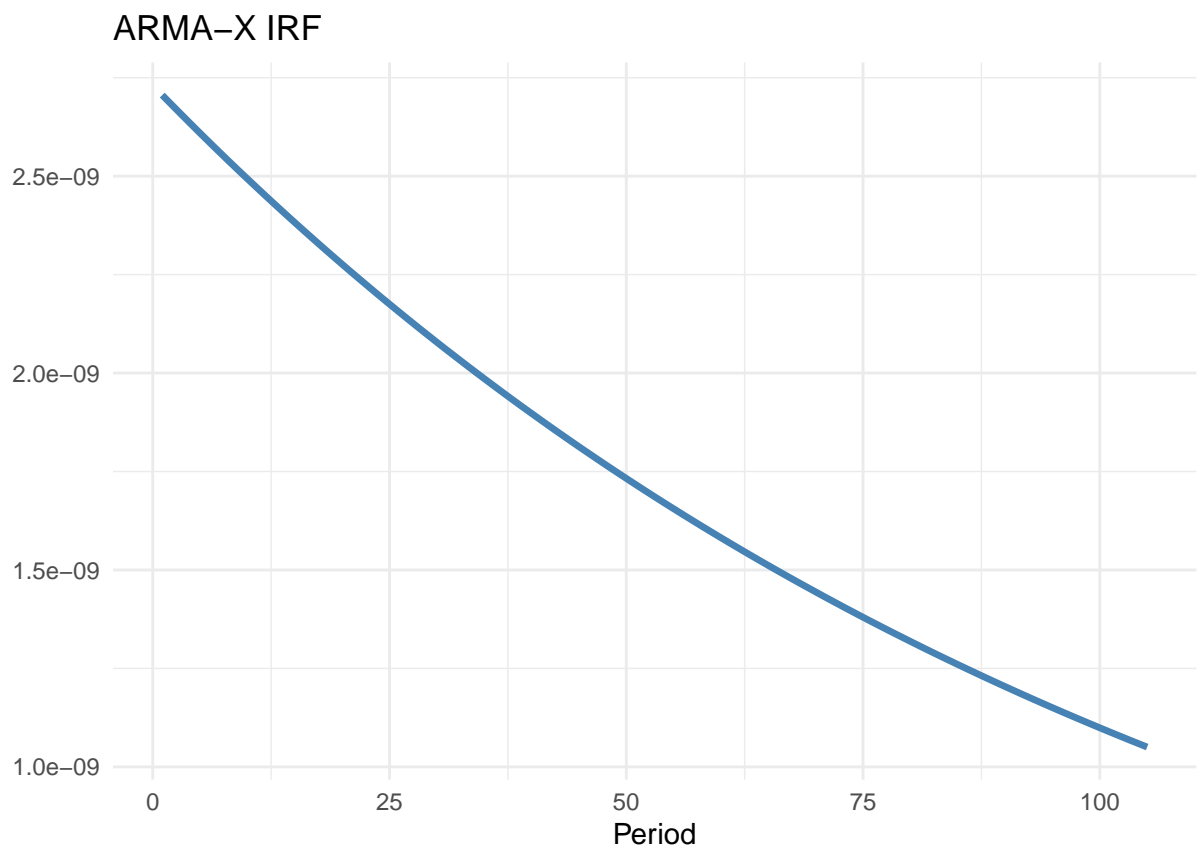
	Model 1
ar1	0.9915***
	(0.0013)
ma1	−0.7488***
	(0.0072)
ma2	−0.1400***
	(0.0087)
ma3	−0.0440***
	(0.0073)
intercept	0.0001***
	(0.0000)
prop_negative_lag_0	0.0001***
	(0.0000)
AIC	−256073.7682
AICc	−256073.7625
BIC	−256018.4539
Log Likelihood	128043.8841
Num. obs.	19971

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

Table 21: ARMAX selected by AIC
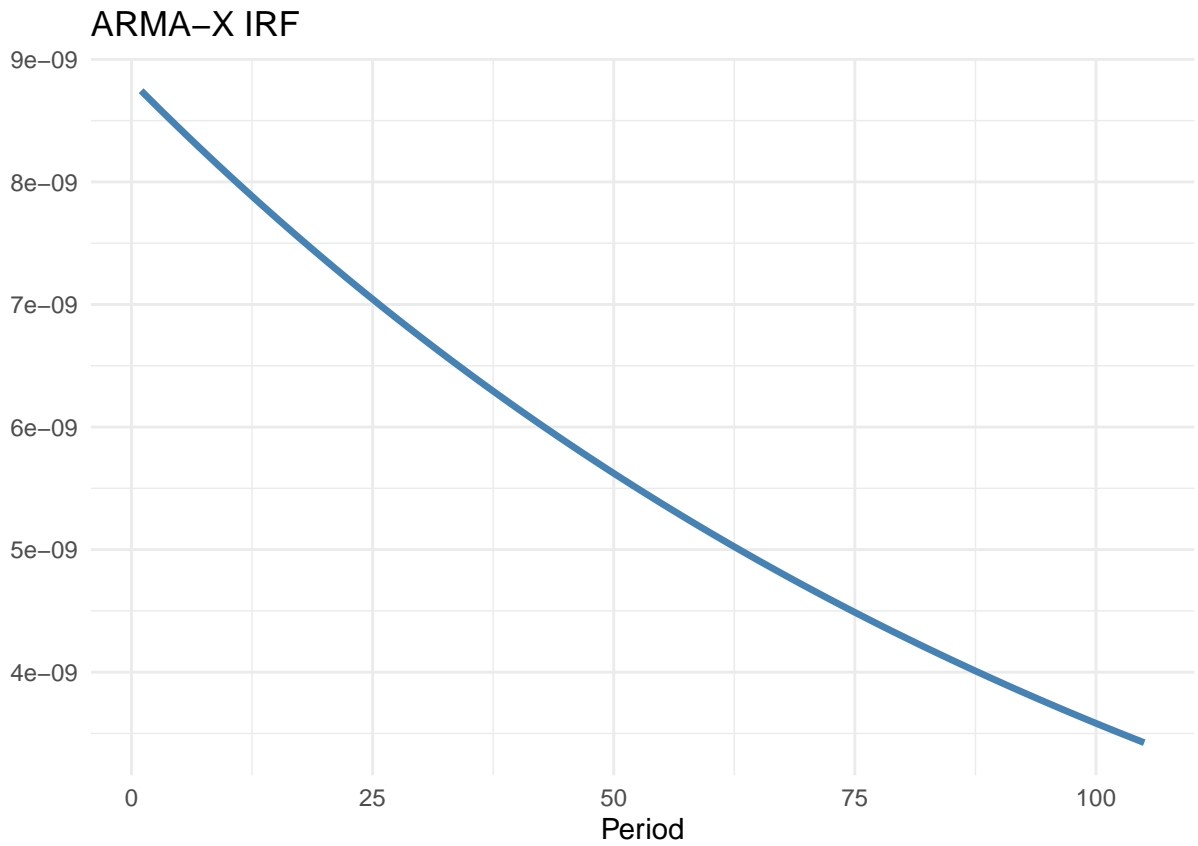
ARMA−X IRF

```
irf.plot(count_fit$model,nb.periods)
```

ARMA−X IRF


```
irf.plot(tariff_fit$model,nb.periods)
```
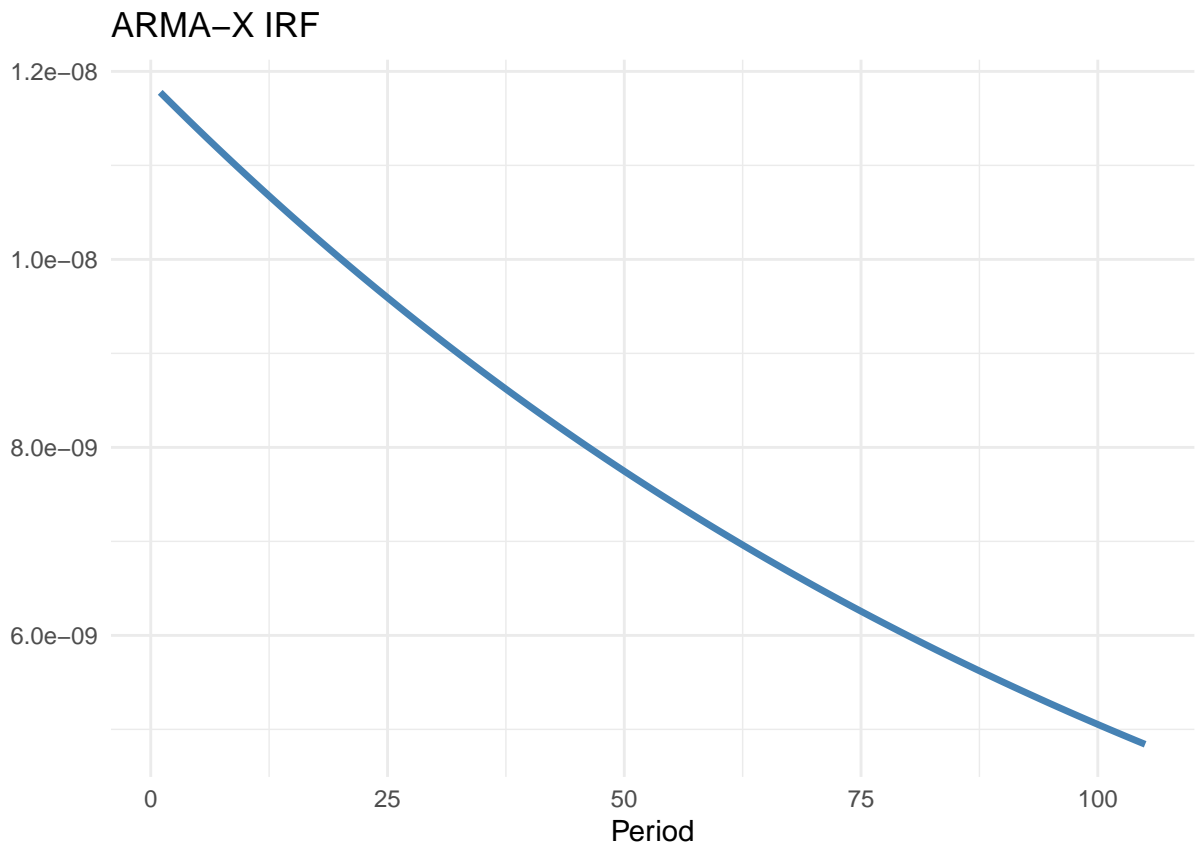
ARMA−X IRF

```r
irf.plot(trade_fit$model,nb.periods)
```
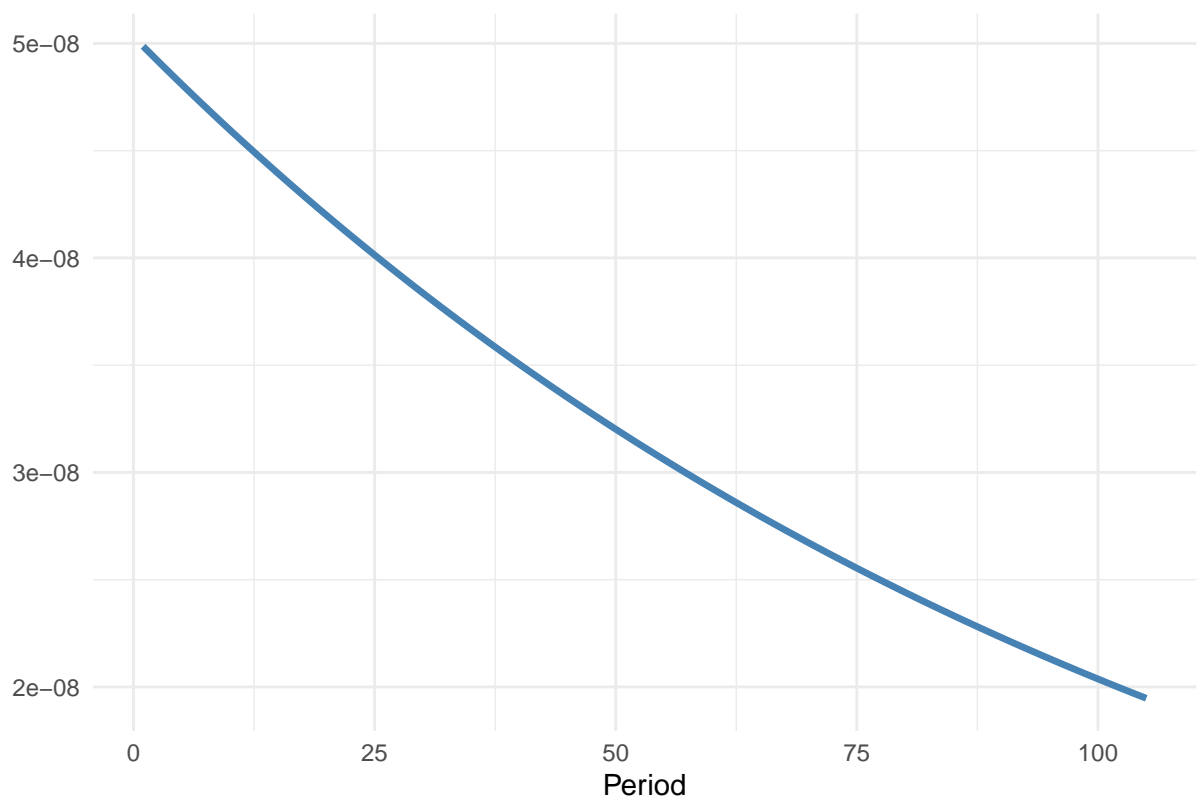
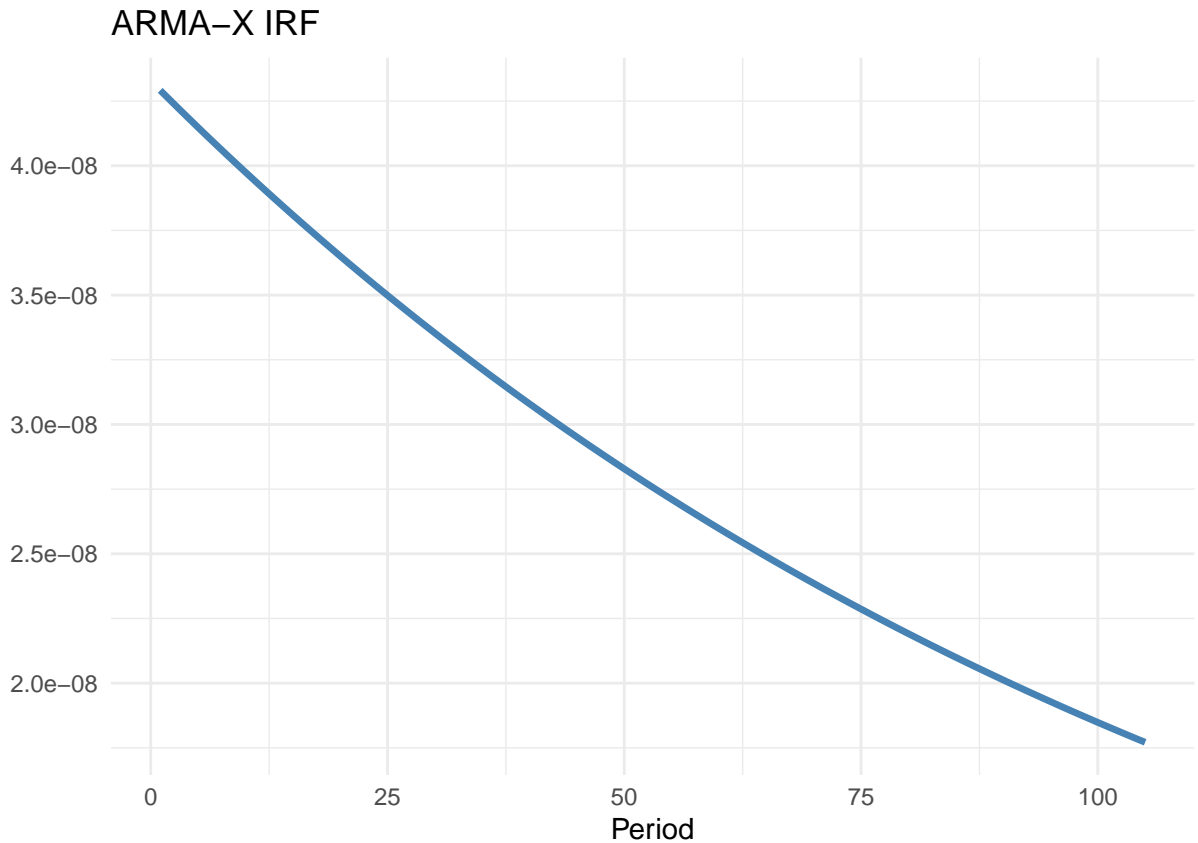## ARMA−X IRF


```
irf.plot(china_fit$model,nb.periods)
```

ARMA−X IRF

```r
irf.plot(positive_fit$model,nb.periods)
```

ARMA−X IRF


```
irf.plot(negative_fit$model,nb.periods)
```

ARMA–X IRF

ASHR Residuals

```
res = checkresiduals(dummy_fit$model, plot = FALSE)
```
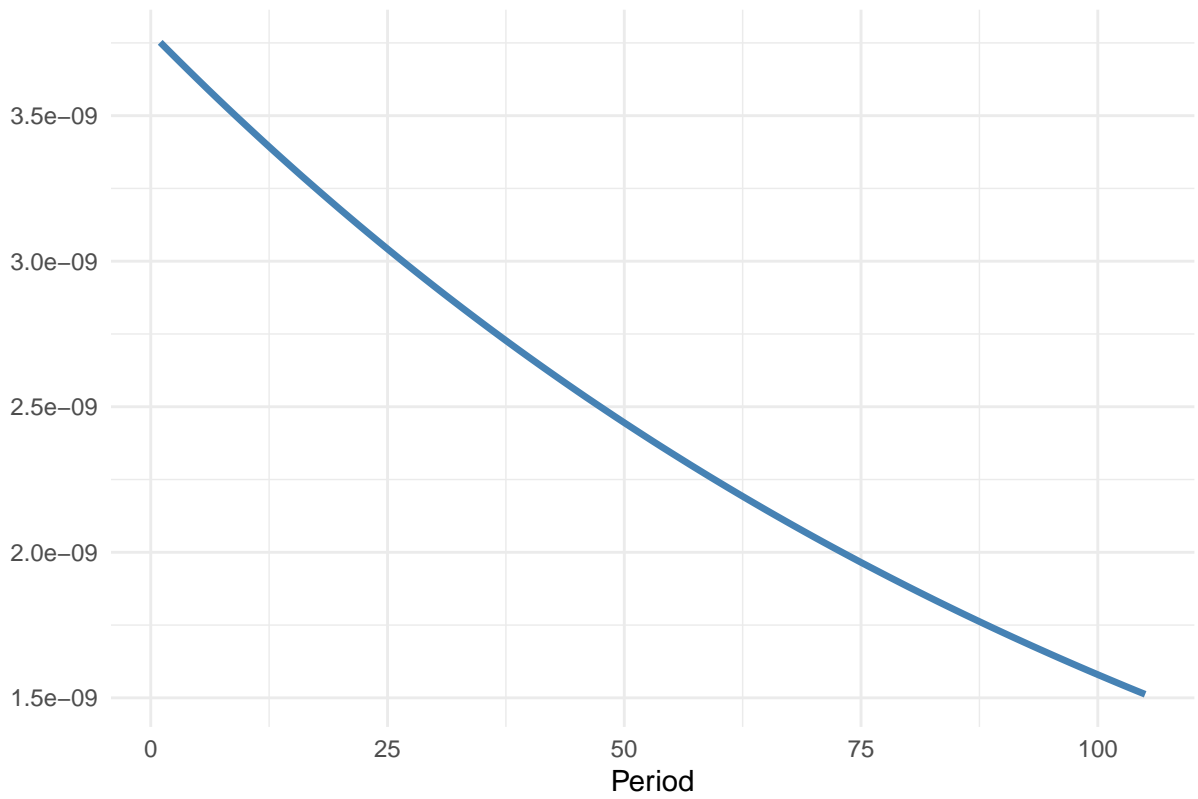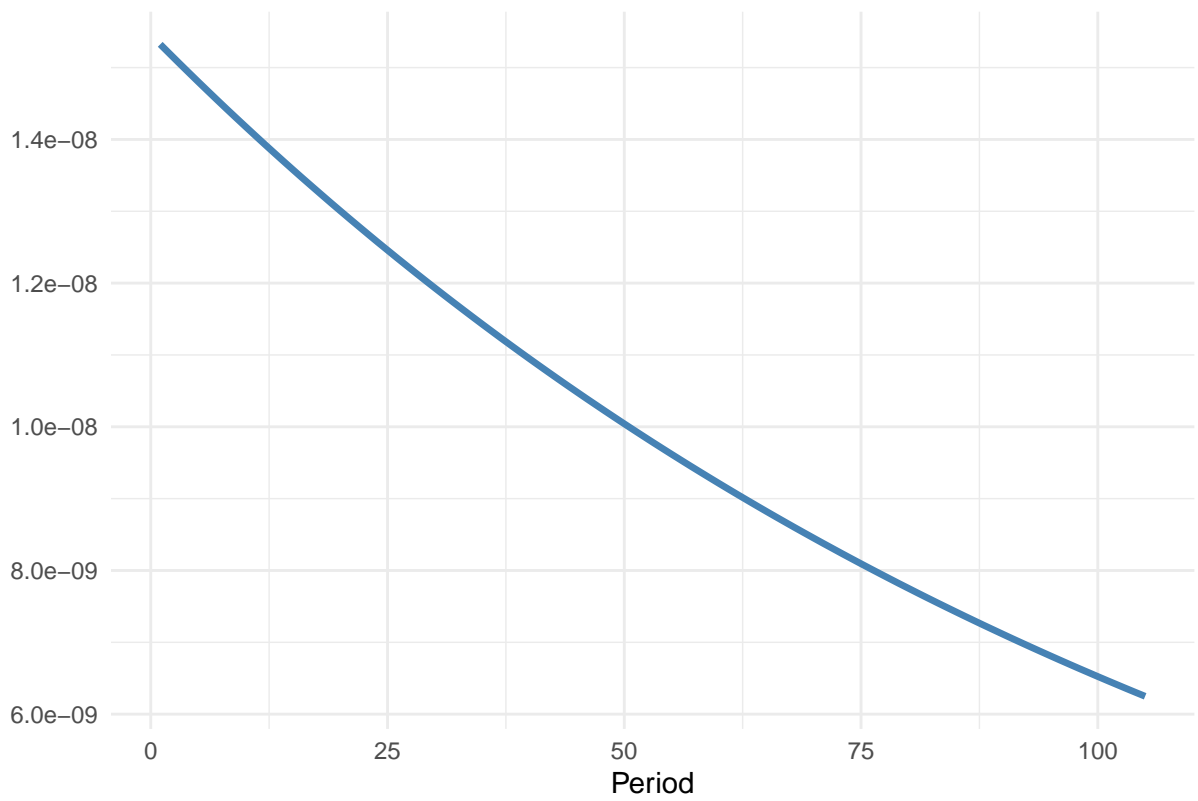
```
##
##  Ljung-Box test
##
## data:  Residuals from Regression with ARIMA(1,0,3) errors
## Q* = 342.99, df = 6, p-value < 2.2e-16
##
## Model df: 4.   Total lags used: 10
```

```
res = checkresiduals(count_fit$model, plot = FALSE)
```

```
##
##  Ljung-Box test
##
## data:  Residuals from Regression with ARIMA(1,0,3) errors
## Q* = 357.28, df = 6, p-value < 2.2e-16
##
## Model df: 4.   Total lags used: 10
```

```r
res = checkresiduals(tariff_fit$model, plot = FALSE)
```

```
##
##  Ljung-Box test
##
## data:  Residuals from Regression with ARIMA(1,0,3) errors
## Q* = 602.55, df = 6, p-value < 2.2e-16
##
## Model df: 4.   Total lags used: 10
```

```r
res = checkresiduals(trade_fit$model, plot = FALSE)
```

```
##
##  Ljung-Box test
##
## data:  Residuals from Regression with ARIMA(1,0,3) errors
## Q* = 587.58, df = 6, p-value < 2.2e-16
##
## Model df: 4.   Total lags used: 10
```

```r
res = checkresiduals(china_fit$model, plot = FALSE)
```

```
##
##  Ljung-Box test
##
## data:  Residuals from Regression with ARIMA(1,0,3) errors
## Q* = 590.9, df = 6, p-value < 2.2e-16
##
## Model df: 4.   Total lags used: 10
```

```r
res = checkresiduals(positive_fit$model, plot = FALSE)
```

```
##
##  Ljung-Box test
##
## data:  Residuals from Regression with ARIMA(1,0,3) errors
## Q* = 476.09, df = 6, p-value < 2.2e-16
##
## Model df: 4.   Total lags used: 10
```

```r
res = checkresiduals(negative_fit$model, plot = FALSE)
```

```
##
##  Ljung-Box test
##
## data:  Residuals from Regression with ARIMA(1,0,3) errors
## Q* = 548.15, df = 6, p-value < 2.2e-16
##
## Model df: 4.   Total lags used: 10
```

	Model 1
ar1	0.2806***
	(0.0217)
ar2	0.1356***
	(0.0217)
ar3	0.5678***
	(0.0214)
ma1	0.1913***
	(0.0176)
ma2	−0.1581***
	(0.0166)
ma3	−0.6627***
	(0.0154)
intercept	0.0168*
	(0.0085)
dummy_lag_0	0.0012***
	(0.0001)
dummy_lag_1	0.0004**
	(0.0001)
dummy_lag_2	−0.0002
	(0.0001)
dummy_lag_3	−0.0008***
	(0.0001)
AIC	−28702.9487
AICc	−28702.9043
BIC	−28620.6381
Log Likelihood	14363.4744
Num. obs.	7039

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

Table 22: ARMAX selected by AIC

First Term

SPY Models

```r
#dummy
dummy_fit = auto.armax.r(data$SPY_vol, x=data$dummy,
                max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```

```r
#count
count_fit = auto.armax.r(data$SPY_vol, x=data$N,
                max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```

```r
#tariffs
tariff_fit = auto.armax.r(data$SPY_vol, x=data$tariff,
                max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```

	Model 1
ar1	0.2835***
	(0.0218)
ar2	0.1357***
	(0.0217)
ar3	0.5648***
	(0.0215)
ma1	0.1903***
	(0.0176)
ma2	−0.1594***
	(0.0166)
ma3	−0.6621***
	(0.0155)
intercept	0.0172*
	(0.0086)
N_lag_0	0.0005***
	(0.0001)
N_lag_1	0.0001*
	(0.0001)
N_lag_2	−0.0001
	(0.0001)
N_lag_3	−0.0003***
	(0.0001)
AIC	−28679.8164
AICc	−28679.7720
BIC	−28597.5057
Log Likelihood	14351.9082
Num. obs.	7039

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

Table 23: ARMAX selected by AIC

	Model 1
ar1	0.2953***
	(0.0225)
ar2	0.1434***
	(0.0220)
ar3	0.5456***
	(0.0223)
ma1	0.1854***
	(0.0180)
ma2	−0.1707***
	(0.0169)
ma3	−0.6557***
	(0.0162)
intercept	0.0174*
	(0.0085)
tariff_lag_0	0.0011
	(0.0010)
AIC	−28604.6559
AICc	−28604.6303
BIC	−28542.9191
Log Likelihood	14311.3279
Num. obs.	7042

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

Table 24: ARMAX selected by AIC

```r
#trade
trade_fit = auto.armax.r(data$SPY_vol, x=data$trade,
                max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```

```r
#china
china_fit = auto.armax.r(data$SPY_vol, x=data$china,
                max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```

```r
#proportion of positive
positive_fit = auto.armax.r(data$SPY_vol, x=data$prop_positive,
                max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```

```r
#proportion of negative
negative_fit = auto.armax.r(data$SPY_vol, x=data$prop_negative,
                max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```

SPY IRFs

```r
#we want to plot the IRFs of these models
nb.periods = 7 * 15

irf.plot(dummy_fit$model,nb.periods)
```

	Model 1
ar1	0.2943***
	(0.0224)
ar2	0.1439***
	(0.0220)
ar3	0.5462***
	(0.0222)
ma1	0.1863***
	(0.0179)
ma2	−0.1706***
	(0.0169)
ma3	−0.6564***
	(0.0161)
intercept	0.0174*
	(0.0086)
trade_lag_0	0.0023**
	(0.0009)
AIC	−28610.2269
AICc	−28610.2013
BIC	−28548.4901
Log Likelihood	14314.1134
Num. obs.	7042

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

Table 25: ARMAX selected by AIC

	Model 1
ar1	0.2927***
	(0.0224)
ar2	0.1438***
	(0.0219)
ar3	0.5480***
	(0.0222)
ma1	0.1866***
	(0.0179)
ma2	−0.1695***
	(0.0168)
ma3	−0.6575***
	(0.0161)
intercept	0.0173*
	(0.0086)
china_lag_0	0.0018**
	(0.0006)
AIC	−28613.1693
AICc	−28613.1437
BIC	−28551.4325
Log Likelihood	14315.5847
Num. obs.	7042

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

Table 26: ARMAX selected by AIC

	Model 1
ar1	0.2916***
	(0.0223)
ar2	0.1414***
	(0.0219)
ar3	0.5512***
	(0.0221)
ma1	0.1867***
	(0.0179)
ma2	-0.1678***
	(0.0168)
ma3	-0.6575***
	(0.0161)
intercept	0.0144
	(0.0085)
prop_positive_lag_0	0.0048***
	(0.0011)
prop_positive_lag_1	0.0045***
	(0.0012)
prop_positive_lag_2	0.0035**
	(0.0011)
AIC	-28615.8662
AICc	-28615.8286
BIC	-28540.4132
Log Likelihood	14318.9331
Num. obs.	7040

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

Table 27: ARMAX selected by AIC

	Model 1
ar1	0.2955***
	(0.0226)
ar2	0.1452***
	(0.0222)
ar3	0.5438***
	(0.0225)
ma1	0.1851***
	(0.0182)
ma2	−0.1728***
	(0.0171)
ma3	−0.6538***
	(0.0164)
intercept	0.0169*
	(0.0086)
prop_negative_lag_0	0.0034**
	(0.0012)
AIC	−28611.2002
AICc	−28611.1746
BIC	−28549.4634
Log Likelihood	14314.6001
Num. obs.	7042

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

Table 28: ARMAX selected by AIC
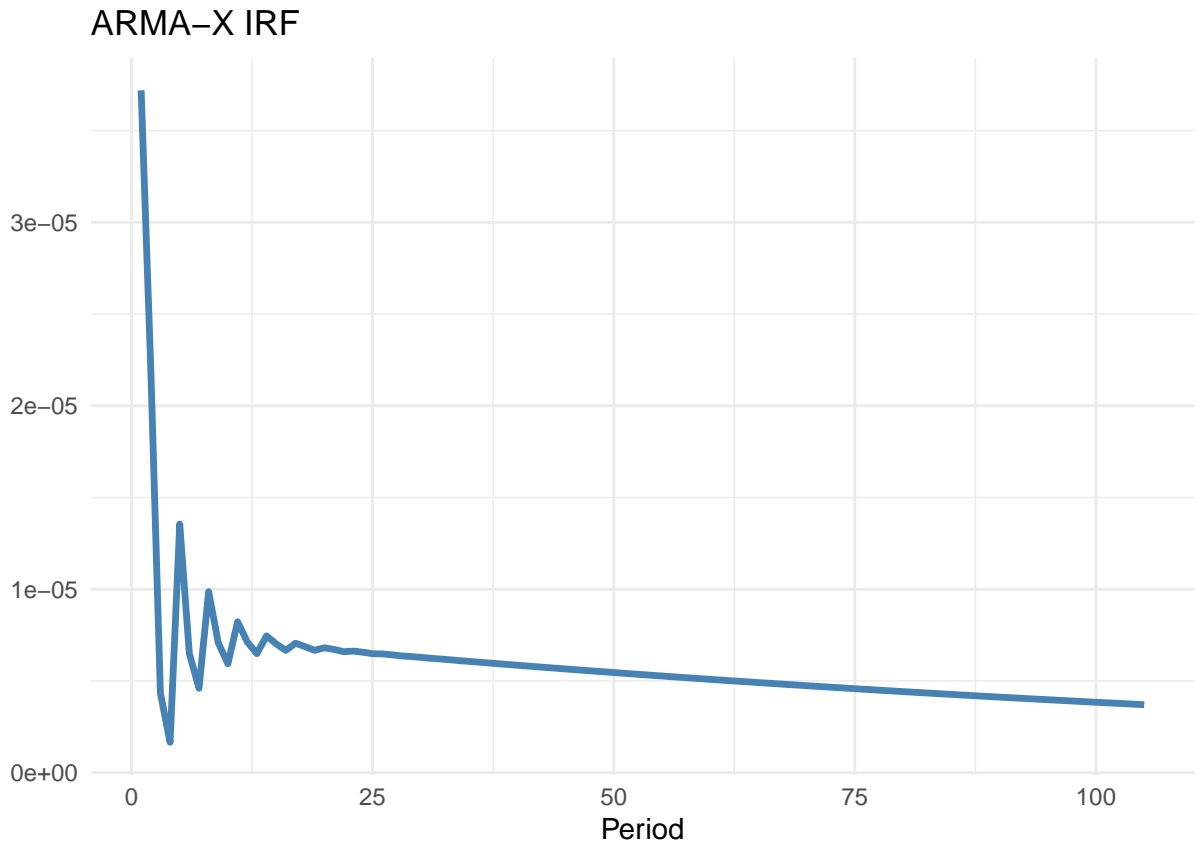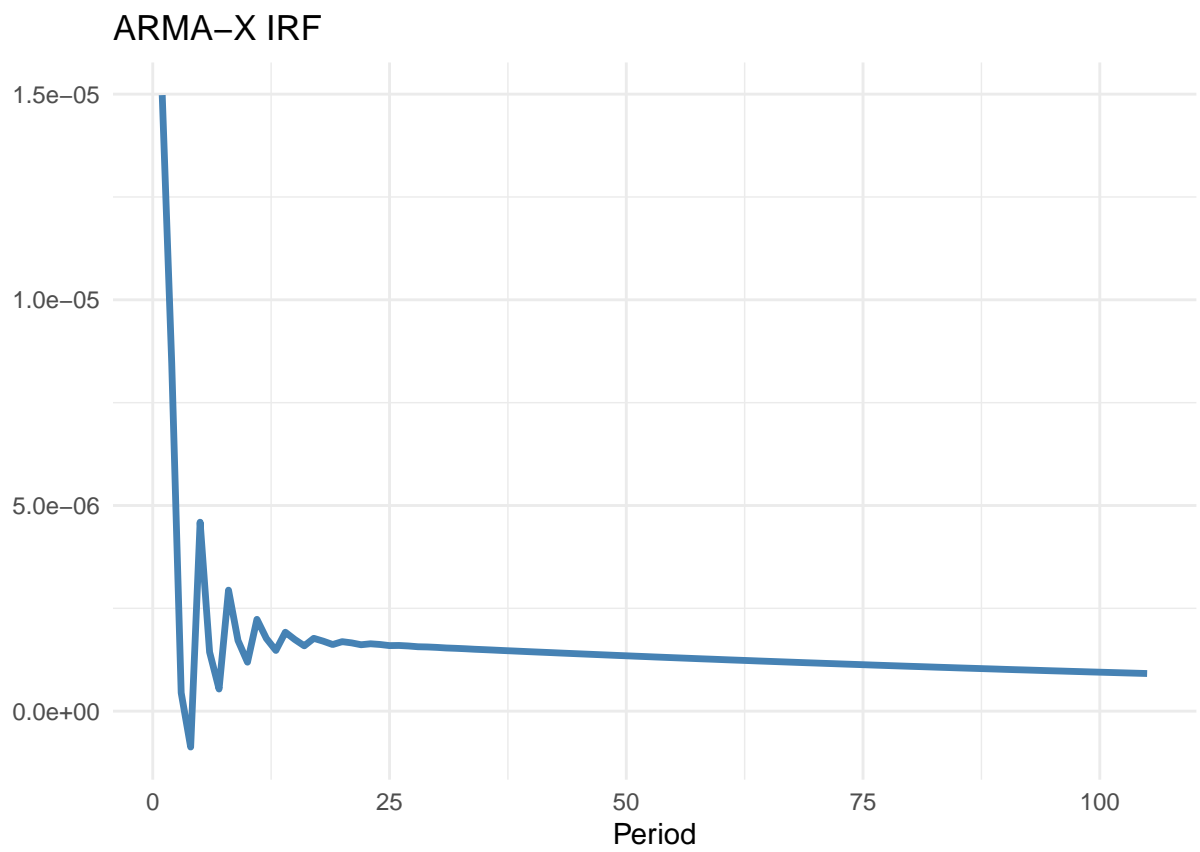
ARMA–X IRF

```
irf.plot(count_fit$model,nb.periods)
```

ARMA−X IRF


```
irf.plot(tariff_fit$model,nb.periods)
```

ARMA−X IRF


```
irf.plot(trade_fit$model,nb.periods)
```

ARMA−X IRF


```
irf.plot(china_fit$model,nb.periods)
```

ARMA−X IRF


```
irf.plot(positive_fit$model,nb.periods)
```

ARMA−X IRF


```
irf.plot(negative_fit$model,nb.periods)
```

ARMA−X IRF

SPY Residuals

```
res = checkresiduals(dummy_fit$model, plot = FALSE)
```
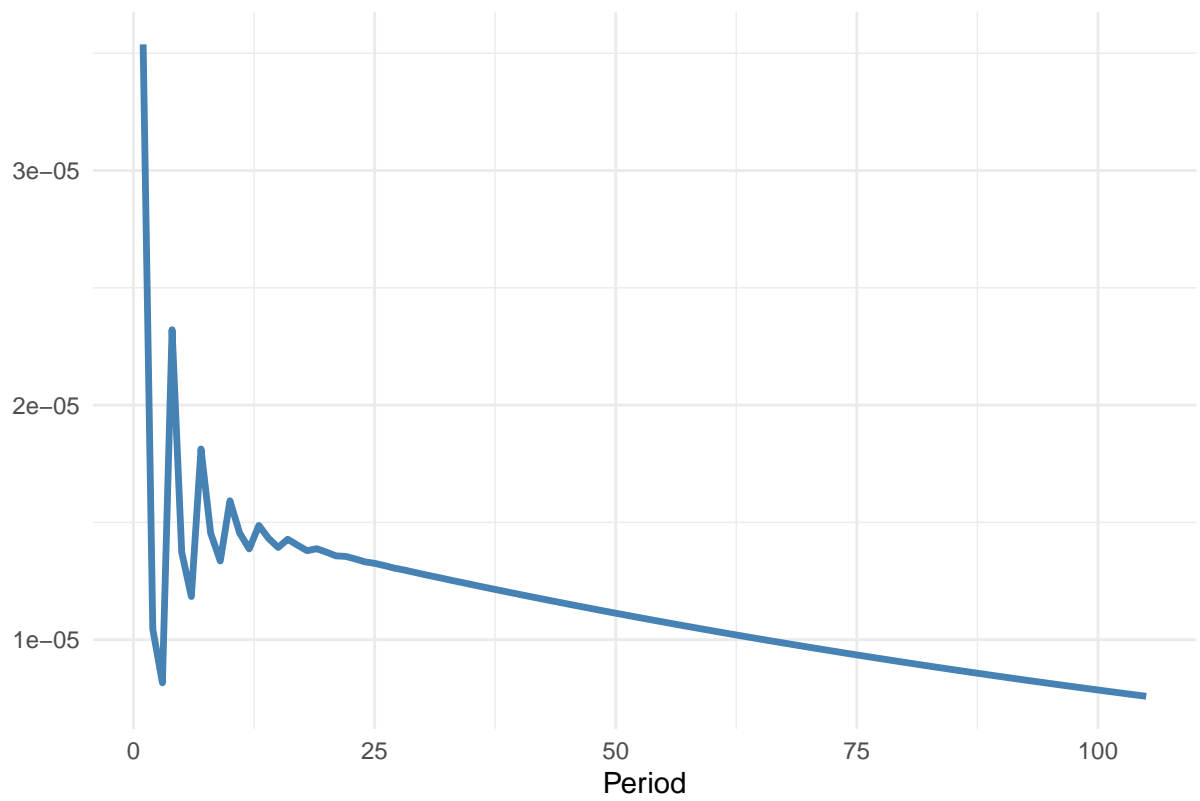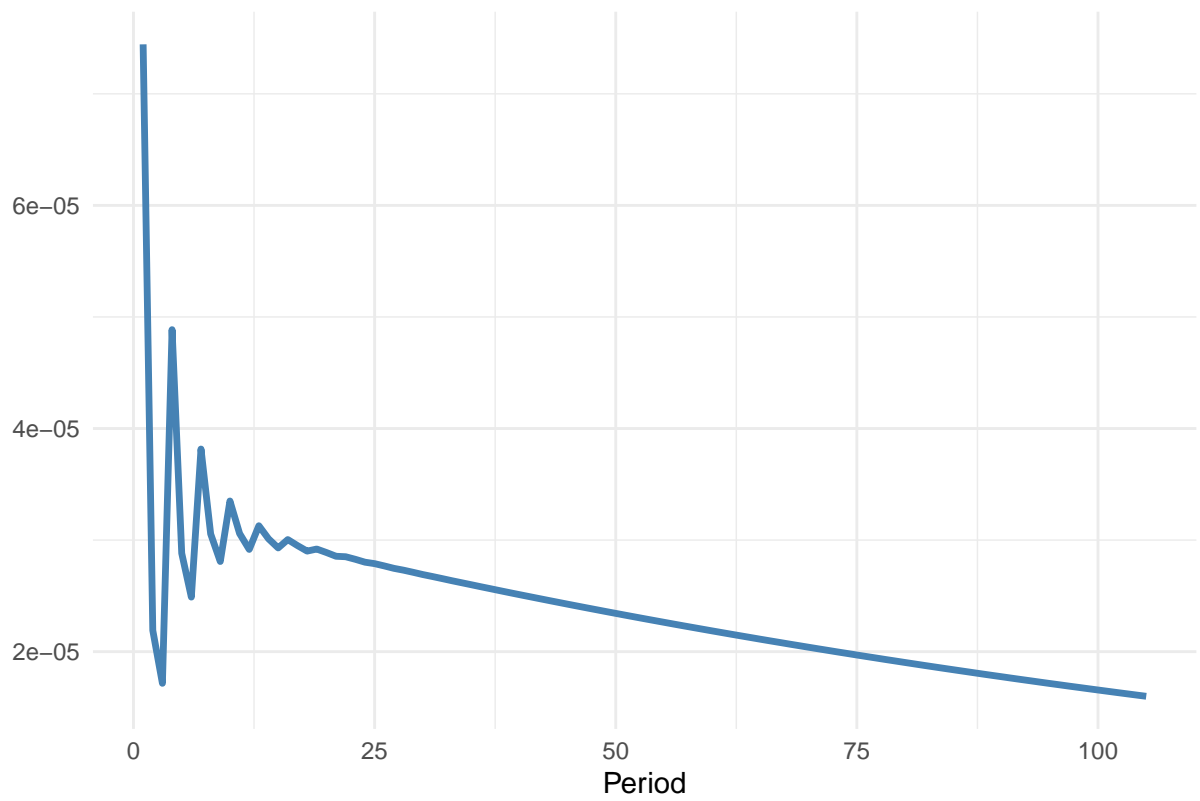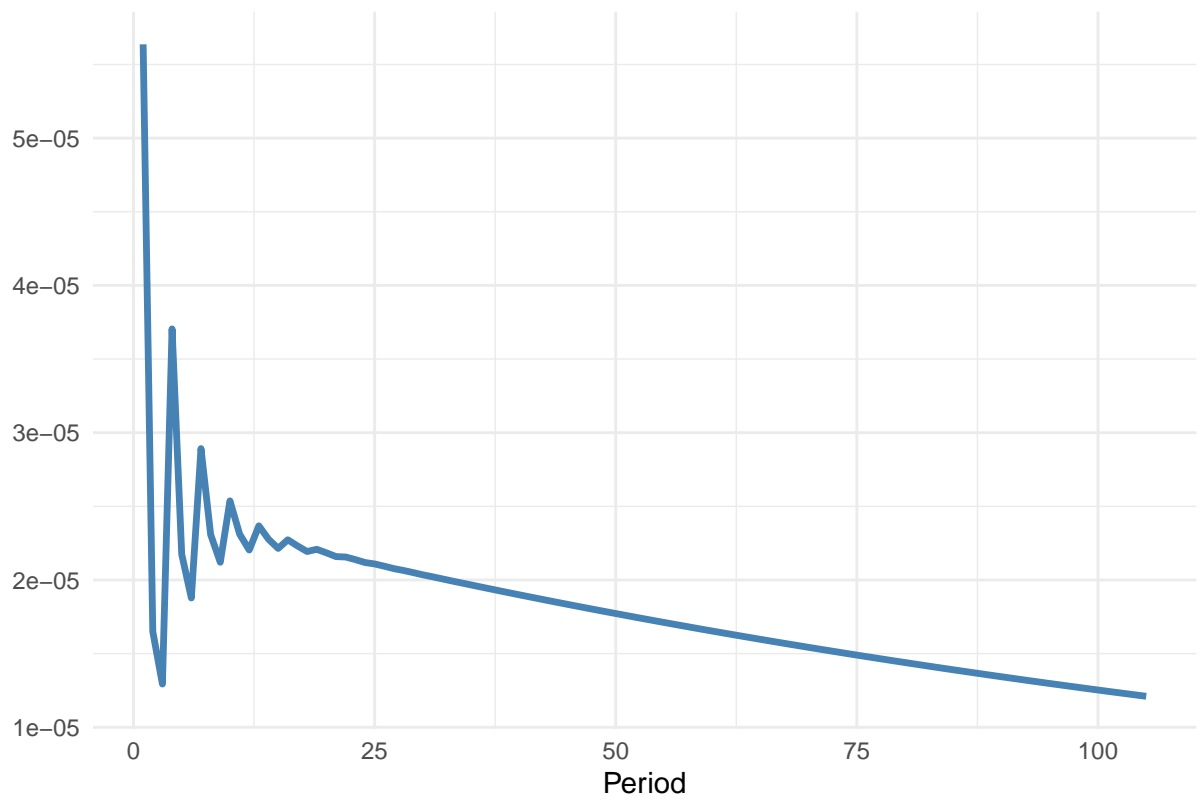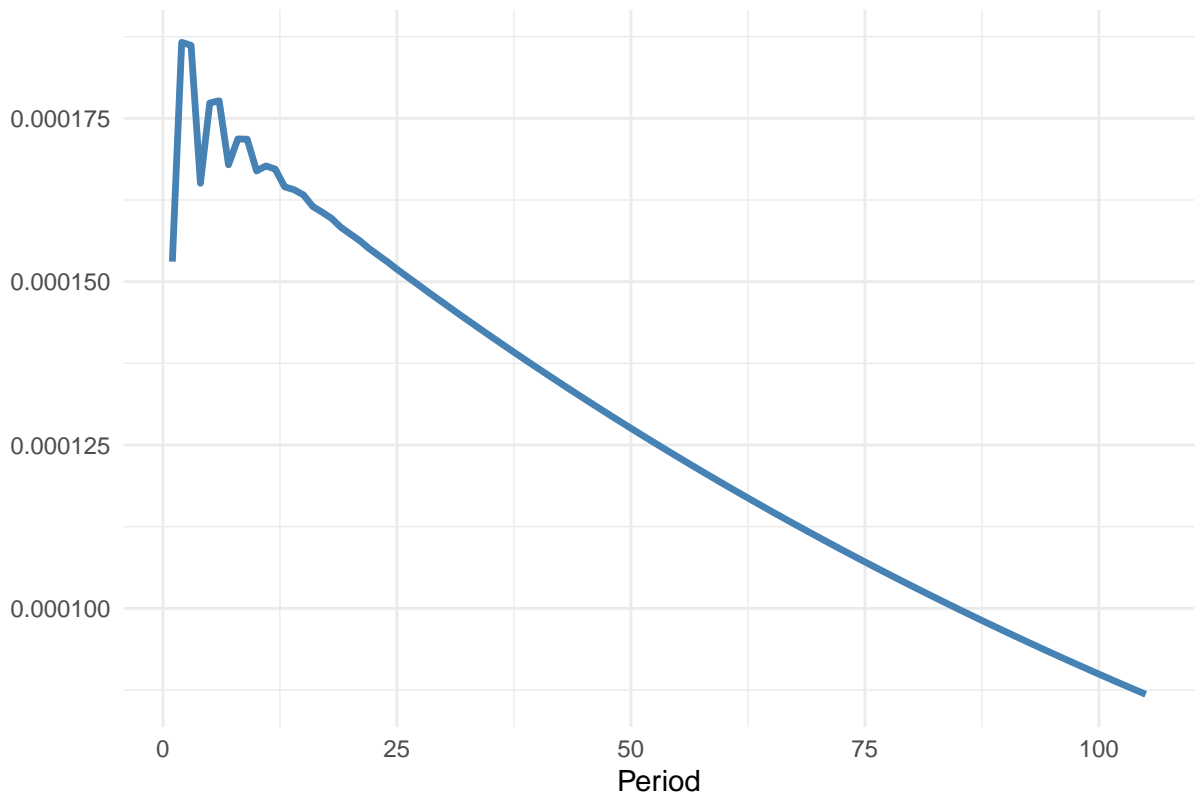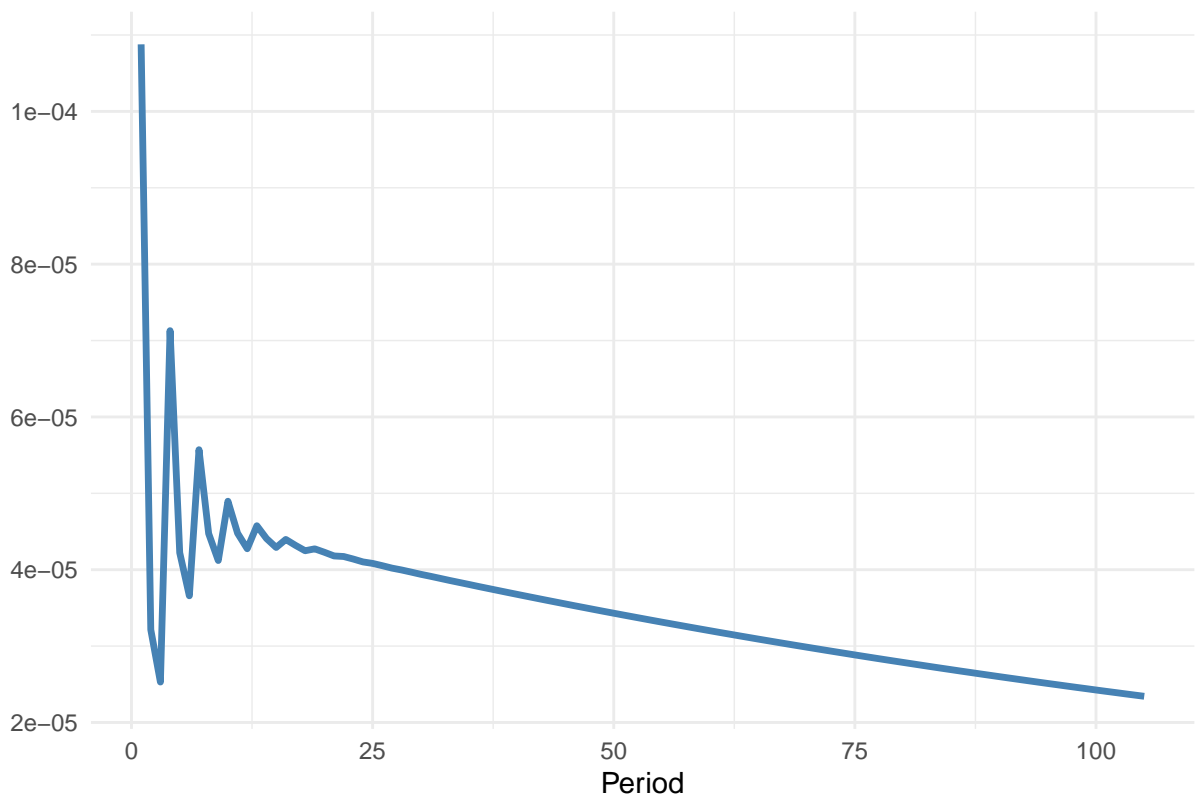
```
##
##  Ljung-Box test
##
## data:  Residuals from Regression with ARIMA(3,0,3) errors
## Q* = 513.57, df = 4, p-value < 2.2e-16
##
## Model df: 6.   Total lags used: 10
```

```
res = checkresiduals(count_fit$model, plot = FALSE)
```

```
##
##  Ljung-Box test
##
## data:  Residuals from Regression with ARIMA(3,0,3) errors
## Q* = 526.61, df = 4, p-value < 2.2e-16
##
## Model df: 6.   Total lags used: 10
```

```
res = checkresiduals(tariff_fit$model, plot = FALSE)
```

```
##
##  Ljung-Box test
##
## data:  Residuals from Regression with ARIMA(3,0,3) errors
## Q* = 613.41, df = 4, p-value < 2.2e-16
##
## Model df: 6.   Total lags used: 10
```

```
res = checkresiduals(trade_fit$model, plot = FALSE)
```

```
##
##  Ljung-Box test
##
## data:  Residuals from Regression with ARIMA(3,0,3) errors
## Q* = 613.1, df = 4, p-value < 2.2e-16
##
## Model df: 6.   Total lags used: 10
```

```
res = checkresiduals(china_fit$model, plot = FALSE)
```

```
##
##  Ljung-Box test
##
## data:  Residuals from Regression with ARIMA(3,0,3) errors
## Q* = 610.2, df = 4, p-value < 2.2e-16
##
## Model df: 6.   Total lags used: 10
```

```
res = checkresiduals(positive_fit$model, plot = FALSE)
```

```
##
##  Ljung-Box test
##
## data:  Residuals from Regression with ARIMA(3,0,3) errors
## Q* = 589.29, df = 4, p-value < 2.2e-16
##
## Model df: 6.   Total lags used: 10
```

```
res = checkresiduals(negative_fit$model, plot = FALSE)
```

```
##
##  Ljung-Box test
##
## data:  Residuals from Regression with ARIMA(3,0,3) errors
## Q* = 609.58, df = 4, p-value < 2.2e-16
##
## Model df: 6.   Total lags used: 10
```

	Model 1
ar1	0.9900***
	(0.0023)
ma1	−0.9459***
	(0.0051)
intercept	0.0003
dummy_lag_0	0.0000
AIC	−70570.1789
AICc	−70570.1704
BIC	−70535.8807
Log Likelihood	35290.0894
Num. obs.	7042

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table 29: ARMAX selected by AIC

	Model 1
ar1	0.9901***
	(0.0023)
ma1	−0.9459***
	(0.0051)
intercept	0.0003
N_lag_0	0.0000
AIC	−70566.3579
AICc	−70566.3494
BIC	−70532.0597
Log Likelihood	35288.1790
Num. obs.	7042

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table 30: ARMAX selected by AIC

VGK Models

```
#dummy
dummy_fit = auto.armax.r(data$VGK_vol, x=data$dummy,
                max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)


#count
count_fit = auto.armax.r(data$VGK_vol, x=data$N,
                max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)


#tariffs
tariff_fit = auto.armax.r(data$VGK_vol, x=data$tariff,
                max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```

	Model 1
ar1	0.9900***
	(0.0023)
ma1	−0.9460***
	(0.0051)
intercept	0.0003**
	(0.0001)
tariff__lag__0	0.0000
	(0.0001)
AIC	−70556.6085
AICc	−70556.6000
BIC	−70522.3103
Log Likelihood	35283.3043
Num. obs.	7042

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table 31: ARMAX selected by AIC

	Model 1
ar1	0.9900***
	(0.0023)
ma1	−0.9458***
	(0.0051)
intercept	0.0003**
	(0.0001)
trade__lag__0	0.0000
	(0.0001)
AIC	−70556.9184
AICc	−70556.9099
BIC	−70522.6202
Log Likelihood	35283.4592
Num. obs.	7042

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table 32: ARMAX selected by AIC

```r
#trade
trade_fit = auto.armax.r(data$VGK_vol, x=data$trade,
              max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```

```r
#china
china_fit = auto.armax.r(data$VGK_vol, x=data$china,
              max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```
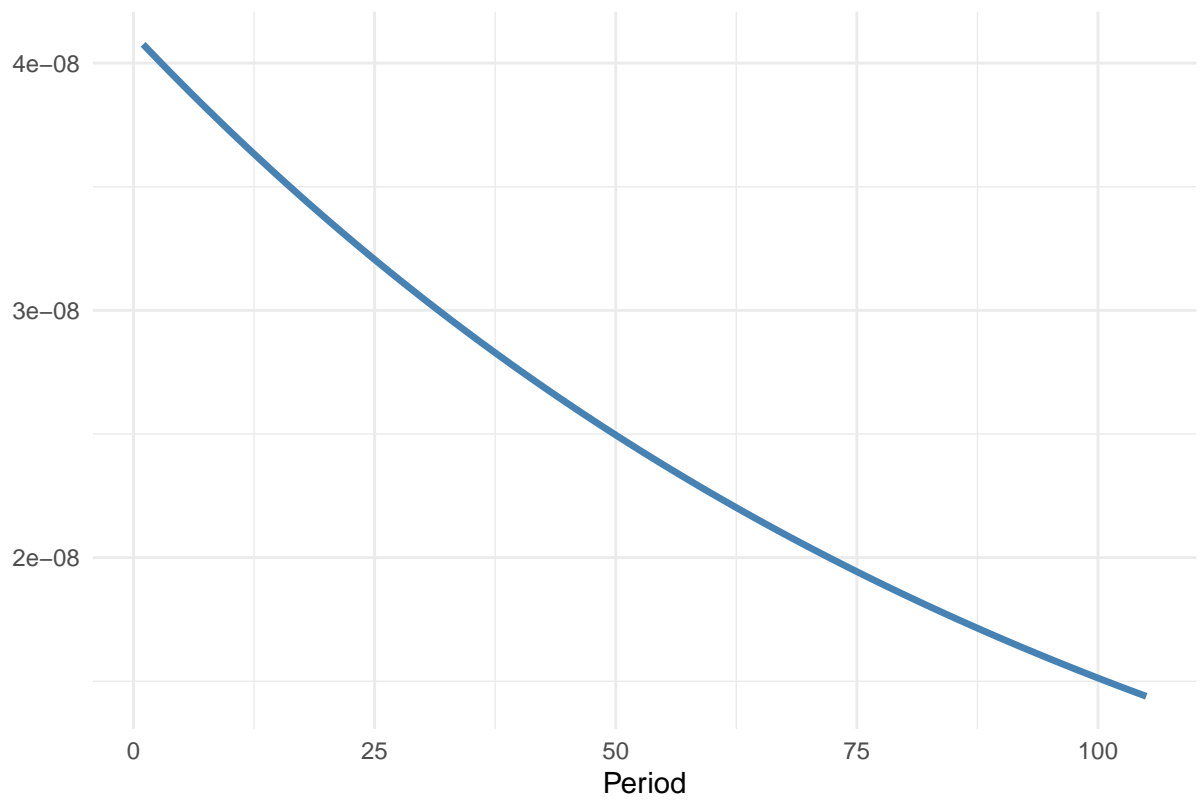
```r
#proportion of positive
positive_fit = auto.armax.r(data$VGK_vol, x=data$prop_positive,
              max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```
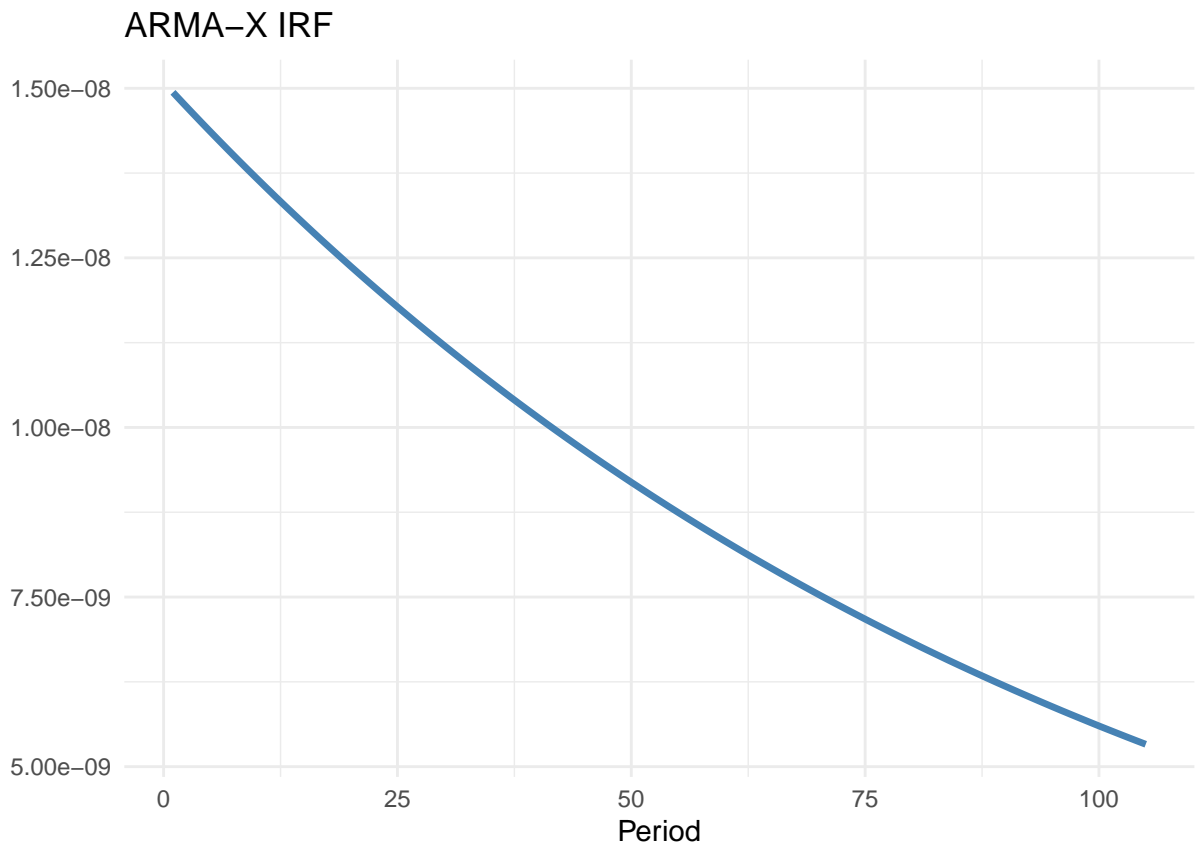
	Model 1
ar1	0.9901***
	(0.0023)
ma1	−0.9459***
	(0.0051)
intercept	0.0003**
	(0.0001)
china_lag_0	0.0000
	(0.0000)
AIC	−70557.6988
AICc	−70557.6903
BIC	−70523.4006
Log Likelihood	35283.8494
Num. obs.	7042

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

Table 33: ARMAX selected by AIC

	Model 1
ar1	0.9901***
	(0.0023)
ma1	−0.9460***
	(0.0051)
intercept	0.0003**
	(0.0001)
prop_positive_lag_0	0.0000
	(0.0001)
AIC	−70556.8894
AICc	−70556.8809
BIC	−70522.5912
Log Likelihood	35283.4447
Num. obs.	7042

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

Table 34: ARMAX selected by AIC

	Model 1
ar1	0.9901***
	(0.0023)
ma1	−0.9459***
	(0.0051)
intercept	0.0003**
	(0.0001)
prop_negative_lag_0	0.0000
	(0.0001)
AIC	−70556.5554
AICc	−70556.5469
BIC	−70522.2572
Log Likelihood	35283.2777
Num. obs.	7042

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

Table 35: ARMAX selected by AIC

```
#proportion of negative
negative_fit = auto.armax.r(data$VGK_vol, x=data$prop_negative,
                max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```

VGK IRFs

```
#we want to plot the IRFs of these models
nb.periods = 7 * 15

irf.plot(dummy_fit$model,nb.periods)
```

ARMA−X IRF


```
irf.plot(count_fit$model,nb.periods)
```

ARMA−X IRF


```
irf.plot(tariff_fit$model,nb.periods)
```

ARMA−X IRF


```r
irf.plot(trade_fit$model,nb.periods)
```
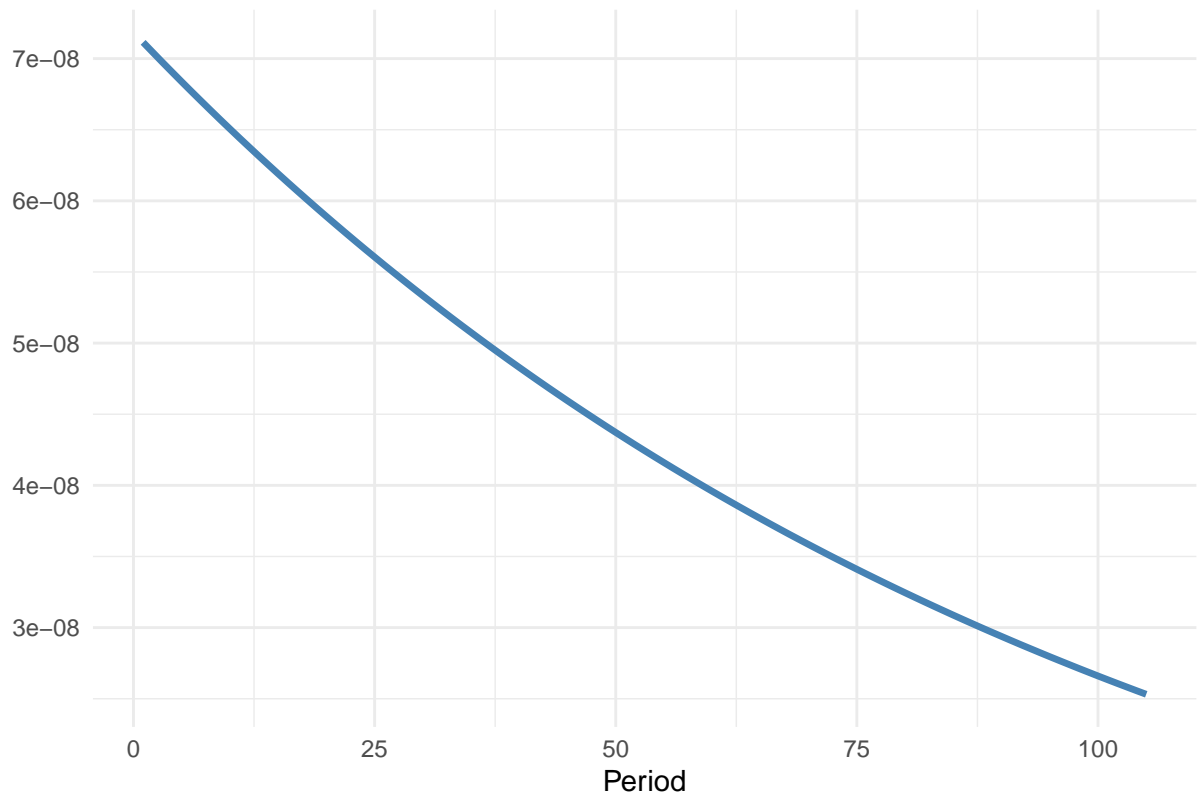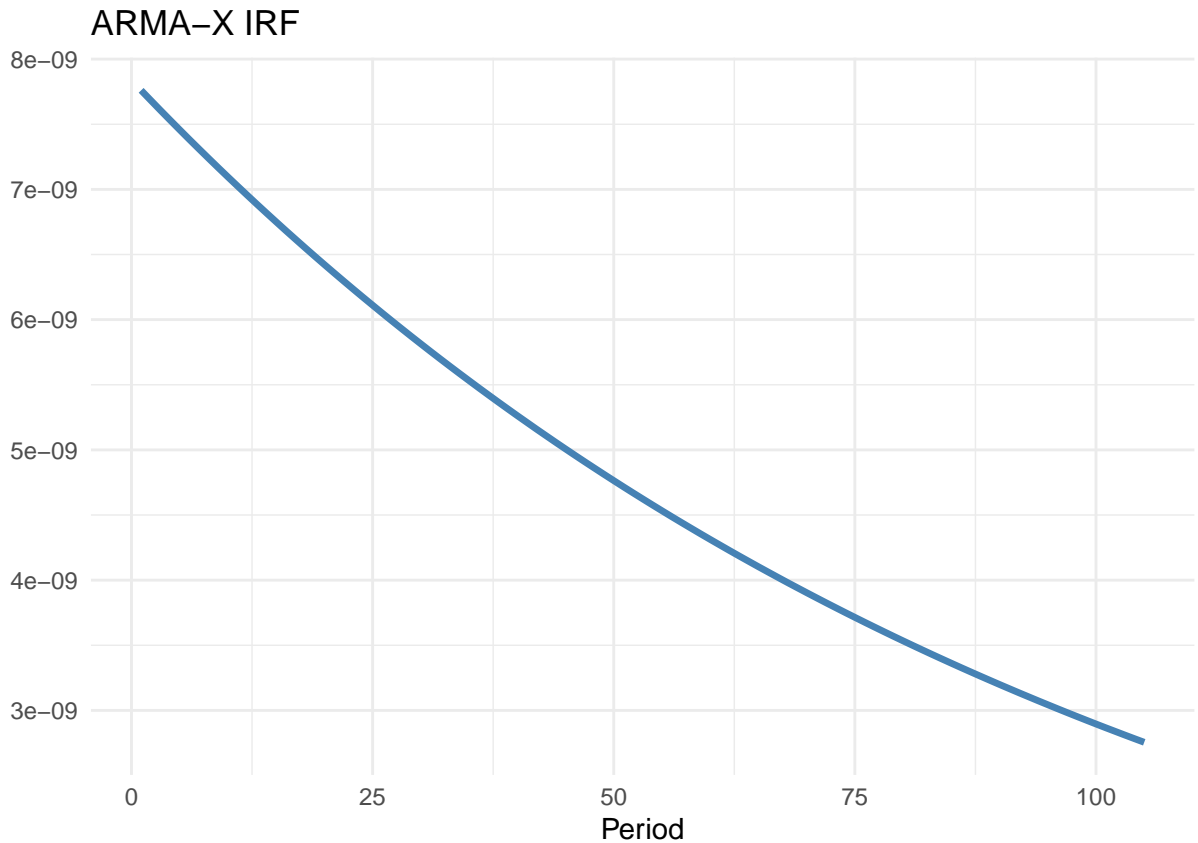
ARMA−X IRF


```
irf.plot(china_fit$model,nb.periods)
```

ARMA−X IRF

```r
irf.plot(positive_fit$model,nb.periods)
```

ARMA−X IRF

```r
irf.plot(negative_fit$model,nb.periods)
```

ARMA−X IRF

VGK Residuals

```
res = checkresiduals(dummy_fit$model, plot = FALSE)
```
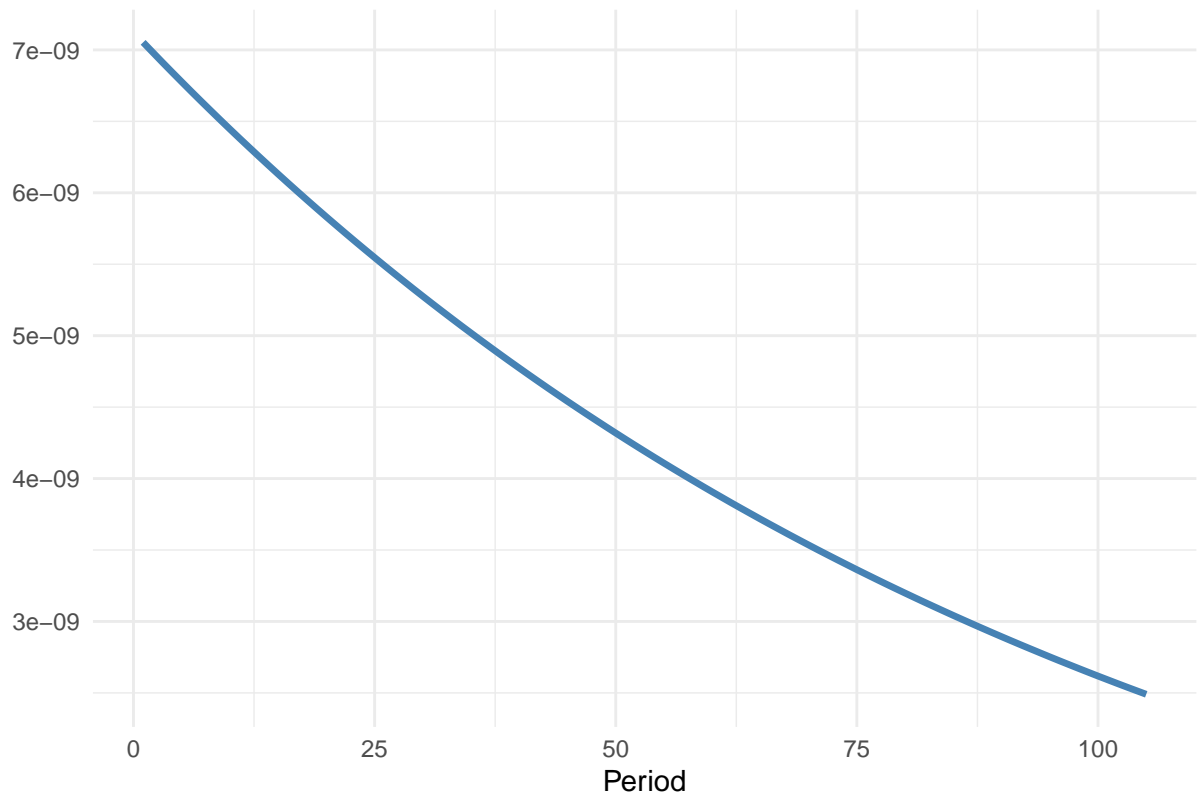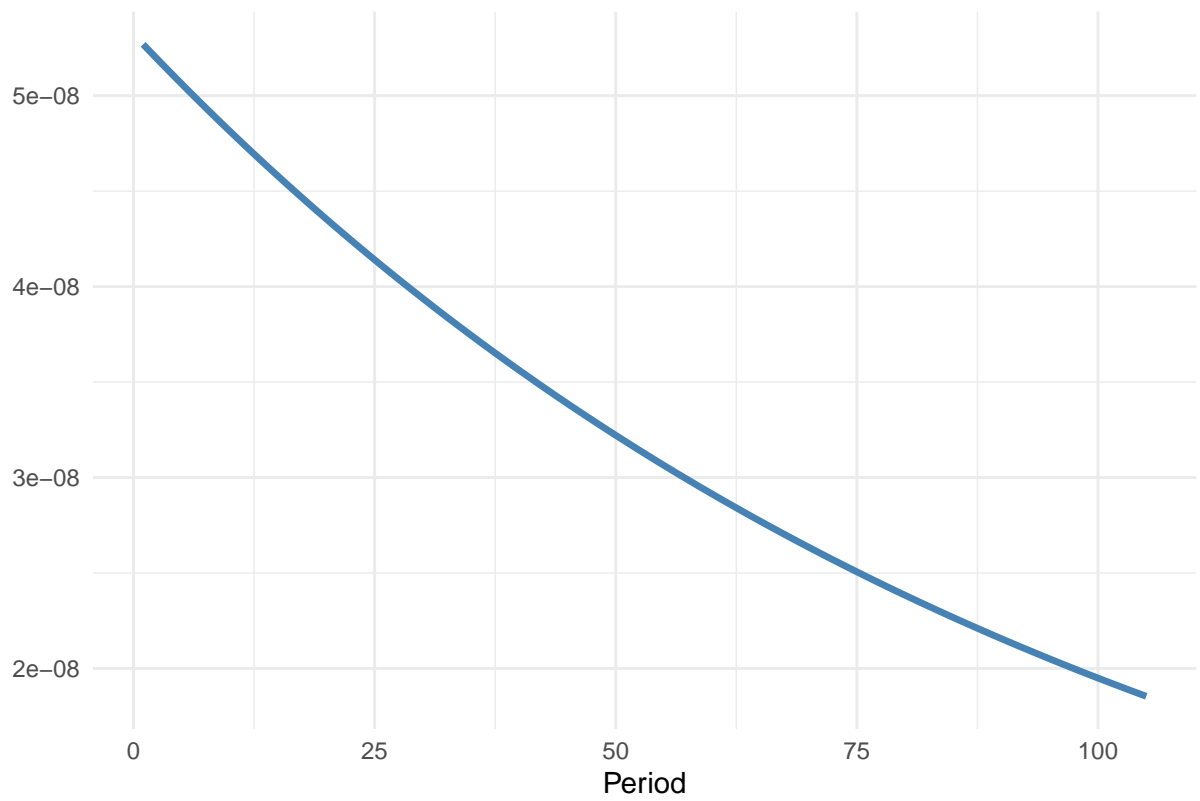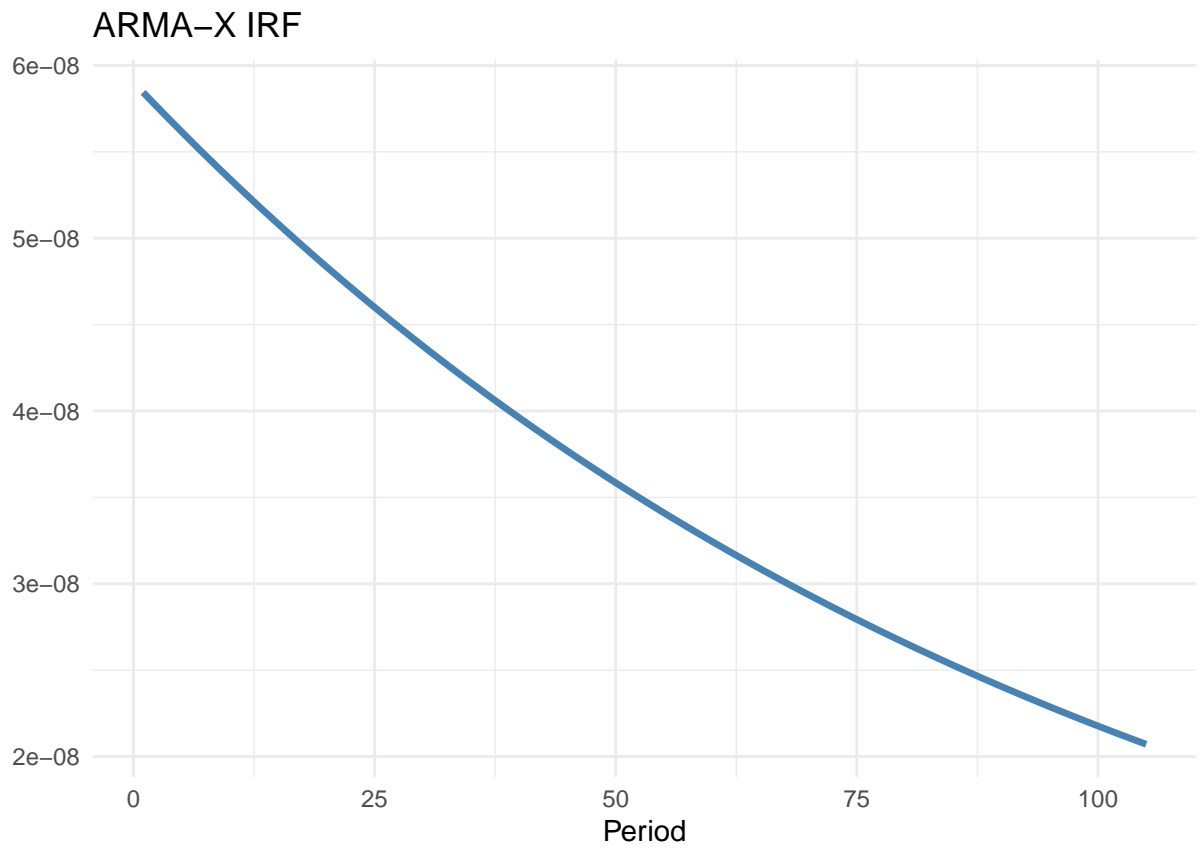
```
##
##   Ljung-Box test
##
## data:  Residuals from Regression with ARIMA(1,0,1) errors
## Q* = 5.2076, df = 8, p-value = 0.7352
##
## Model df: 2.   Total lags used: 10
```

```
res = checkresiduals(count_fit$model, plot = FALSE)
```

```
##
##   Ljung-Box test
##
## data:  Residuals from Regression with ARIMA(1,0,1) errors
## Q* = 5.3135, df = 8, p-value = 0.7236
##
## Model df: 2.   Total lags used: 10
```

```
res = checkresiduals(tariff_fit$model, plot = FALSE)
```

```
##
##  Ljung-Box test
##
## data:  Residuals from Regression with ARIMA(1,0,1) errors
## Q* = 5.672, df = 8, p-value = 0.6839
##
## Model df: 2.   Total lags used: 10
```

```
res = checkresiduals(trade_fit$model, plot = FALSE)
```

```
##
##  Ljung-Box test
##
## data:  Residuals from Regression with ARIMA(1,0,1) errors
## Q* = 5.6804, df = 8, p-value = 0.683
##
## Model df: 2.   Total lags used: 10
```

```
res = checkresiduals(china_fit$model, plot = FALSE)
```

```
##
##  Ljung-Box test
##
## data:  Residuals from Regression with ARIMA(1,0,1) errors
## Q* = 5.6558, df = 8, p-value = 0.6857
##
## Model df: 2.   Total lags used: 10
```

```
res = checkresiduals(positive_fit$model, plot = FALSE)
```

```
##
##  Ljung-Box test
##
## data:  Residuals from Regression with ARIMA(1,0,1) errors
## Q* = 5.6522, df = 8, p-value = 0.6861
##
## Model df: 2.   Total lags used: 10
```

```
res = checkresiduals(negative_fit$model, plot = FALSE)
```

```
##
##  Ljung-Box test
##
## data:  Residuals from Regression with ARIMA(1,0,1) errors
## Q* = 5.7122, df = 8, p-value = 0.6794
##
## Model df: 2.   Total lags used: 10
```

	Model 1
ar1	1.1174***
	(0.0132)
ar2	−0.1544***
	(0.0178)
ar3	0.0292*
	(0.0126)
ma1	−0.9256***
	(0.0058)
intercept	0.0001
dummy_lag_0	0.0000
AIC	−99130.5963
AICc	−99130.5804
BIC	−99082.5788
Log Likelihood	49572.2982
Num. obs.	7042

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table 36: ARMAX selected by AIC

ASHR Models

```
#dummy
dummy_fit = auto.armax.r(data$ASHR_vol, x=data$dummy,
              max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```

```
#count
count_fit = auto.armax.r(data$ASHR_vol, x=data$N,
              max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```

```
#tariffs
tariff_fit = auto.armax.r(data$ASHR_vol, x=data$tariff,
              max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```

```
#trade
trade_fit = auto.armax.r(data$ASHR_vol, x=data$trade,
              max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```

```
#china
china_fit = auto.armax.r(data$ASHR_vol, x=data$china,
              max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```

```
#proportion of positive
positive_fit = auto.armax.r(data$ASHR_vol, x=data$prop_positive,
              max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```

	Model 1
ar1	1.1183***
	(0.0132)
ar2	−0.1574***
	(0.0178)
ar3	0.0314*
	(0.0126)
ma1	−0.9259***
	(0.0058)
intercept	0.0001
N_lag_0	0.0000
AIC	−99042.9843
AICc	−99042.9684
BIC	−98994.9668
Log Likelihood	49528.4922
Num. obs.	7042

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

Table 37: ARMAX selected by AIC

	Model 1
ar1	1.1181***
	(0.0131)
ar2	−0.1602***
	(0.0178)
ar3	0.0346**
	(0.0125)
ma1	−0.9279***
	(0.0056)
intercept	0.0001***
	(0.0000)
tariff_lag_0	0.0000
	(0.0000)
AIC	−98862.1298
AICc	−98862.1139
BIC	−98814.1123
Log Likelihood	49438.0649
Num. obs.	7042

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

Table 38: ARMAX selected by AIC

	Model 1
ar1	1.1187***
	(0.0131)
ar2	−0.1613***
	(0.0178)
ar3	0.0350**
	(0.0125)
ma1	−0.9276***
	(0.0056)
intercept	0.0001***
	(0.0000)
trade_lag_0	0.0000
	(0.0000)
AIC	−98866.7403
AICc	−98866.7244
BIC	−98818.7228
Log Likelihood	49440.3701
Num. obs.	7042

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

Table 39: ARMAX selected by AIC

	Model 1
ar1	1.1187***
	(0.0131)
ar2	−0.1605***
	(0.0178)
ar3	0.0343**
	(0.0125)
ma1	−0.9280***
	(0.0056)
intercept	0.0001*
	(0.0000)
china_lag_0	0.0000
	(0.0000)
AIC	−98878.3382
AICc	−98878.3223
BIC	−98830.3207
Log Likelihood	49446.1691
Num. obs.	7042

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

Table 40: ARMAX selected by AIC

	Model 1
ar1	1.1178***
	(0.0131)
ar2	−0.1600***
	(0.0178)
ar3	0.0346**
	(0.0125)
ma1	−0.9271***
	(0.0056)
intercept	0.0001**
	(0.0000)
prop_positive_lag_0	0.0001***
	(0.0000)
AIC	−98917.4883
AICc	−98917.4723
BIC	−98869.4707
Log Likelihood	49465.7441
Num. obs.	7042

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

Table 41: ARMAX selected by AIC

```r
#proportion of negative
negative_fit = auto.armax.r(data$ASHR_vol, x=data$prop_negative,
                max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```

ASHR IRFs

```r
#we want to plot the IRFs of these models
nb.periods = 7 * 15

irf.plot(dummy_fit$model,nb.periods)
```

	Model 1
ar1	1.1198***
	(0.0131)
ar2	−0.1639***
	(0.0178)
ar3	0.0365**
	(0.0125)
ma1	−0.9274***
	(0.0056)
intercept	0.0001***
	(0.0000)
prop_negative_lag_0	0.0001***
	(0.0000)
AIC	−98891.2157
AICc	−98891.1997
BIC	−98843.1981
Log Likelihood	49452.6078
Num. obs.	7042

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

Table 42: ARMAX selected by AIC
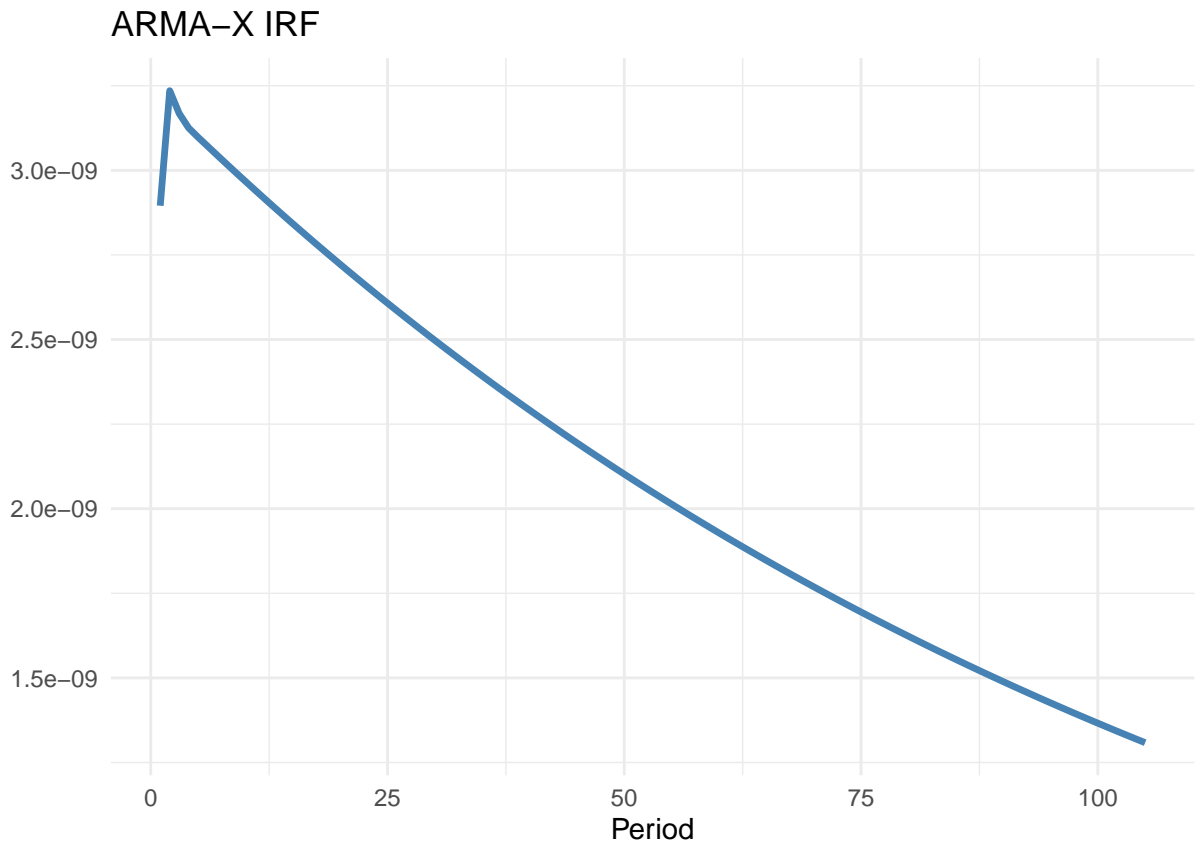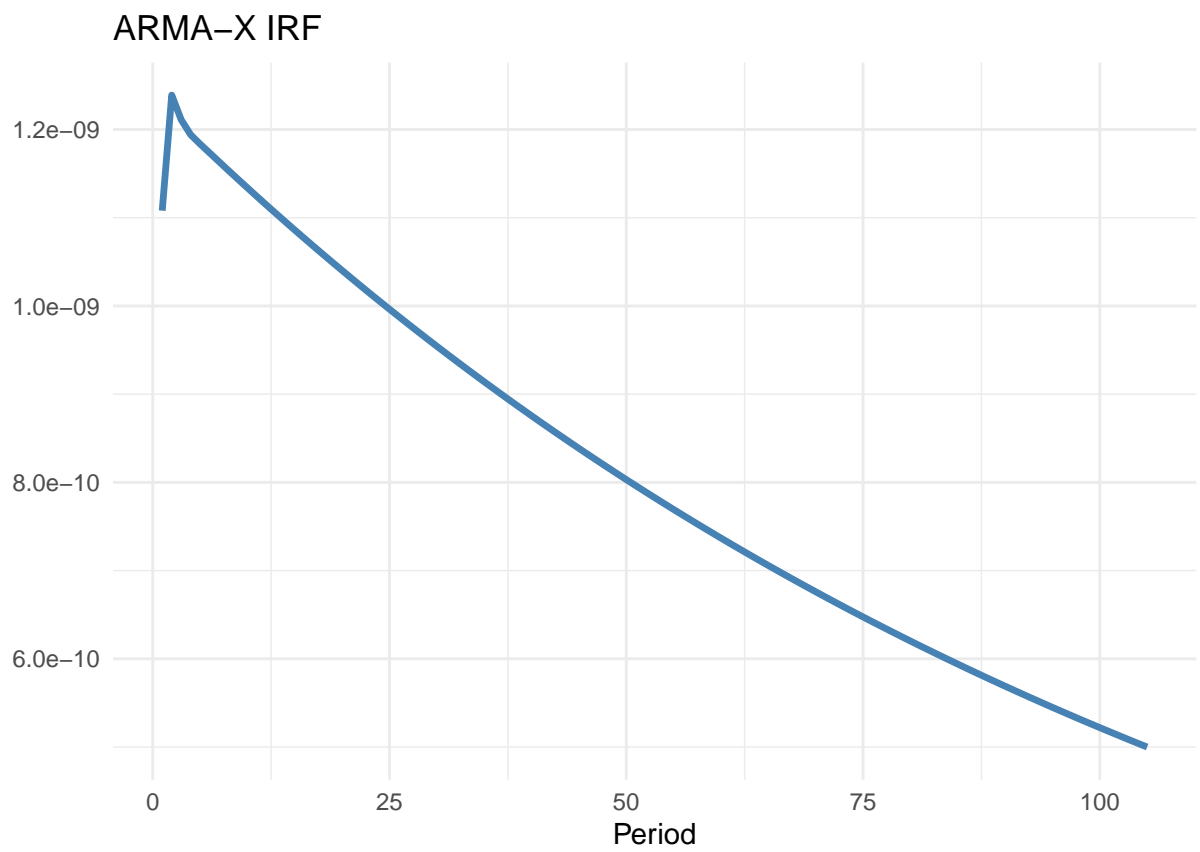
ARMA−X IRF

```
irf.plot(count_fit$model,nb.periods)
```

ARMA−X IRF


```
irf.plot(tariff_fit$model,nb.periods)
```

ARMA−X IRF


```
irf.plot(trade_fit$model,nb.periods)
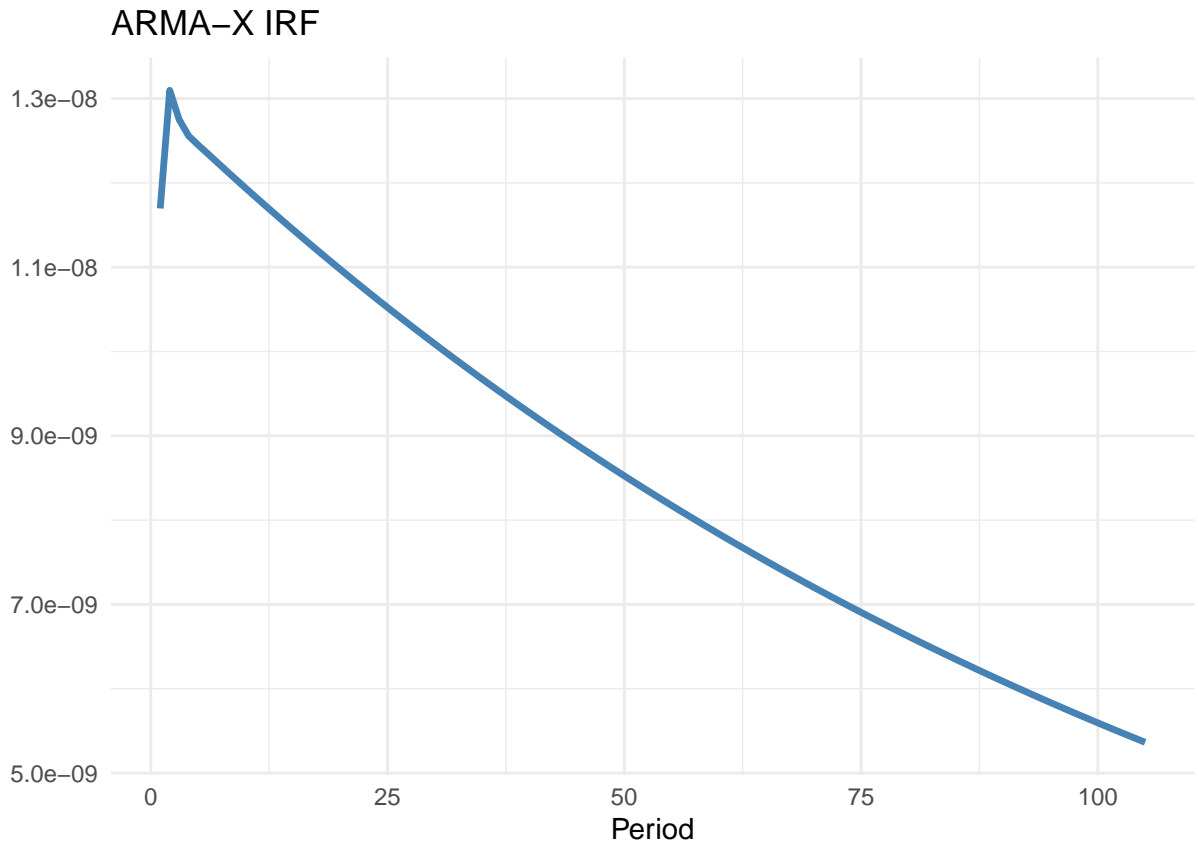```

## ARMA−X IRF

```
irf.plot(china_fit$model,nb.periods)
```

ARMA−X IRF


```
irf.plot(positive_fit$model,nb.periods)
```

ARMA–X IRF


```
irf.plot(negative_fit$model,nb.periods)
```

ARMA–X IRF

ASHR Residuals

```
res = checkresiduals(dummy_fit$model, plot = FALSE)
```
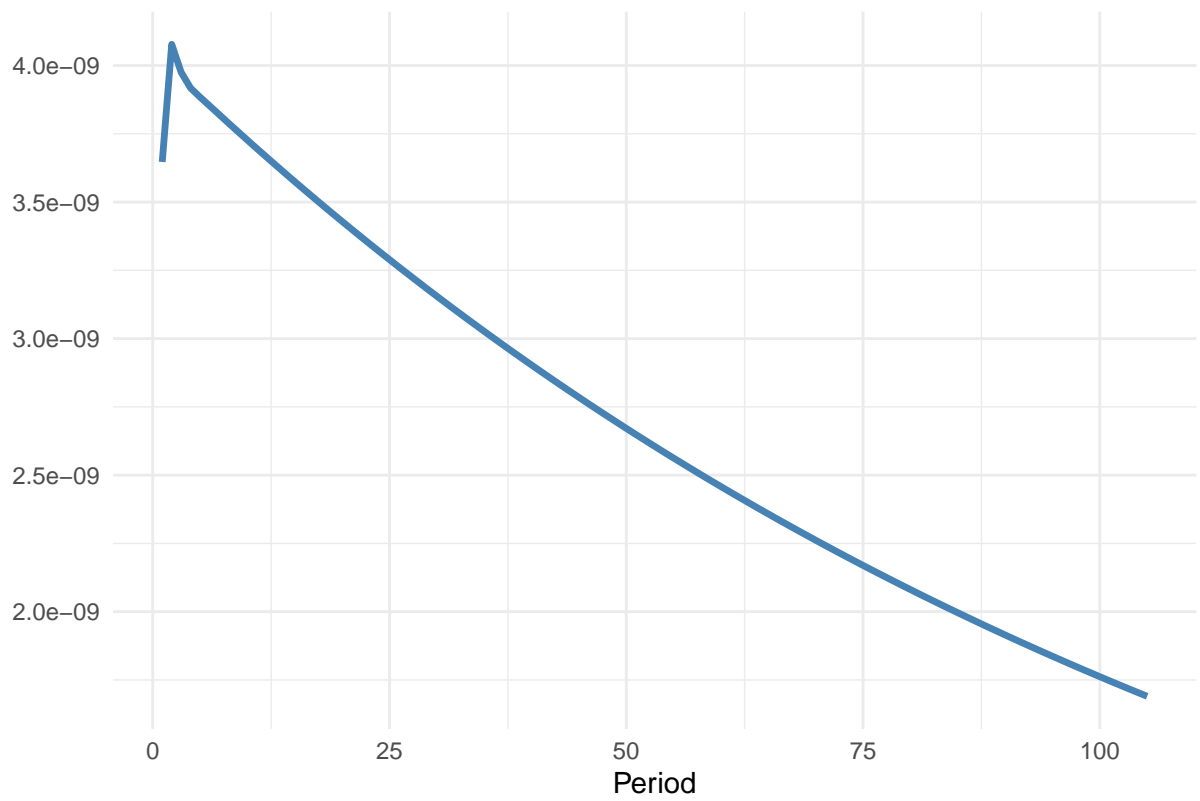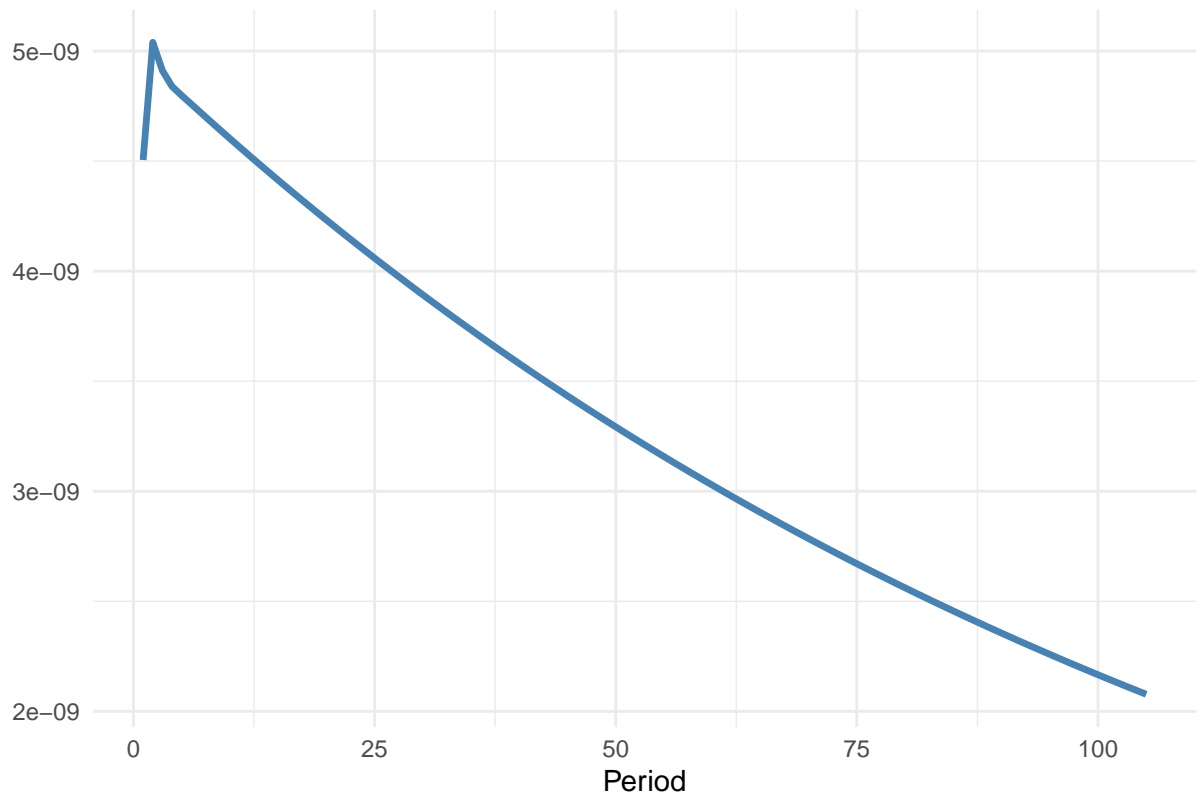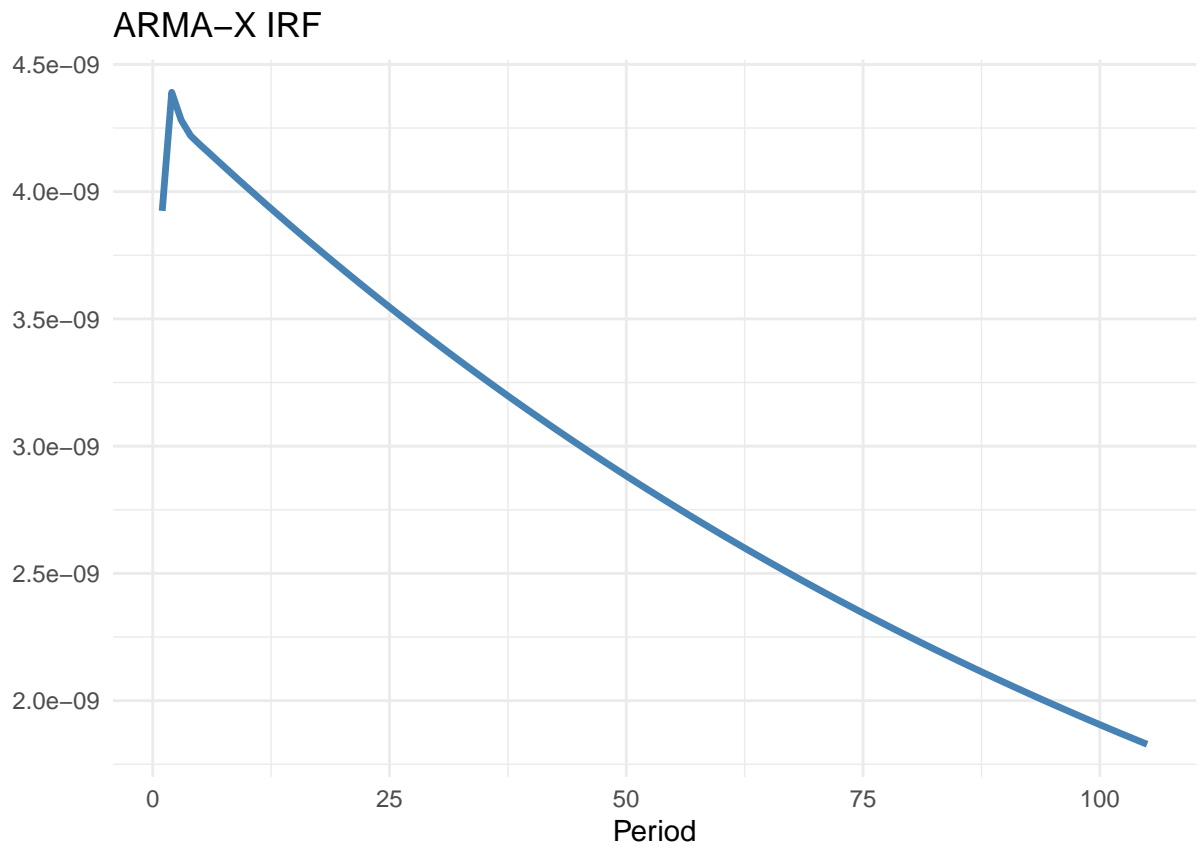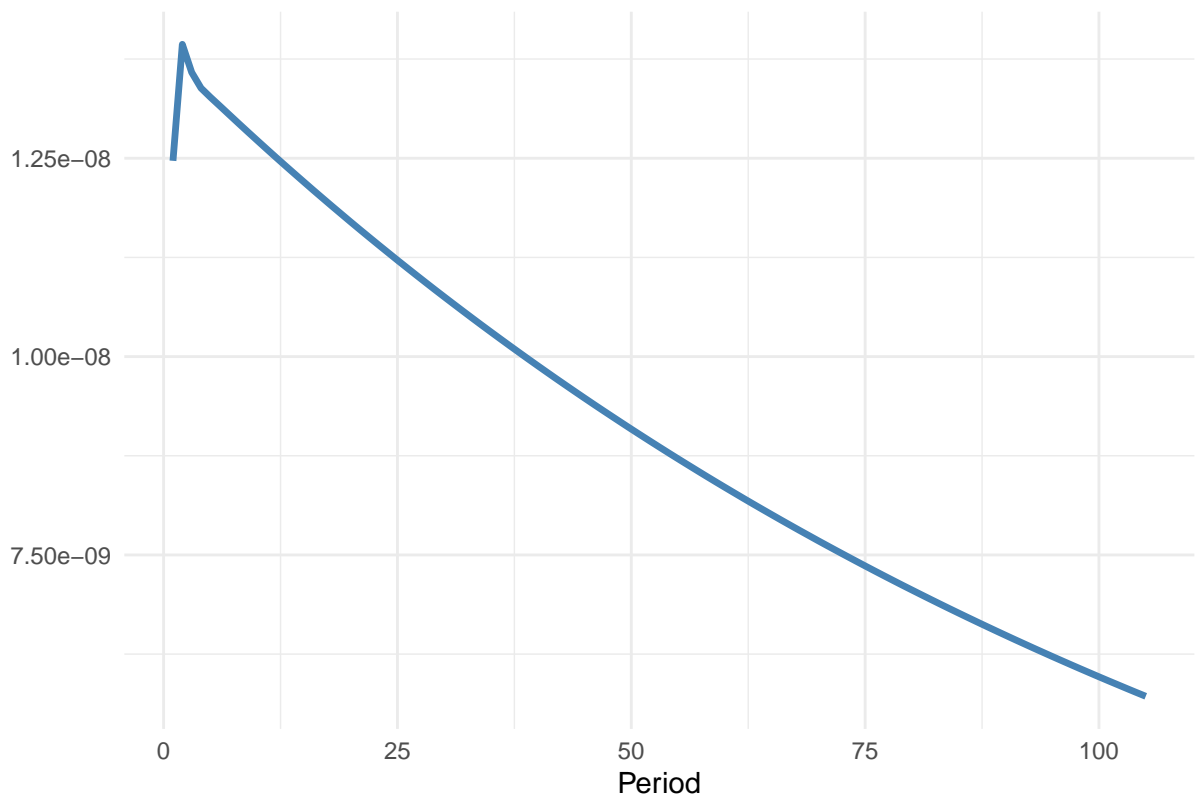
```
##
##  Ljung-Box test
##
## data:  Residuals from Regression with ARIMA(3,0,1) errors
## Q* = 144.43, df = 6, p-value < 2.2e-16
##
## Model df: 4.   Total lags used: 10
```

```
res = checkresiduals(count_fit$model, plot = FALSE)
```

```
##
##  Ljung-Box test
##
## data:  Residuals from Regression with ARIMA(3,0,1) errors
## Q* = 162.63, df = 6, p-value < 2.2e-16
##
## Model df: 4.   Total lags used: 10
```

```r
res = checkresiduals(tariff_fit$model, plot = FALSE)
```

```
##
##  Ljung-Box test
##
## data:  Residuals from Regression with ARIMA(3,0,1) errors
## Q* = 239.92, df = 6, p-value < 2.2e-16
##
## Model df: 4.   Total lags used: 10
```

```r
res = checkresiduals(trade_fit$model, plot = FALSE)
```

```
##
##  Ljung-Box test
##
## data:  Residuals from Regression with ARIMA(3,0,1) errors
## Q* = 236.7, df = 6, p-value < 2.2e-16
##
## Model df: 4.   Total lags used: 10
```

```r
res = checkresiduals(china_fit$model, plot = FALSE)
```

```
##
##  Ljung-Box test
##
## data:  Residuals from Regression with ARIMA(3,0,1) errors
## Q* = 233.67, df = 6, p-value < 2.2e-16
##
## Model df: 4.   Total lags used: 10
```

```r
res = checkresiduals(positive_fit$model, plot = FALSE)
```

```
##
##  Ljung-Box test
##
## data:  Residuals from Regression with ARIMA(3,0,1) errors
## Q* = 215.12, df = 6, p-value < 2.2e-16
##
## Model df: 4.   Total lags used: 10
```

```r
res = checkresiduals(negative_fit$model, plot = FALSE)
```

```
##
##  Ljung-Box test
##
## data:  Residuals from Regression with ARIMA(3,0,1) errors
## Q* = 230.4, df = 6, p-value < 2.2e-16
##
## Model df: 4.   Total lags used: 10
```

	Model 1
ar1	0.9683***
	(0.0162)
ma1	−0.6923***
	(0.0470)
ma2	−0.1730***
	(0.0438)
intercept	0.1151
	(0.0807)
dummy_lag_0	0.0049
	(0.0066)
dummy_lag_1	0.0095
	(0.0065)
AIC	637.7953
AICc	638.0154
BIC	667.5316
Log Likelihood	−311.8977
Num. obs.	517

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table 43: ARMAX selected by AIC

Second Term

SPY Models

```r
#dummy
dummy_fit = auto.armax.r(data$SPY_vol, x=data$dummy,
                max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```

```r
#count
count_fit = auto.armax.r(data$SPY_vol, x=data$N,
                max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```

```r
#tariffs
tariff_fit = auto.armax.r(data$SPY_vol, x=data$tariff,
                max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```

```r
#trade
trade_fit = auto.armax.r(data$SPY_vol, x=data$trade,
                max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```

```r
#china
china_fit = auto.armax.r(data$SPY_vol, x=data$china,
                max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```

	Model 1
ar1	0.9684***
	(0.0163)
ma1	−0.6907***
	(0.0470)
ma2	−0.1756***
	(0.0438)
intercept	0.1347
	(0.0793)
N_lag_0	0.0004
	(0.0019)
AIC	638.2287
AICc	638.3931
BIC	663.7285
Log Likelihood	−313.1143
Num. obs.	518

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table 44: ARMAX selected by AIC

	Model 1
ar1	0.9686***
	(0.0163)
ma1	−0.6965***
	(0.0469)
ma2	−0.1732***
	(0.0437)
intercept	0.1170
	(0.0775)
tariff_lag_0	0.0048
	(0.0099)
tariff_lag_1	0.0278**
	(0.0102)
tariff_lag_2	0.0168
	(0.0099)
AIC	633.4836
AICc	633.7676
BIC	667.4525
Log Likelihood	−308.7418
Num. obs.	516

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table 45: ARMAX selected by AIC

	Model 1
ar1	0.9683***
	(0.0163)
ma1	−0.6905***
	(0.0469)
ma2	−0.1755***
	(0.0438)
intercept	0.1372
	(0.0791)
trade_lag_0	−0.0074
	(0.0297)
AIC	638.2093
AICc	638.3737
BIC	663.7092
Log Likelihood	−313.1047
Num. obs.	518

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table 46: ARMAX selected by AIC

	Model 1
ar1	0.9693***
	(0.0161)
ma1	−0.7207***
	(0.0467)
ma2	−0.1609***
	(0.0434)
intercept	0.1044
	(0.0704)
china_lag_0	0.0173
	(0.0319)
china_lag_1	0.1515***
	(0.0324)
china_lag_2	0.1309***
	(0.0319)
AIC	610.2140
AICc	610.4980
BIC	644.1829
Log Likelihood	−297.1070
Num. obs.	516

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table 47: ARMAX selected by AIC

	Model 1
ar1	0.9686***
	(0.0162)
ma1	−0.6855***
	(0.0473)
ma2	−0.1833***
	(0.0441)
intercept	0.0862
	(0.0853)
prop_positive_lag_0	0.0416
	(0.0517)
prop_positive_lag_1	0.0145
	(0.0541)
prop_positive_lag_2	0.1014
	(0.0517)
AIC	637.4076
AICc	637.6916
BIC	671.3764
Log Likelihood	−310.7038
Num. obs.	516

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table 48: ARMAX selected by AIC

```
#proportion of positive
positive_fit = auto.armax.r(data$SPY_vol, x=data$prop_positive,
                max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```

```
#proportion of negative
negative_fit = auto.armax.r(data$SPY_vol, x=data$prop_negative,
                max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```

SPY IRFs

```
#we want to plot the IRFs of these models
nb.periods = 7 * 15

irf.plot(dummy_fit$model,nb.periods)
```
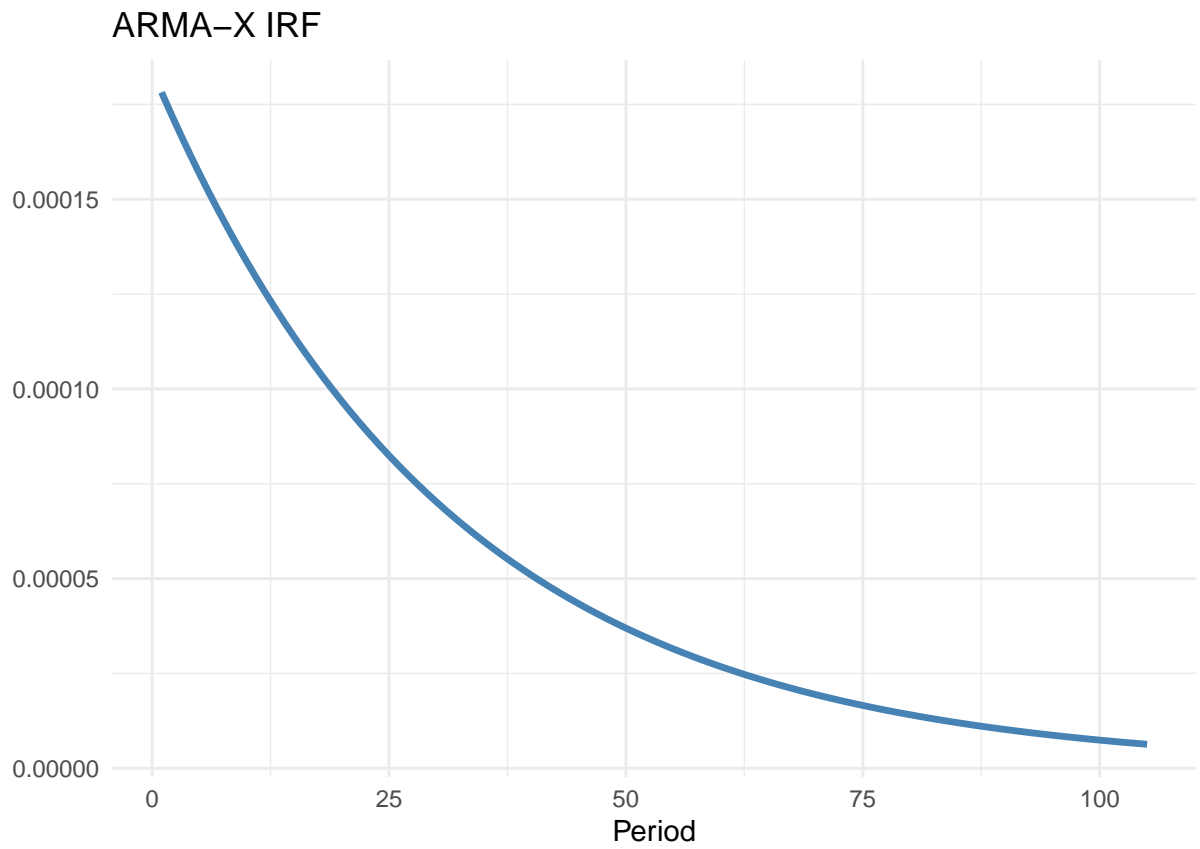
	Model 1
ar1	0.9684***
	(0.0163)
ma1	−0.6906***
	(0.0470)
ma2	−0.1759***
	(0.0438)
intercept	0.1351
	(0.0798)
prop_negative_lag_0	0.0056
	(0.0841)
AIC	638.2670
AICc	638.4313
BIC	663.7668
Log Likelihood	−313.1335
Num. obs.	518

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table 49: ARMAX selected by AIC
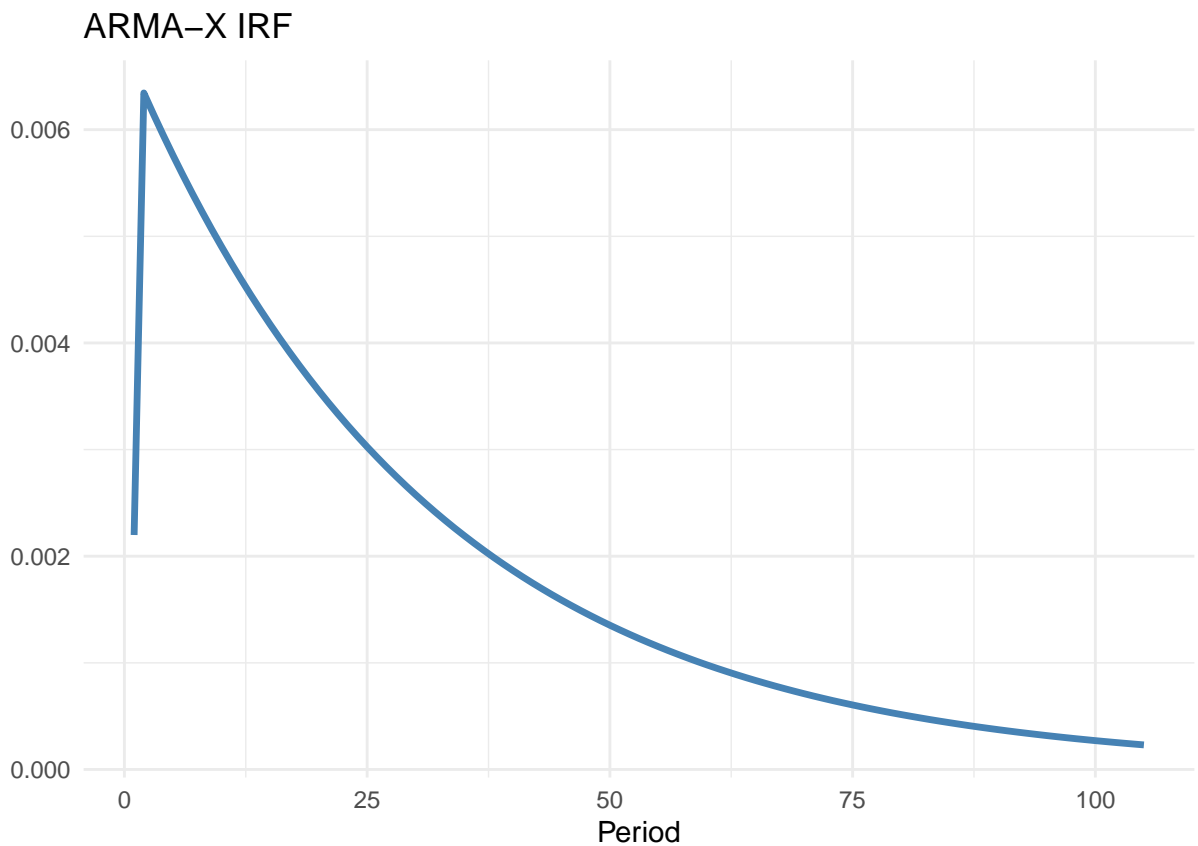
ARMA−X IRF


```
irf.plot(count_fit$model,nb.periods)
```
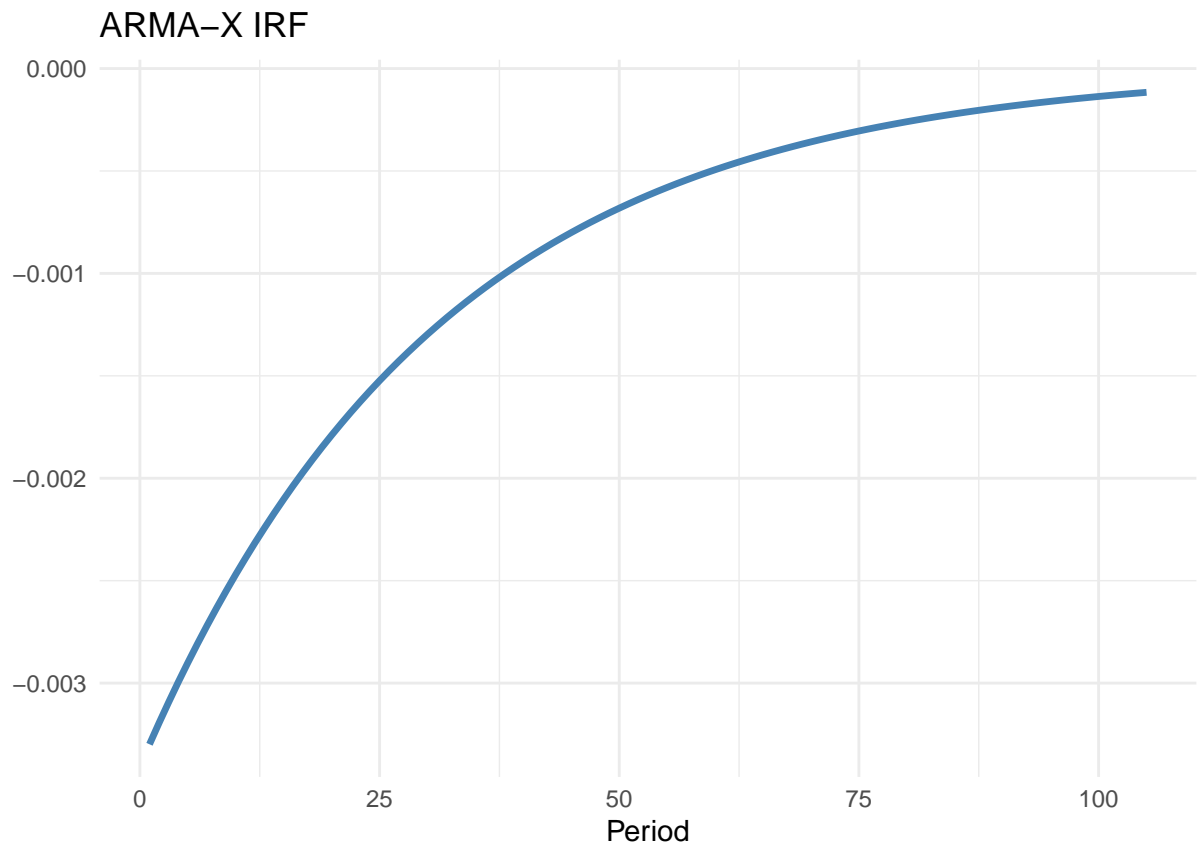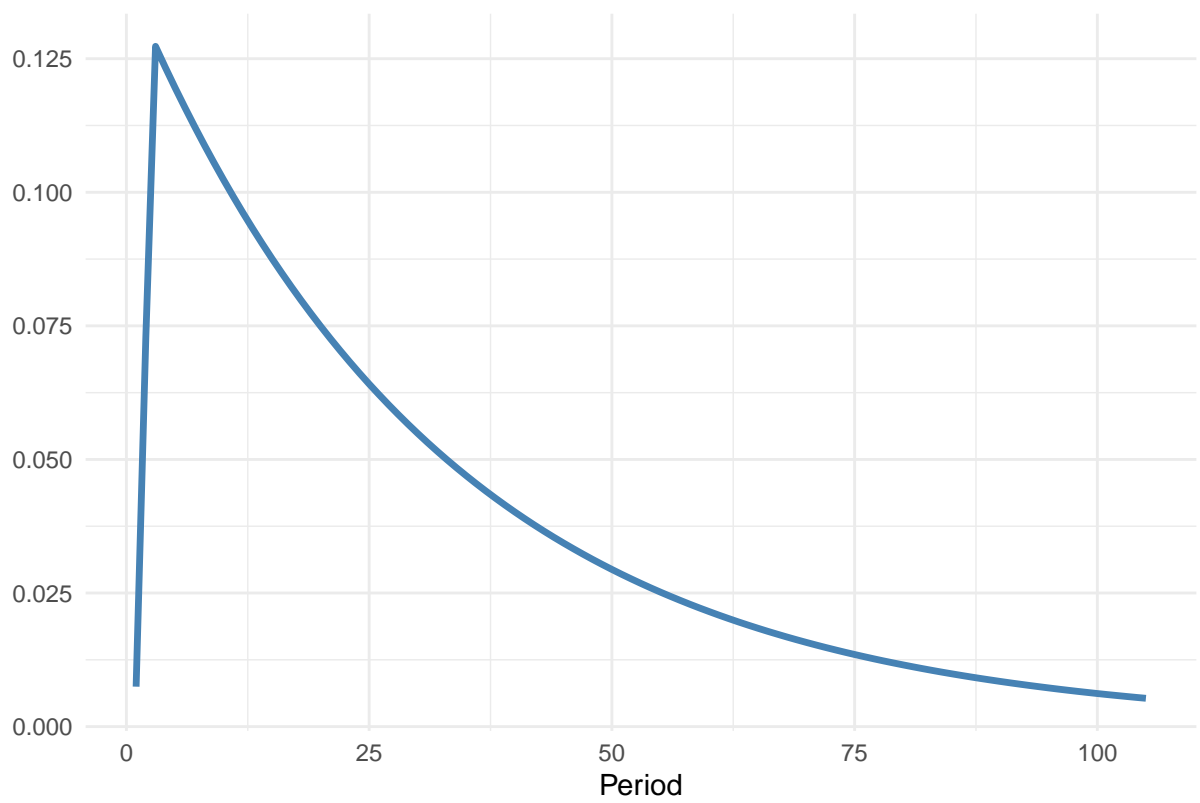
```
irf.plot(tariff_fit$model,nb.periods)
```

ARMA–X IRF


```
irf.plot(trade_fit$model,nb.periods)
```
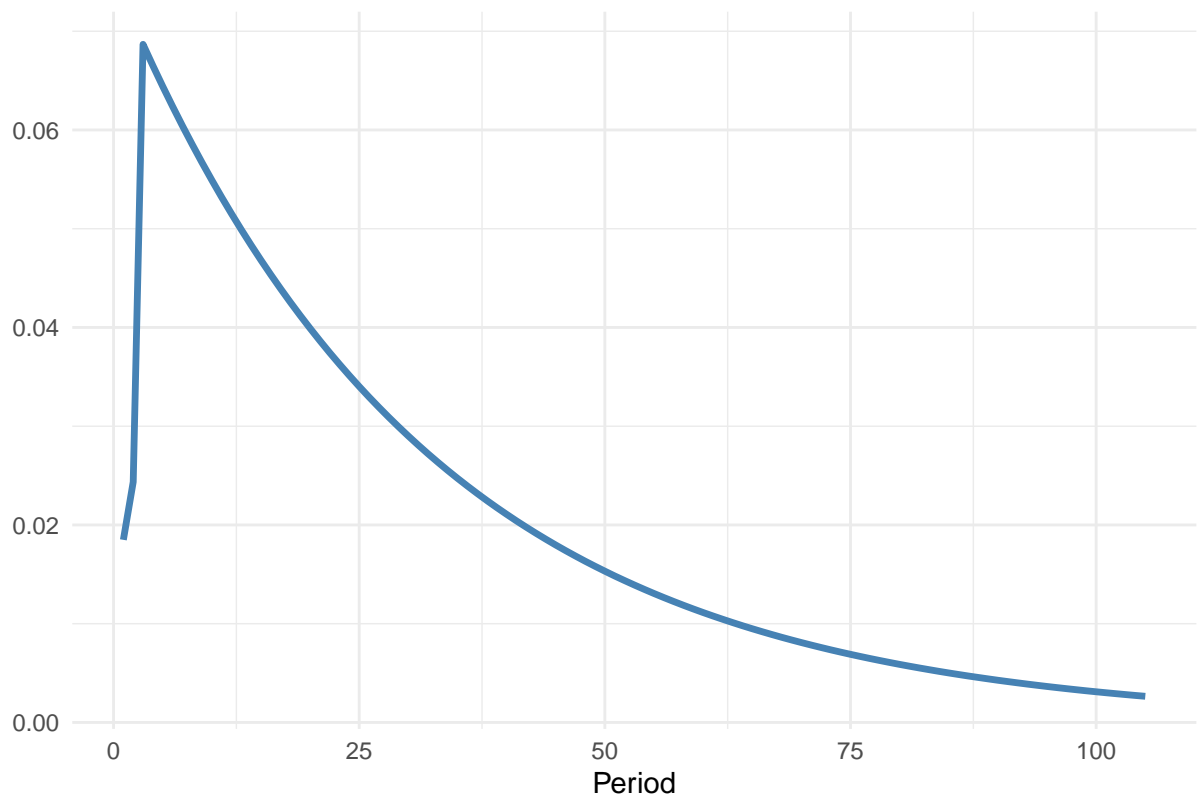
ARMA–X IRF

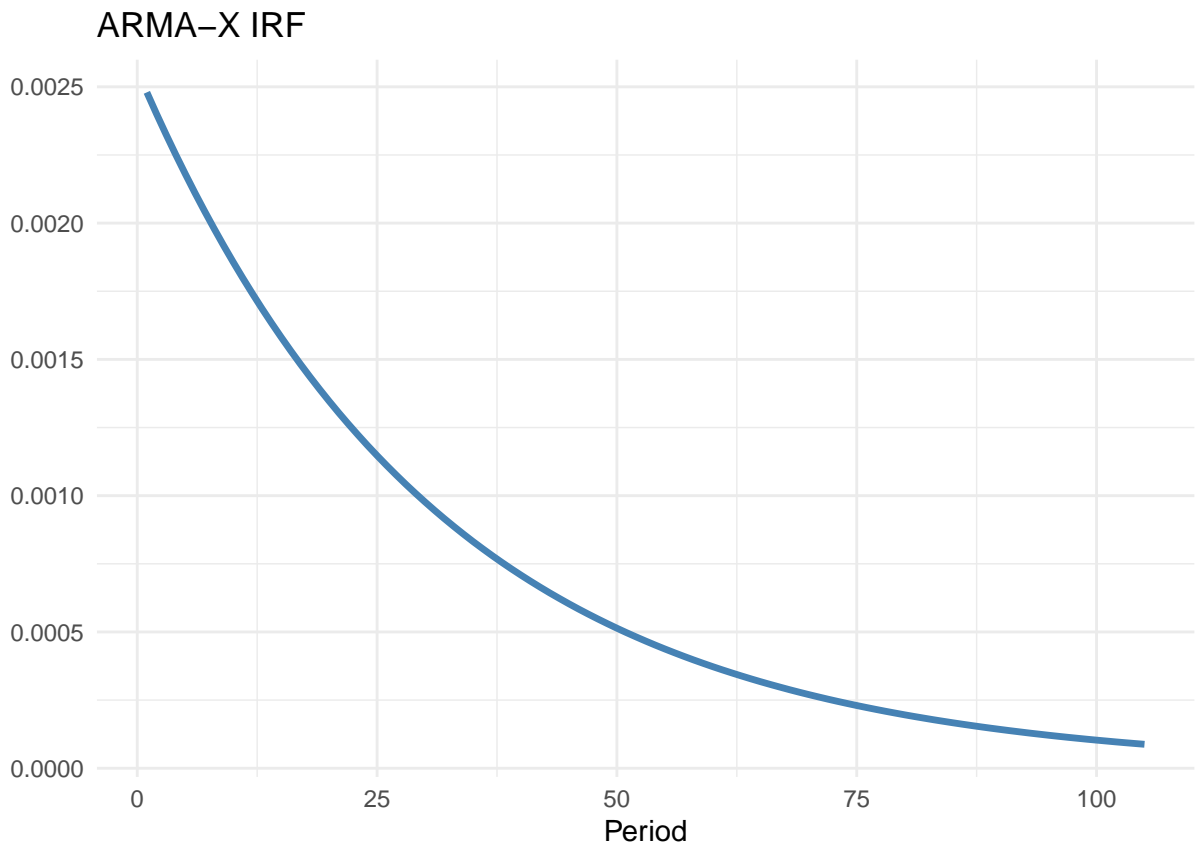```r
irf.plot(china_fit$model,nb.periods)
```

ARMA−X IRF


```
irf.plot(positive_fit$model,nb.periods)
```

ARMA−X IRF


```
irf.plot(negative_fit$model,nb.periods)
```

ARMA–X IRF

SPY Residuals

```r
res = checkresiduals(dummy_fit$model, plot = FALSE)
```

```
## 
##  Ljung-Box test
## 
## data:  Residuals from Regression with ARIMA(1,0,2) errors
## Q* = 3.0398, df = 7, p-value = 0.8813
## 
## Model df: 3.   Total lags used: 10
```

```r
res = checkresiduals(count_fit$model, plot = FALSE)
```

```
## 
##  Ljung-Box test
## 
## data:  Residuals from Regression with ARIMA(1,0,2) errors
## Q* = 3.4498, df = 7, p-value = 0.8405
## 
## Model df: 3.   Total lags used: 10
```

```
res = checkresiduals(tariff_fit$model, plot = FALSE)
```

```
##
##  Ljung-Box test
##
## data:  Residuals from Regression with ARIMA(1,0,2) errors
## Q* = 3.3682, df = 7, p-value = 0.849
##
## Model df: 3.   Total lags used: 10
```

```
res = checkresiduals(trade_fit$model, plot = FALSE)
```

```
##
##  Ljung-Box test
##
## data:  Residuals from Regression with ARIMA(1,0,2) errors
## Q* = 3.5284, df = 7, p-value = 0.8322
##
## Model df: 3.   Total lags used: 10
```

```
res = checkresiduals(china_fit$model, plot = FALSE)
```

```
##
##  Ljung-Box test
##
## data:  Residuals from Regression with ARIMA(1,0,2) errors
## Q* = 6.2381, df = 7, p-value = 0.5122
##
## Model df: 3.   Total lags used: 10
```

```
res = checkresiduals(positive_fit$model, plot = FALSE)
```

```
##
##  Ljung-Box test
##
## data:  Residuals from Regression with ARIMA(1,0,2) errors
## Q* = 3.7261, df = 7, p-value = 0.8107
##
## Model df: 3.   Total lags used: 10
```

```
res = checkresiduals(negative_fit$model, plot = FALSE)
```

```
##
##  Ljung-Box test
##
## data:  Residuals from Regression with ARIMA(1,0,2) errors
## Q* = 3.4705, df = 7, p-value = 0.8383
##
## Model df: 3.   Total lags used: 10
```

	Model 1
ar1	0.9655***
	(0.0183)
ma1	−0.7925***
	(0.0482)
ma2	−0.0926*
	(0.0443)
intercept	0.0010
	(0.0006)
dummy_lag_0	0.0000
	(0.0001)
AIC	−4213.9337
AICc	−4213.7693
BIC	−4188.4338
Log Likelihood	2112.9669
Num. obs.	518

$^{***}p < 0.001;\ ^{**}p < 0.01;\ ^{*}p < 0.05$

Table 50: ARMAX selected by AIC

VGK Models

```r
#dummy
dummy_fit = auto.armax.r(data$VGK_vol, x=data$dummy,
                max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```

```r
#count
count_fit = auto.armax.r(data$VGK_vol, x=data$N,
                max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```

```r
#tariffs
tariff_fit = auto.armax.r(data$VGK_vol, x=data$tariff,
                max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```

```r
#trade
trade_fit = auto.armax.r(data$VGK_vol, x=data$trade,
                max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```

```r
#china
china_fit = auto.armax.r(data$VGK_vol, x=data$china,
                max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```

```r
#proportion of positive
positive_fit = auto.armax.r(data$VGK_vol, x=data$prop_positive,
                max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```

	Model 1
ar1	0.9655***
	(0.0180)
ma1	−0.7924***
	(0.0482)
ma2	−0.0927*
	(0.0442)
intercept	0.0010
N_lag_0	0.0000
AIC	−4213.9232
AICc	−4213.7588
BIC	−4188.4234
Log Likelihood	2112.9616
Num. obs.	518

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

Table 51: ARMAX selected by AIC

	Model 1
ar1	0.9655***
	(0.0183)
ma1	−0.7924***
	(0.0483)
ma2	−0.0928*
	(0.0443)
intercept	0.0010
	(0.0006)
tariff_lag_0	−0.0000
	(0.0001)
AIC	−4213.9090
AICc	−4213.7446
BIC	−4188.4092
Log Likelihood	2112.9545
Num. obs.	518

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

Table 52: ARMAX selected by AIC

	Model 1
ar1	−0.4124***
	(0.0436)
ar2	0.4156***
	(0.0366)
ar3	0.8710***
	(0.0395)
ma1	0.5639***
	(0.0422)
ma2	−0.2968***
	(0.0524)
ma3	−0.8499***
	(0.0383)
intercept	0.0011
	(0.0006)
trade_lag_0	−0.0001
	(0.0003)
AIC	−4217.5958
AICc	−4217.2415
BIC	−4179.3461
Log Likelihood	2117.7979
Num. obs.	518

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

Table 53: ARMAX selected by AIC

	Model 1
ar1	0.1017
	(0.0538)
ar2	0.9345***
	(0.0262)
ar3	−0.0843
	(0.0487)
ma1	0.0834**
	(0.0299)
ma2	−0.8961***
	(0.0301)
intercept	0.0011
	(0.0007)
china_lag_0	−0.0001
	(0.0003)
AIC	−4214.4968
AICc	−4214.2139
BIC	−4180.4970
Log Likelihood	2115.2484
Num. obs.	518

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

Table 54: ARMAX selected by AIC

	Model 1
ar1	2.1242***
	(0.0463)
ar2	−1.3360***
	(0.0874)
ar3	0.2010***
	(0.0437)
ma1	−1.9668***
	(0.0228)
ma2	0.9921***
	(0.0227)
intercept	0.0012**
	(0.0004)
prop_positive_lag_0	−0.0003
	(0.0004)
AIC	−4223.7160
AICc	−4223.4331
BIC	−4189.7162
Log Likelihood	2119.8580
Num. obs.	518

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

Table 55: ARMAX selected by AIC

```r
#proportion of negative
negative_fit = auto.armax.r(data$VGK_vol, x=data$prop_negative,
                 max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```

VGK IRFs

```r
#we want to plot the IRFs of these models
nb.periods = 7 * 15

irf.plot(dummy_fit$model,nb.periods)
```
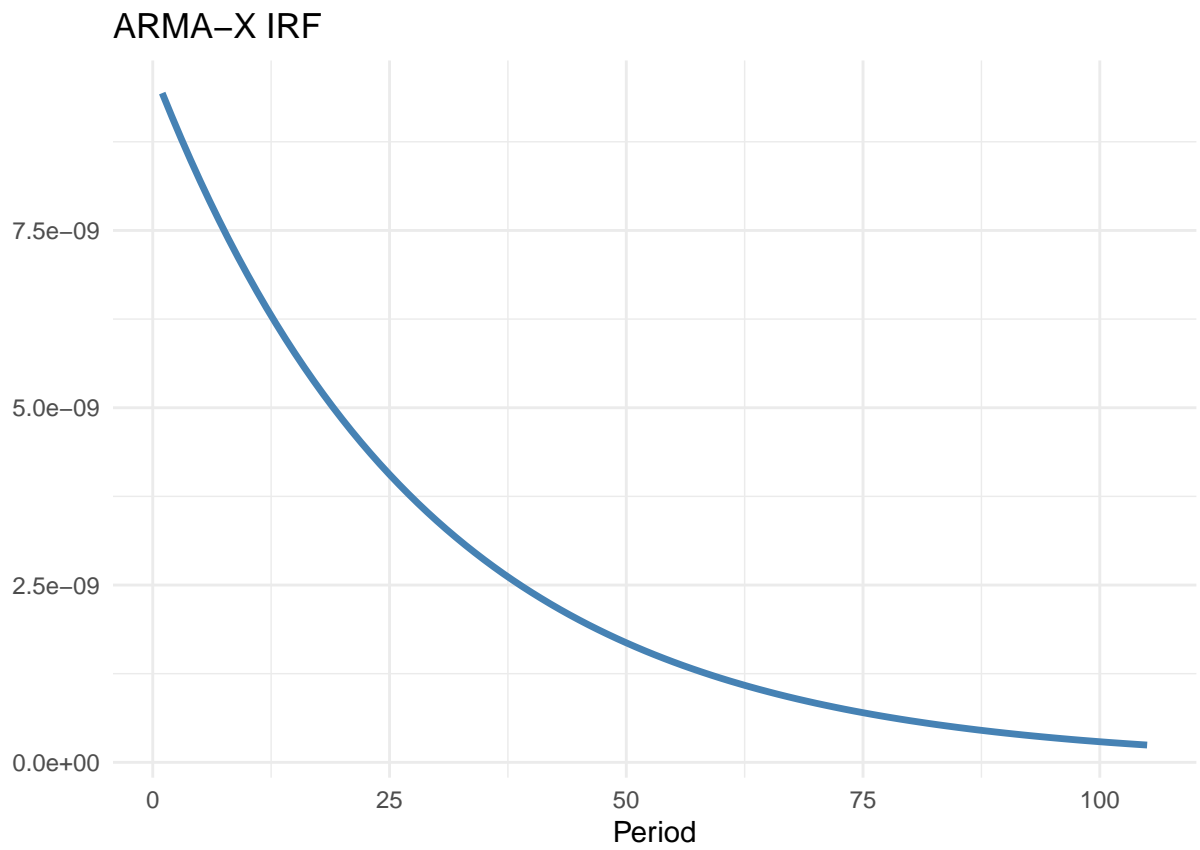
	Model 1
ar1	2.1045***
	(0.0451)
ar2	−1.3011***
	(0.0868)
ar3	0.1857***
	(0.0440)
ma1	−1.9567***
	(0.0147)
ma2	0.9821***
	(0.0149)
intercept	0.0011*
	(0.0004)
prop_negative_lag_0	0.0002
	(0.0008)
AIC	−4223.9232
AICc	−4223.6403
BIC	−4189.9234
Log Likelihood	2119.9616
Num. obs.	518

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

Table 56: ARMAX selected by AIC
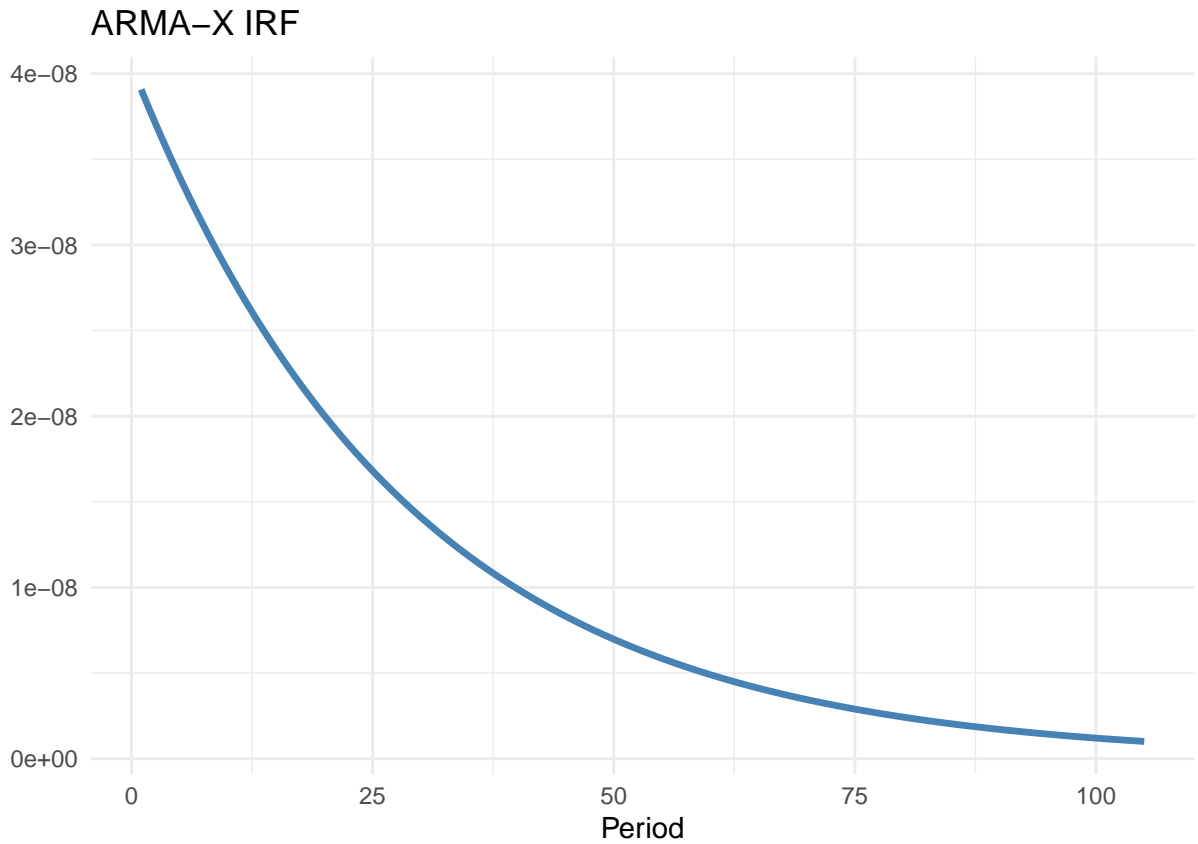
ARMA−X IRF

```
irf.plot(count_fit$model,nb.periods)
```

ARMA−X IRF


```
irf.plot(tariff_fit$model,nb.periods)
```

ARMA–X IRF


```
irf.plot(trade_fit$model,nb.periods)
```
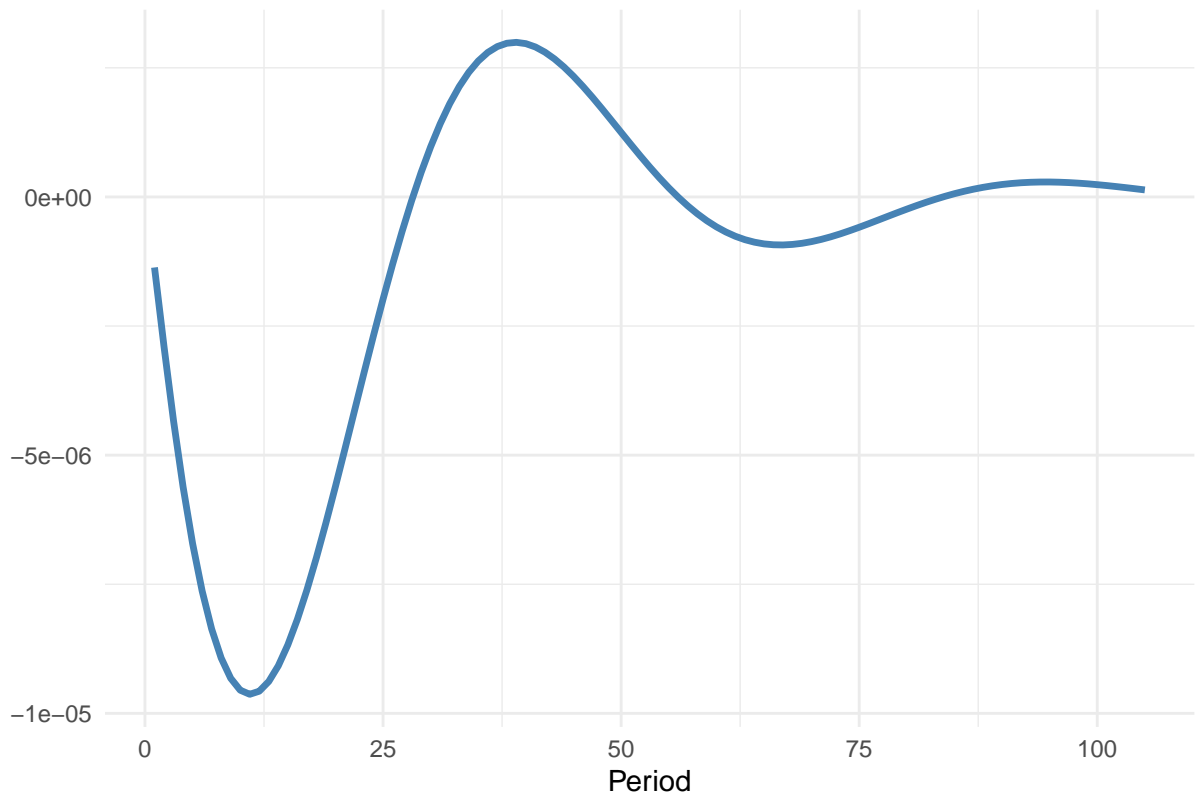
ARMA−X IRF


```
irf.plot(china_fit$model,nb.periods)
```
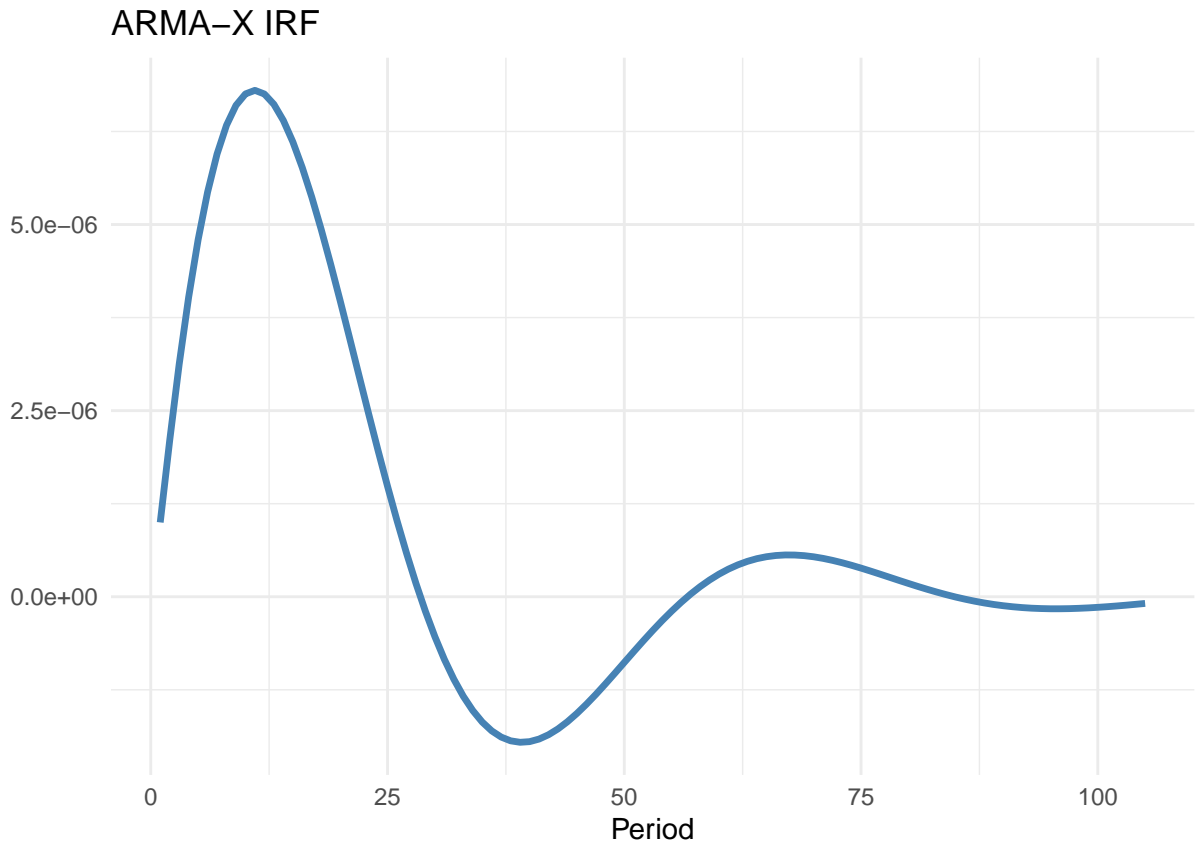
ARMA−X IRF

```r
irf.plot(positive_fit$model,nb.periods)
```

ARMA−X IRF


```r
irf.plot(negative_fit$model,nb.periods)
```

ARMA–X IRF

VGK Residuals

```
res = checkresiduals(dummy_fit$model, plot = FALSE)
```
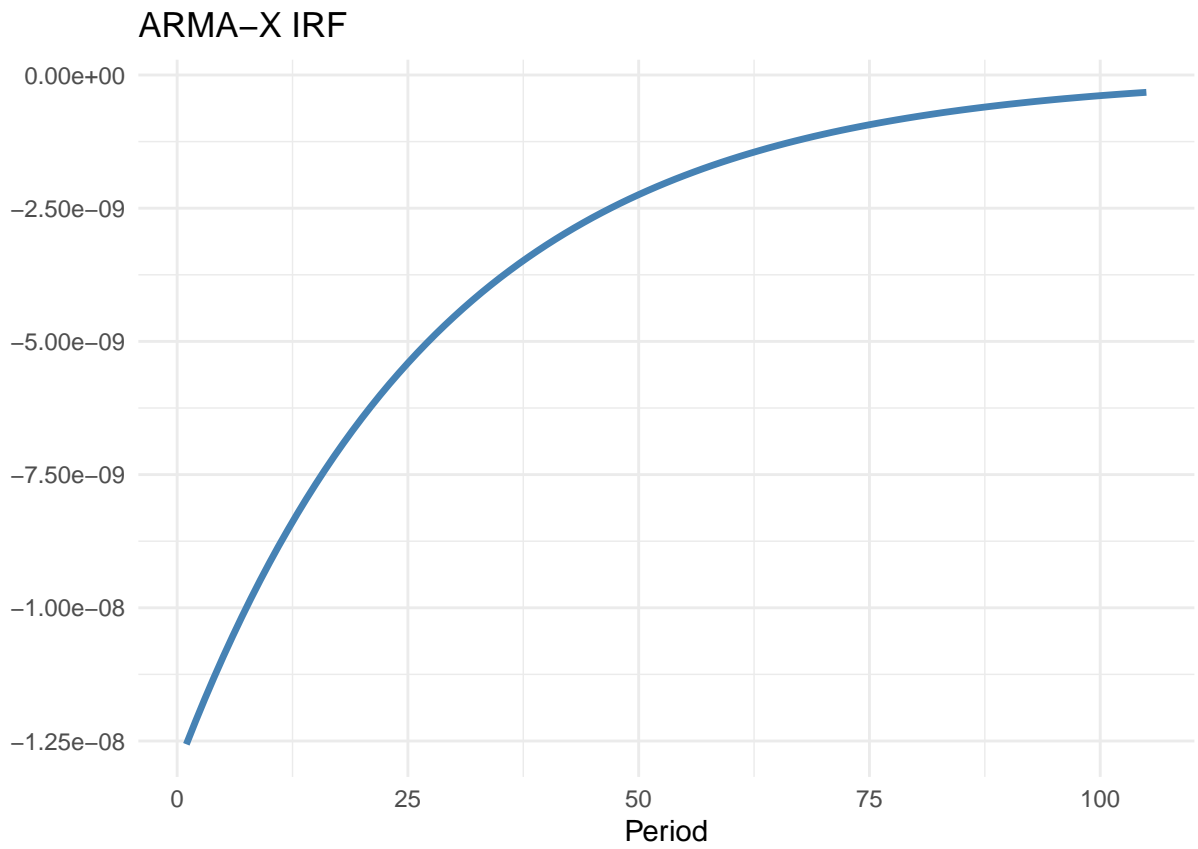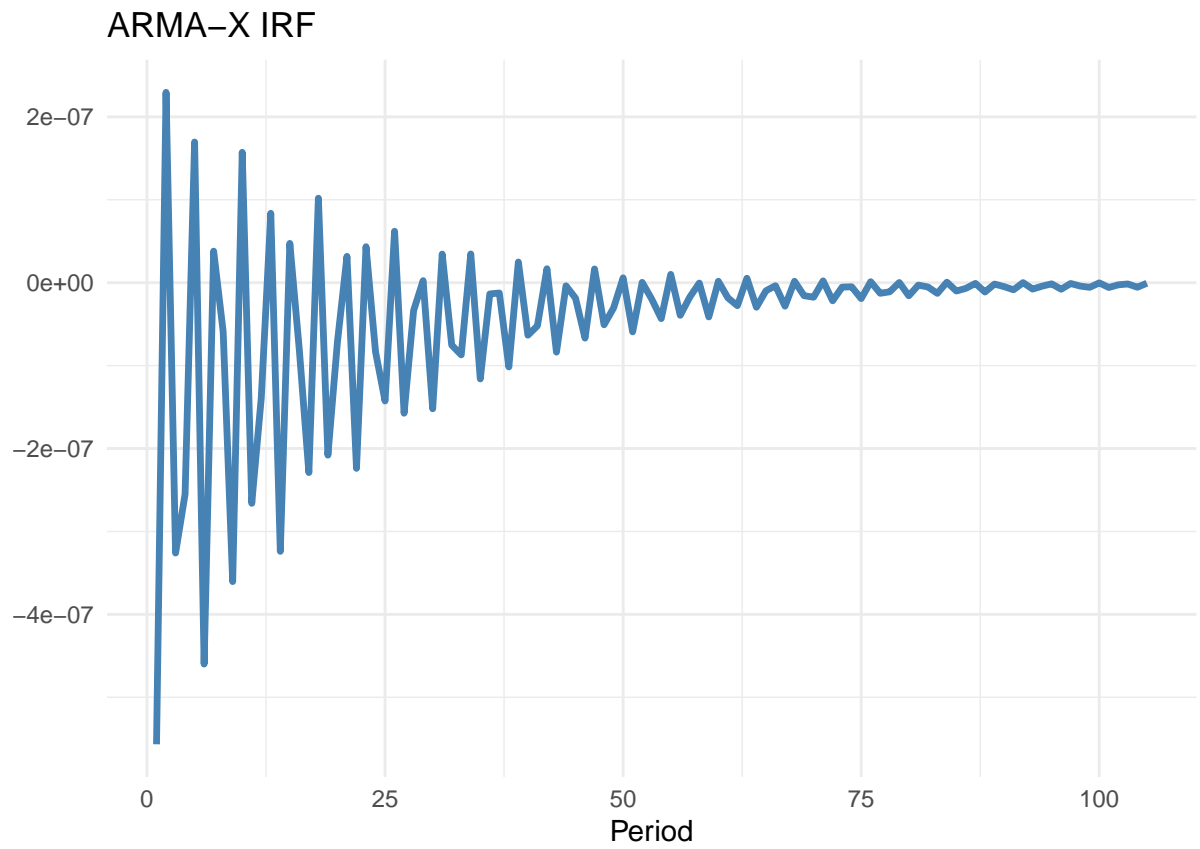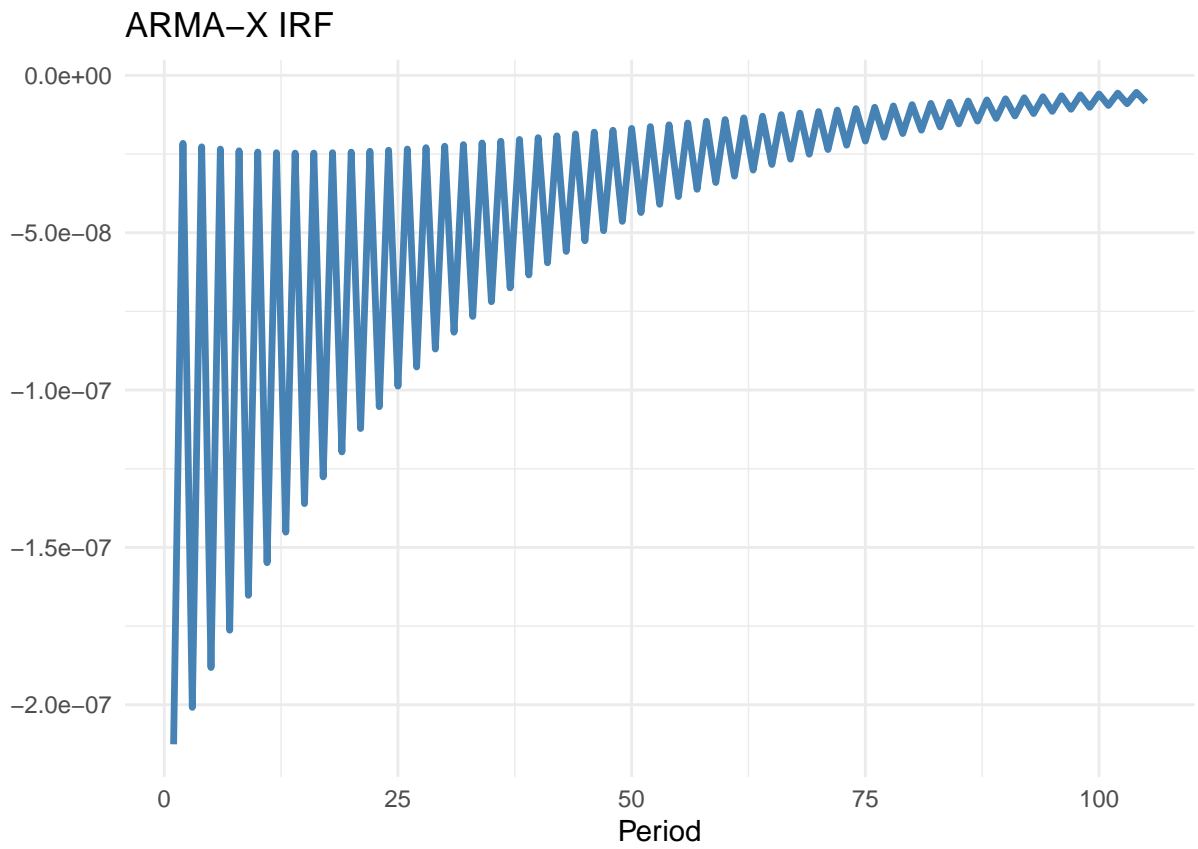
```
##
##   Ljung-Box test
##
## data:  Residuals from Regression with ARIMA(1,0,2) errors
## Q* = 2.7556, df = 7, p-value = 0.9067
##
## Model df: 3.   Total lags used: 10
```

```
res = checkresiduals(count_fit$model, plot = FALSE)
```

```
##
##   Ljung-Box test
##
## data:  Residuals from Regression with ARIMA(1,0,2) errors
## Q* = 2.7588, df = 7, p-value = 0.9064
##
## Model df: 3.   Total lags used: 10
```

```r
res = checkresiduals(tariff_fit$model, plot = FALSE)
```

```
##
##  Ljung-Box test
##
## data:  Residuals from Regression with ARIMA(1,0,2) errors
## Q* = 2.753, df = 7, p-value = 0.9069
##
## Model df: 3.   Total lags used: 10
```

```r
res = checkresiduals(trade_fit$model, plot = FALSE)
```

```
##
##  Ljung-Box test
##
## data:  Residuals from Regression with ARIMA(3,0,3) errors
## Q* = 5.4067, df = 4, p-value = 0.2481
##
## Model df: 6.   Total lags used: 10
```

```r
res = checkresiduals(china_fit$model, plot = FALSE)
```

```
##
##  Ljung-Box test
##
## data:  Residuals from Regression with ARIMA(3,0,2) errors
## Q* = 3.8495, df = 5, p-value = 0.5713
##
## Model df: 5.   Total lags used: 10
```

```r
res = checkresiduals(positive_fit$model, plot = FALSE)
```

```
##
##  Ljung-Box test
##
## data:  Residuals from Regression with ARIMA(3,0,2) errors
## Q* = 5.5511, df = 5, p-value = 0.3524
##
## Model df: 5.   Total lags used: 10
```

```r
res = checkresiduals(negative_fit$model, plot = FALSE)
```

```
##
##  Ljung-Box test
##
## data:  Residuals from Regression with ARIMA(3,0,2) errors
## Q* = 5.1699, df = 5, p-value = 0.3955
##
## Model df: 5.   Total lags used: 10
```

	Model 1
ar1	0.9605***
	(0.0197)
ma1	−0.5186***
	(0.0485)
ma2	−0.1564***
	(0.0474)
ma3	−0.1526***
	(0.0431)
intercept	0.0001
dummy_lag_0	0.0000
AIC	−7346.1081
AICc	−7345.8885
BIC	−7316.3583
Log Likelihood	3680.0541
Num. obs.	518

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

Table 57: ARMAX selected by AIC

ASHR Models

```
#dummy
dummy_fit = auto.armax.r(data$ASHR_vol, x=data$dummy,
                max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```

```
#count
count_fit = auto.armax.r(data$ASHR_vol, x=data$N,
                max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```

```
#tariffs
tariff_fit = auto.armax.r(data$ASHR_vol, x=data$tariff,
                max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```

```
#trade
trade_fit = auto.armax.r(data$ASHR_vol, x=data$trade,
                max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```

```
#china
china_fit = auto.armax.r(data$ASHR_vol, x=data$china,
                max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```

```
#proportion of positive
positive_fit = auto.armax.r(data$ASHR_vol, x=data$prop_positive,
                max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```

	Model 1
ar1	0.9606***
	(0.0198)
ma1	−0.5192***
	(0.0485)
ma2	−0.1579***
	(0.0473)
ma3	−0.1506***
	(0.0430)
intercept	0.0001
N_lag_0	0.0000
AIC	−7342.1193
AICc	−7341.8997
BIC	−7312.3695
Log Likelihood	3678.0597
Num. obs.	518

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

Table 58: ARMAX selected by AIC

	Model 1
ar1	0.4497*
	(0.1972)
ar2	0.4884**
	(0.1872)
ma1	−0.0140
	(0.1964)
ma2	−0.4553***
	(0.1158)
ma3	−0.2640***
	(0.0599)
intercept	0.0001
tariff_lag_0	0.0000
AIC	−7340.0355
AICc	−7339.7526
BIC	−7306.0357
Log Likelihood	3678.0177
Num. obs.	518

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

Table 59: ARMAX selected by AIC

	Model 1
ar1	0.9606***
	(0.0199)
ma1	−0.5199***
	(0.0486)
ma2	−0.1665***
	(0.0494)
ma3	−0.1442**
	(0.0452)
intercept	0.0001
	(0.0001)
trade_lag_0	0.0000
	(0.0001)
AIC	−7337.3403
AICc	−7337.1207
BIC	−7307.5905
Log Likelihood	3675.6701
Num. obs.	518

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

Table 60: ARMAX selected by AIC

	Model 1
ar1	0.4363*
	(0.1855)
ar2	0.5031**
	(0.1772)
ma1	0.0016
	(0.1857)
ma2	−0.4725***
	(0.1168)
ma3	−0.2700***
	(0.0594)
intercept	0.0001
	(0.0001)
china_lag_0	0.0000
	(0.0001)
AIC	−7339.9489
AICc	−7339.6660
BIC	−7305.9491
Log Likelihood	3677.9744
Num. obs.	518

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

Table 61: ARMAX selected by AIC

	Model 1
ar1	0.9603***
	(0.0199)
ma1	−0.5226***
	(0.0487)
ma2	−0.1646***
	(0.0474)
ma3	−0.1424**
	(0.0437)
intercept	0.0001
	(0.0001)
prop_positive_lag_0	0.0000
	(0.0000)
AIC	−7339.9687
AICc	−7339.7491
BIC	−7310.2189
Log Likelihood	3676.9844
Num. obs.	518

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

Table 62: ARMAX selected by AIC

```r
#proportion of negative
negative_fit = auto.armax.r(data$ASHR_vol, x=data$prop_negative,
                max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```

ASHR IRFs

```r
#we want to plot the IRFs of these models
nb.periods = 7 * 15

irf.plot(dummy_fit$model,nb.periods)
```
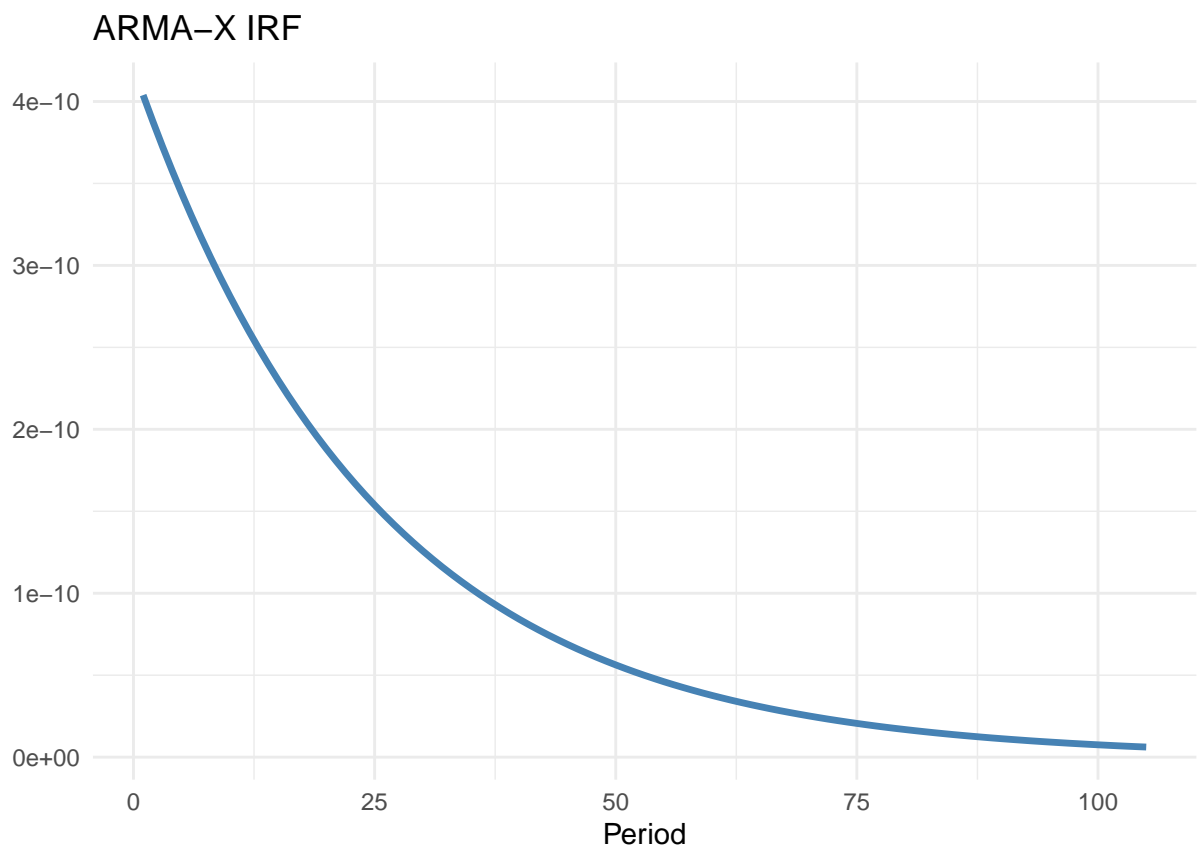
	Model 1
ar1	0.4424*
	(0.2057)
ar2	0.4952*
	(0.1950)
ma1	−0.0092
	(0.2053)
ma2	−0.4531***
	(0.1229)
ma3	−0.2671***
	(0.0598)
intercept	0.0001
	(0.0001)
prop_negative_lag_0	0.0001
	(0.0001)
AIC	−7339.7972
AICc	−7339.5143
BIC	−7305.7974
Log Likelihood	3677.8986
Num. obs.	518

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table 63: ARMAX selected by AIC
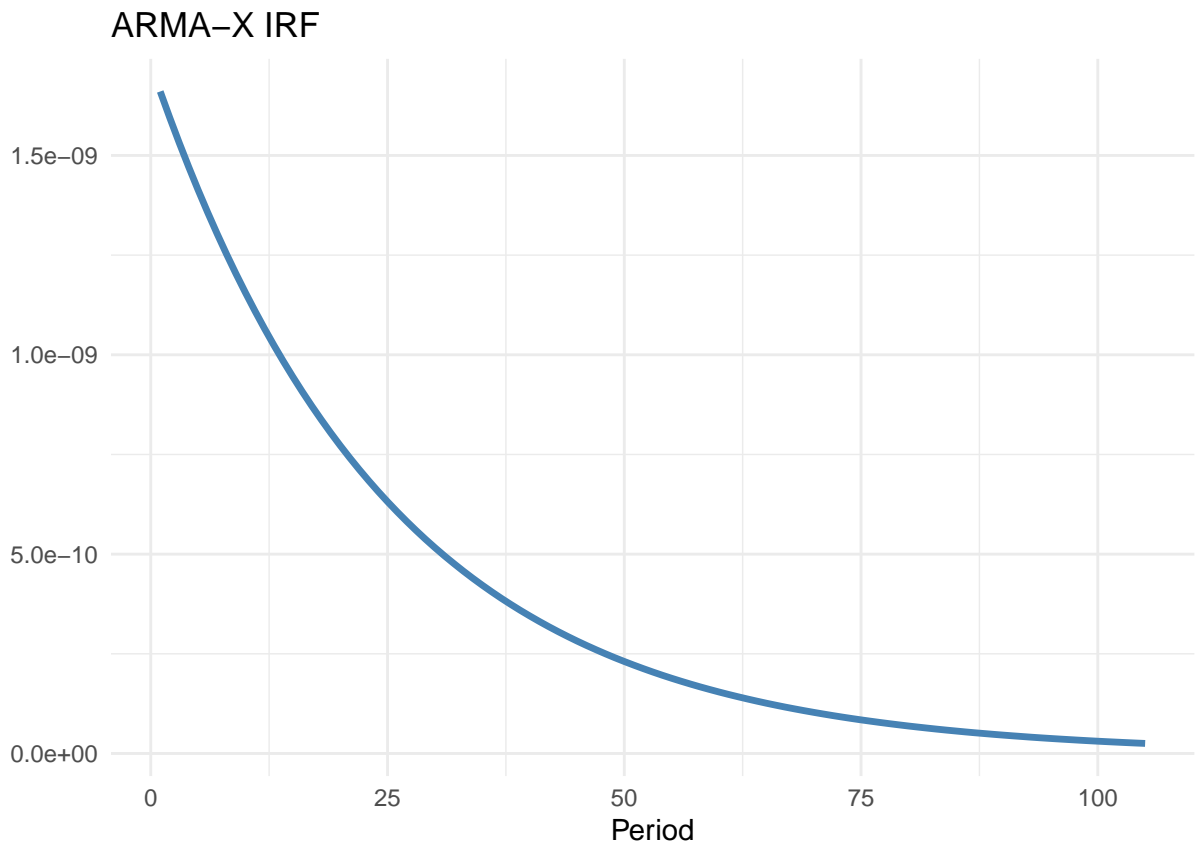
ARMA–X IRF

```r
irf.plot(count_fit$model,nb.periods)
```

ARMA–X IRF


```r
irf.plot(tariff_fit$model,nb.periods)
```

ARMA−X IRF


```r
irf.plot(trade_fit$model,nb.periods)
```
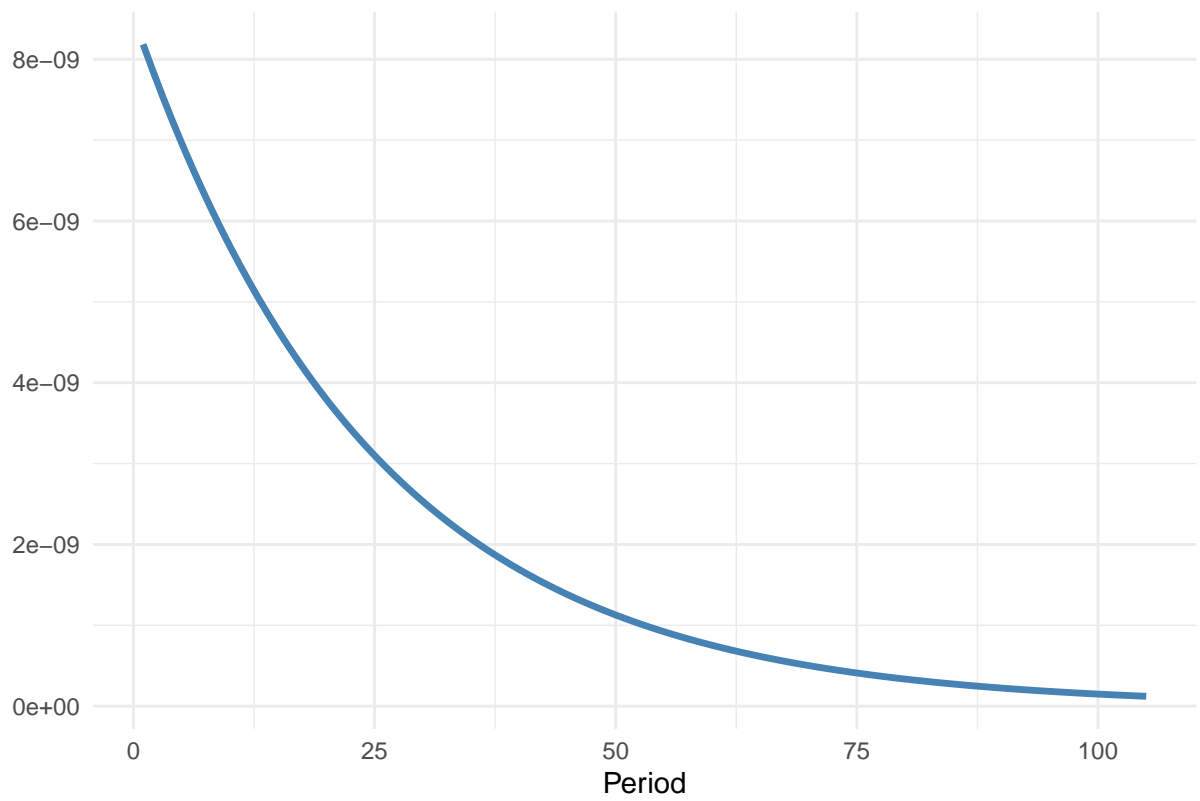
ARMA−X IRF

```
irf.plot(china_fit$model,nb.periods)
```
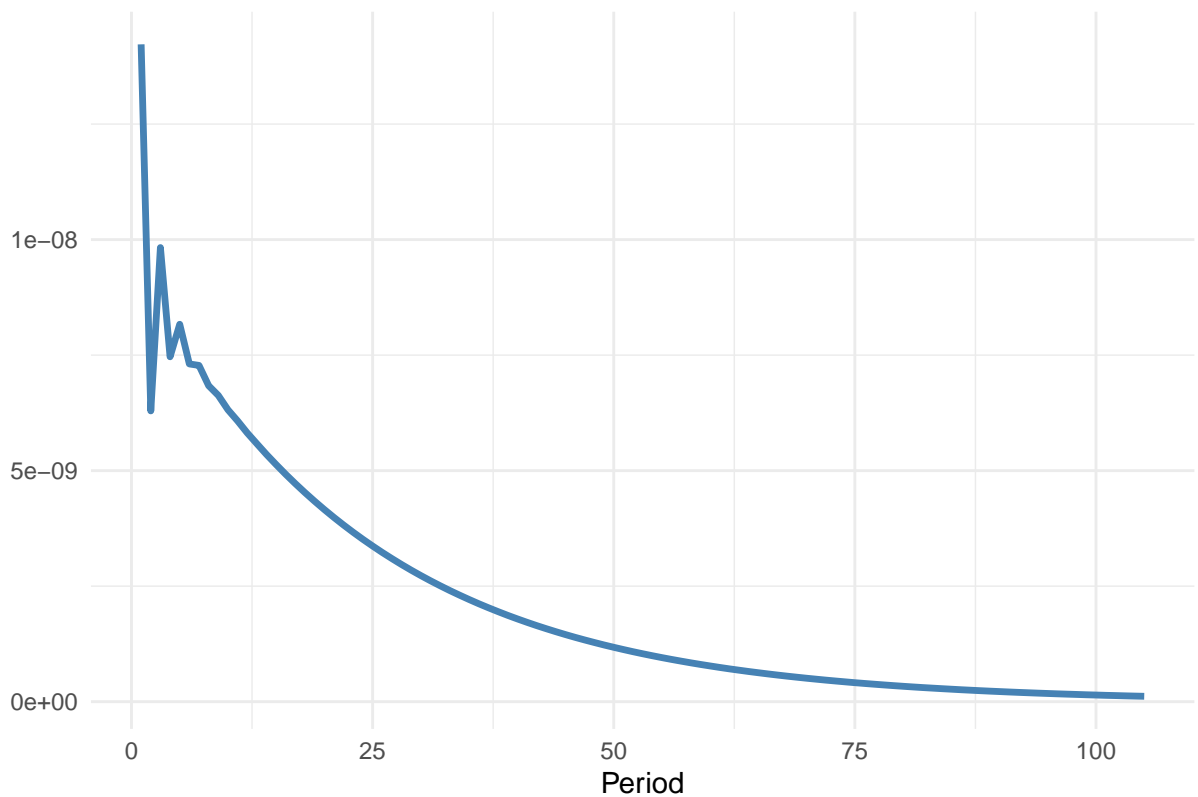
ARMA−X IRF


```r
irf.plot(positive_fit$model,nb.periods)
```

ARMA−X IRF


```
irf.plot(negative_fit$model,nb.periods)
```

ARMA−X IRF

ASHR Residuals

```
res = checkresiduals(dummy_fit$model, plot = FALSE)
```
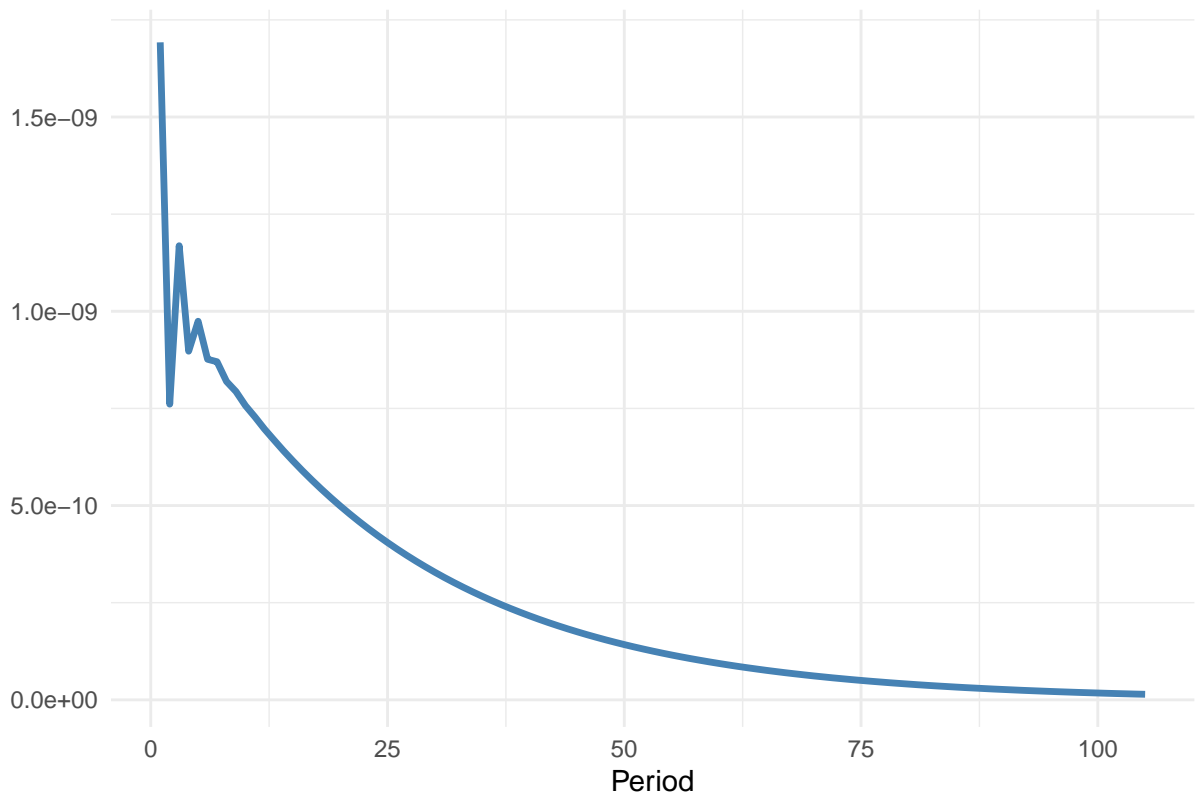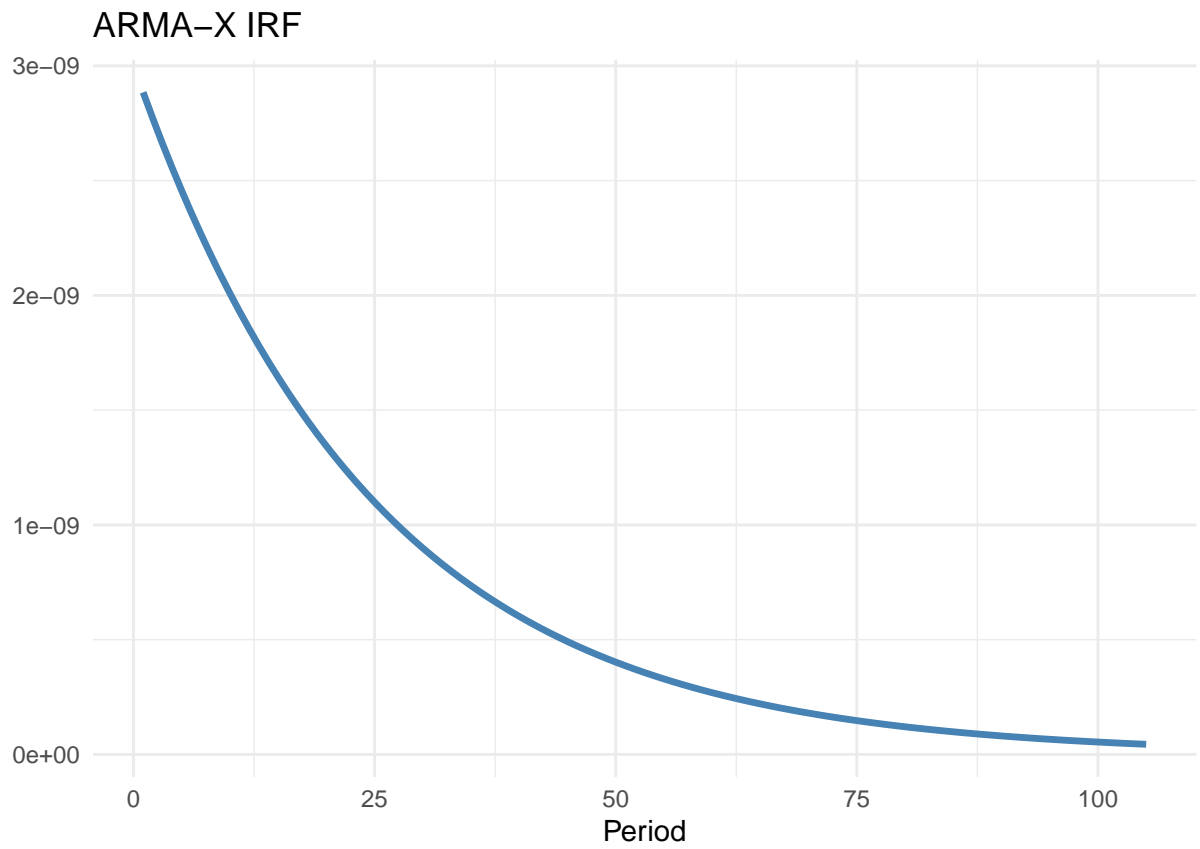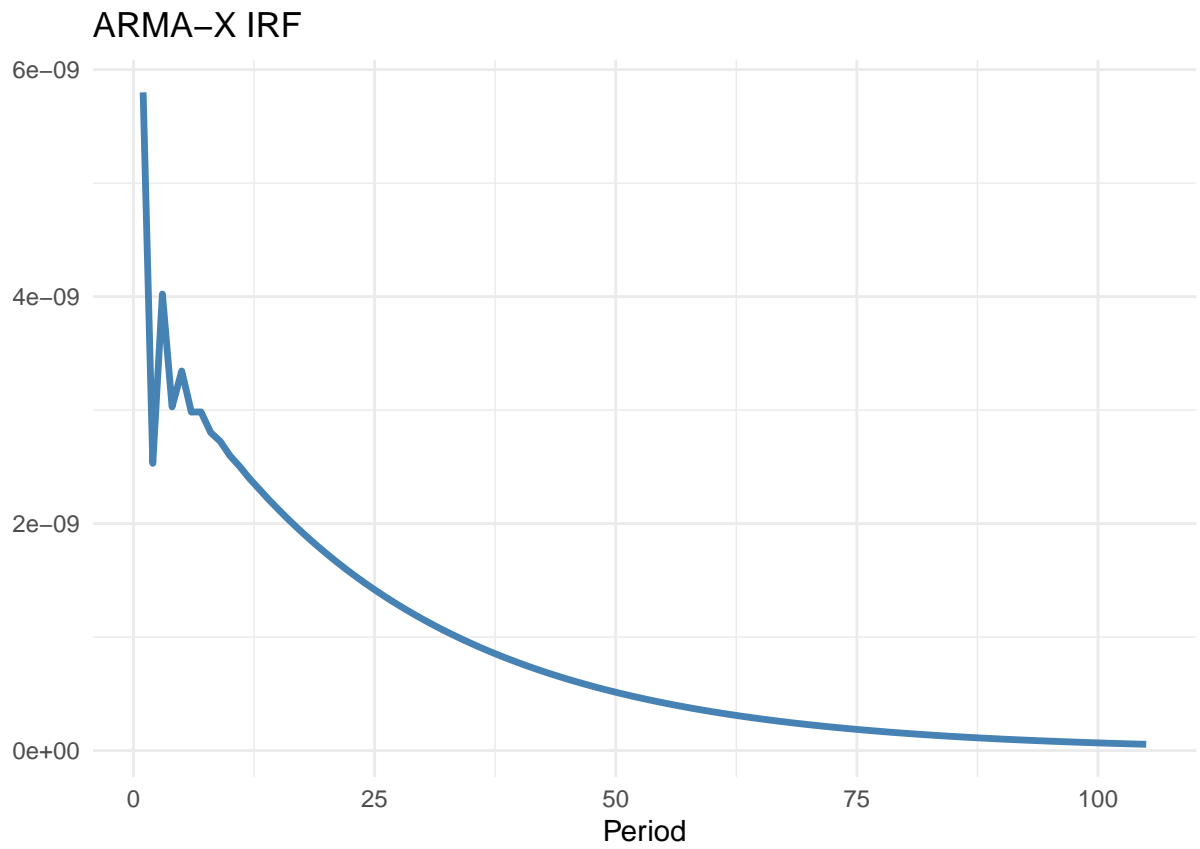
```
##
##  Ljung-Box test
##
## data:  Residuals from Regression with ARIMA(1,0,3) errors
## Q* = 25.247, df = 6, p-value = 0.0003073
##
## Model df: 4.   Total lags used: 10
```

```
res = checkresiduals(count_fit$model, plot = FALSE)
```

```
##
##  Ljung-Box test
##
## data:  Residuals from Regression with ARIMA(1,0,3) errors
## Q* = 25.016, df = 6, p-value = 0.0003392
##
## Model df: 4.   Total lags used: 10
```

```r
res = checkresiduals(tariff_fit$model, plot = FALSE)
```

```
##
##  Ljung-Box test
##
## data:  Residuals from Regression with ARIMA(2,0,3) errors
## Q* = 24.465, df = 5, p-value = 0.0001767
##
## Model df: 5.   Total lags used: 10
```

```r
res = checkresiduals(trade_fit$model, plot = FALSE)
```

```
##
##  Ljung-Box test
##
## data:  Residuals from Regression with ARIMA(1,0,3) errors
## Q* = 24.008, df = 6, p-value = 0.0005204
##
## Model df: 4.   Total lags used: 10
```

```r
res = checkresiduals(china_fit$model, plot = FALSE)
```

```
##
##  Ljung-Box test
##
## data:  Residuals from Regression with ARIMA(2,0,3) errors
## Q* = 25.002, df = 5, p-value = 0.0001392
##
## Model df: 5.   Total lags used: 10
```

```r
res = checkresiduals(positive_fit$model, plot = FALSE)
```

```
##
##  Ljung-Box test
##
## data:  Residuals from Regression with ARIMA(1,0,3) errors
## Q* = 24.311, df = 6, p-value = 0.0004577
##
## Model df: 4.   Total lags used: 10
```

```r
res = checkresiduals(negative_fit$model, plot = FALSE)
```

```
##
##  Ljung-Box test
##
## data:  Residuals from Regression with ARIMA(2,0,3) errors
## Q* = 25.996, df = 5, p-value = 8.941e-05
##
## Model df: 5.   Total lags used: 10
```