SPY ARMA-X Analysis

Contents

	Model 1
ar1	0.9828***
	(0.0017)
ma1	−0.6786***
	(0.0073)
ma2	−0.2118***
	(0.0087)
ma3	−0.0120
	(0.0080)
ma4	0.0331***
	(0.0071)
intercept	0.0202***
	(0.0041)
dummy_lag_0	0.0013***
	(0.0002)
dummy_lag_1	0.0007***
	(0.0002)
dummy_lag_2	0.0001
	(0.0002)
AIC	−45719.7236
AICc	−45719.7126
BIC	−45640.7043
Log Likelihood	22869.8618
Num. obs.	19969

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

Table 1: ARMAX Model Results

Stationarity

```
adf.test(data$SPY_vol)

adf.test(data$N)
adf.test(data$tariff)
adf.test(data$china)
```

S&P500 Univariate ARMA-X Models

Tweet Dummy as Exogenous

```
#auto.armax selects the lowest AIC value given r (exogenous variable lags)
res1 = auto.armax(data$SPY_vol,xreg=data$dummy,nb.lags=2,
                  latex=T,max.p = 6, max.q = 6, max.d=0)
```

```
#armax enables a custom armax specification with p,q,r
res2 = armax(data$SPY_vol, xreg=data$dummy, nb.lags=2,
                    p=5, q=0, d=0, latex=T)
```

	Model 1
ar1	0.3576***
	(0.0071)
ar2	0.0416***
	(0.0075)
ar3	0.0994***
	(0.0074)
ar4	0.1045***
	(0.0075)
ar5	0.0816***
	(0.0071)
intercept	0.0199***
	(0.0018)
dummy_lag_0	0.0015***
	(0.0002)
dummy_lag_1	0.0009***
	(0.0002)
dummy_lag_2	0.0001
	(0.0002)
AIC	−44706.1942
AICc	−44706.1832
BIC	−44627.1749
Log Likelihood	22363.0971
Num. obs.	19969

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

Table 2: ARMAX Model Results

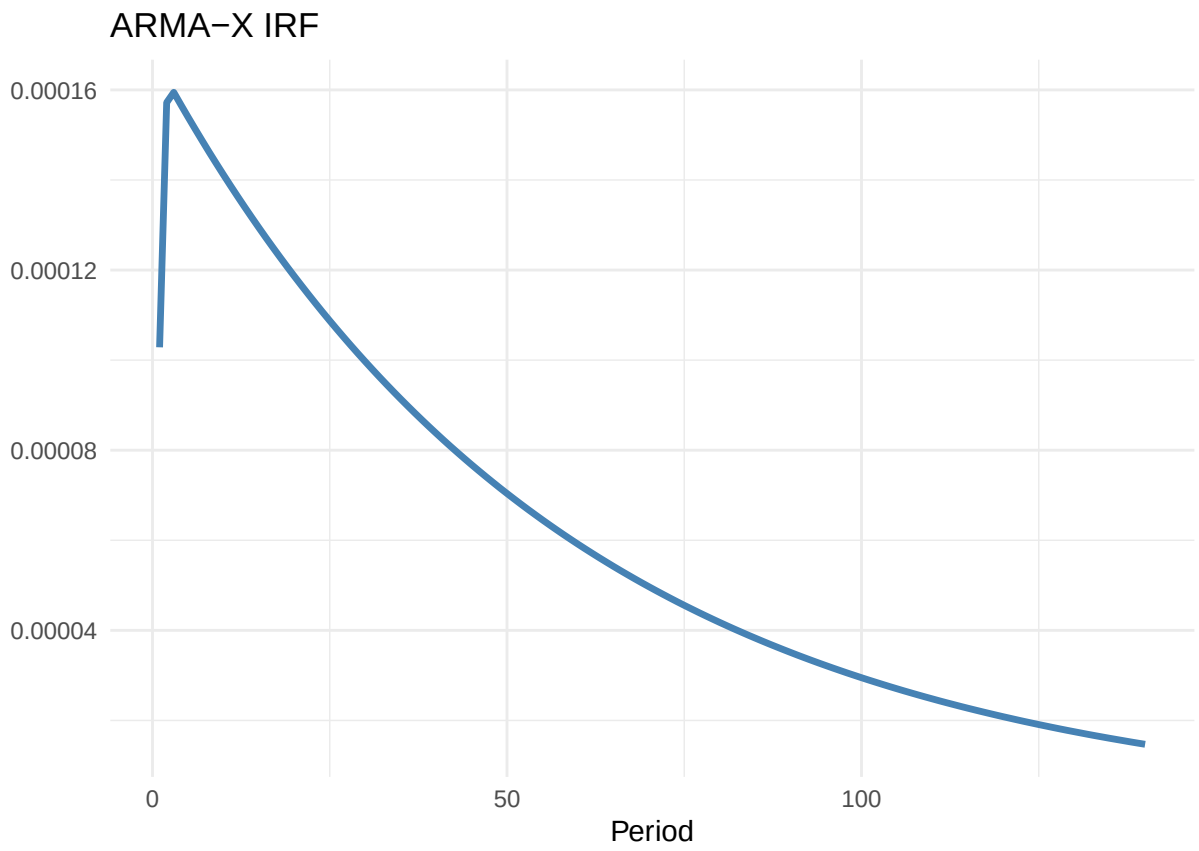
	Model 1
ar1	0.0300
	(0.0510)
ar2	0.7229***
	(0.0397)
ar3	0.2110***
	(0.0287)
ma1	0.2751***
	(0.0496)
ma2	−0.6445***
	(0.0284)
ma3	−0.3527***
	(0.0256)
intercept	0.0202***
	(0.0042)
dummy_lag_0	0.0014***
	(0.0002)
dummy_lag_1	0.0008***
	(0.0002)
AIC	−45761.2161
AICc	−45761.2051
BIC	−45682.1963
Log Likelihood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

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

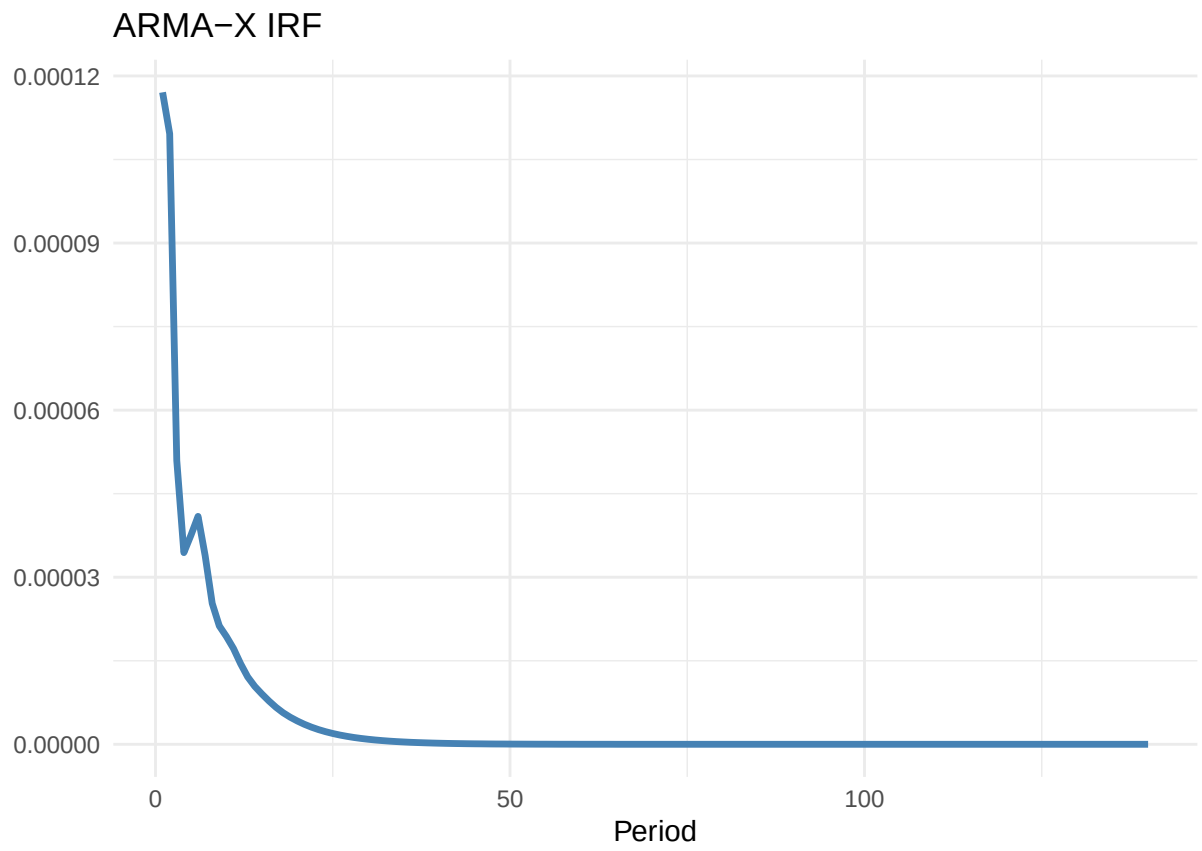
Table 3: ARMAX selected by AIC

```
#auto.armax.r selects the lowest AIC checking all 3 p,q,r values
res3 = auto.armax.r(data$SPY_vol, x=data$dummy,
                max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```

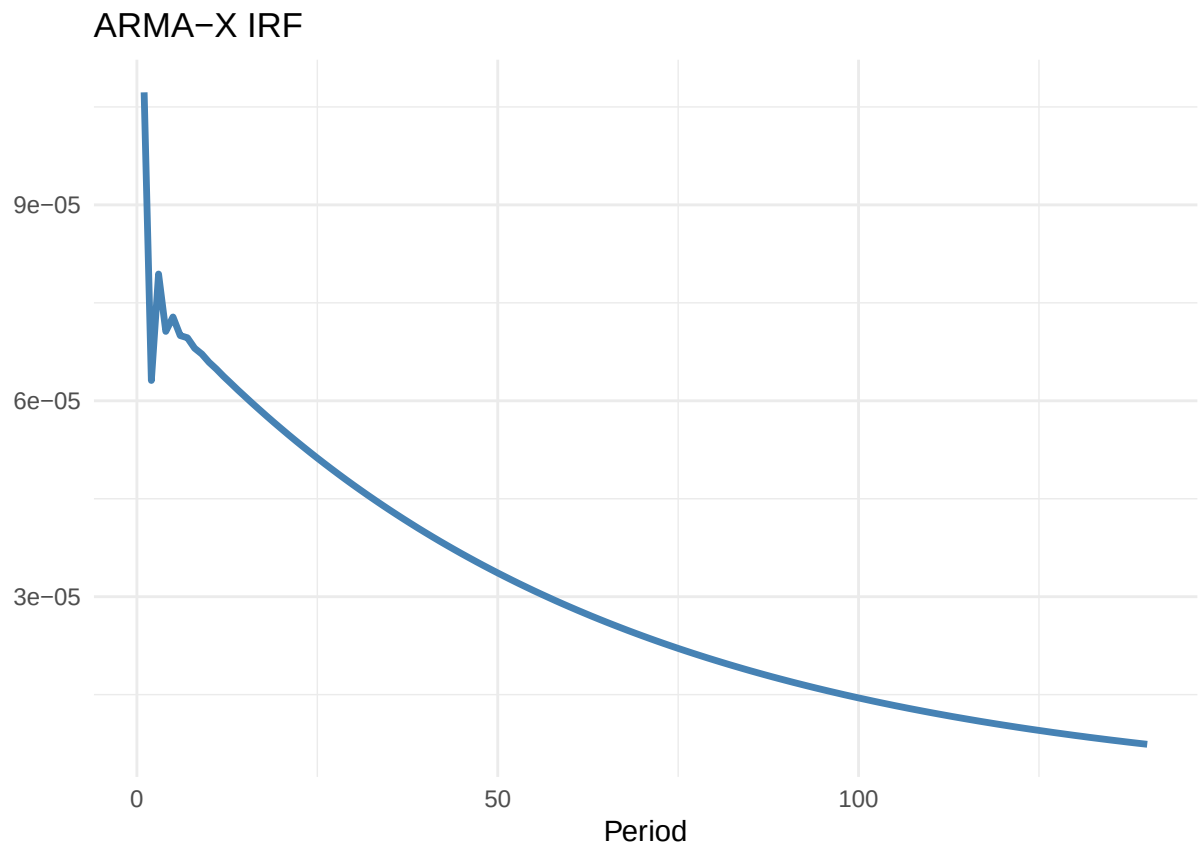
```
#we want to plot the IRFs of these models
nb.periods = 7 * 20

irf.plot(res1,nb.periods)
```




```
irf.plot(res2,nb.periods)
```




```
irf.plot(res3$model,nb.periods)
```



Tweet Count as Exogenous

```
#auto.armax selects the lowest AIC value given r (exogenous variable lags)
res1 = auto.armax(data$SPY_vol,xreg=data$N,nb.lags=2,
                  latex=T,max.p = 6, max.q = 6, max.d=0)
```

```
#armax enables a custom armax specification with p,q,r
res2 = armax(data$SPY_vol, xreg=data$N, nb.lags=2,
                    p=5, q=0, d=0, latex=T)
```

```
#auto.armax.r selects the lowest AIC checking all 3 p,q,r values
res3 = auto.armax.r(data$SPY_vol, x=data$N,
                  max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```

```
#we want to plot the IRFs of these models
nb.periods = 7 * 20

irf.plot(res1,nb.periods)
```

	Model 1
ar1	0.9828^{***}
	(0.0017)
ma1	-0.6780^{***}
	(0.0073)
ma2	-0.2129^{***}
	(0.0086)
ma3	-0.0118
	(0.0080)
ma4	0.0335^{***}
	(0.0071)
intercept	0.0210^{***}
	(0.0041)
N_lag_0	0.0003^{***}
	(0.0001)
N_lag_1	0.0002^{**}
	(0.0001)
N_lag_2	0.0000
	(0.0001)
AIC	−45696.1228
AICc	−45696.1118
BIC	−45617.1034
Log Likelihood	22858.0614
Num. obs.	19969

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

Table 4: ARMAX Model Results

	Model 1
ar1	0.3584***
	(0.0071)
ar2	0.0410***
	(0.0075)
ar3	0.0991***
	(0.0074)
ar4	0.1040***
	(0.0075)
ar5	0.0815***
	(0.0071)
intercept	0.0208***
	(0.0018)
N_lag_0	0.0004***
	(0.0001)
N_lag_1	0.0002***
	(0.0001)
N_lag_2	0.0000
	(0.0001)
AIC	−44677.6875
AICc	−44677.6765
BIC	−44598.6682
Log Likelihood	22348.8438
Num. obs.	19969

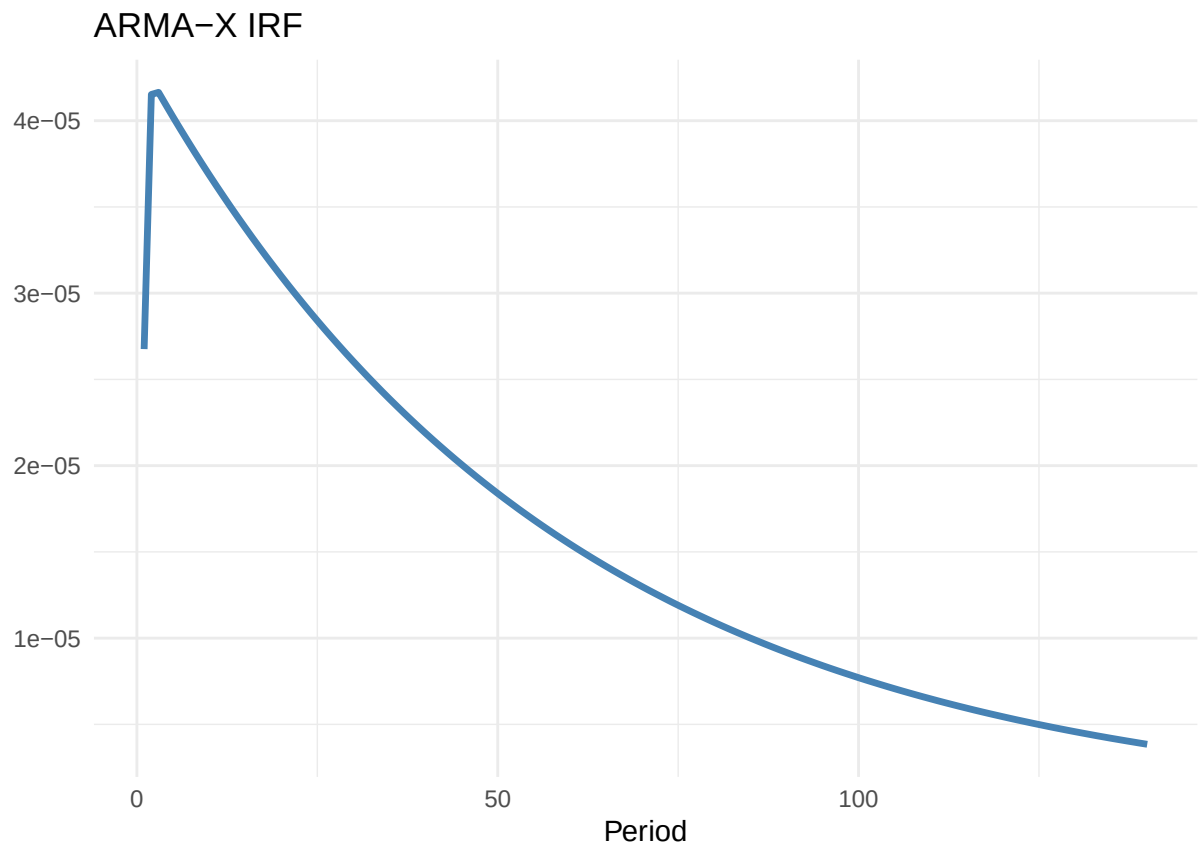
***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

Table 5: ARMAX Model Results

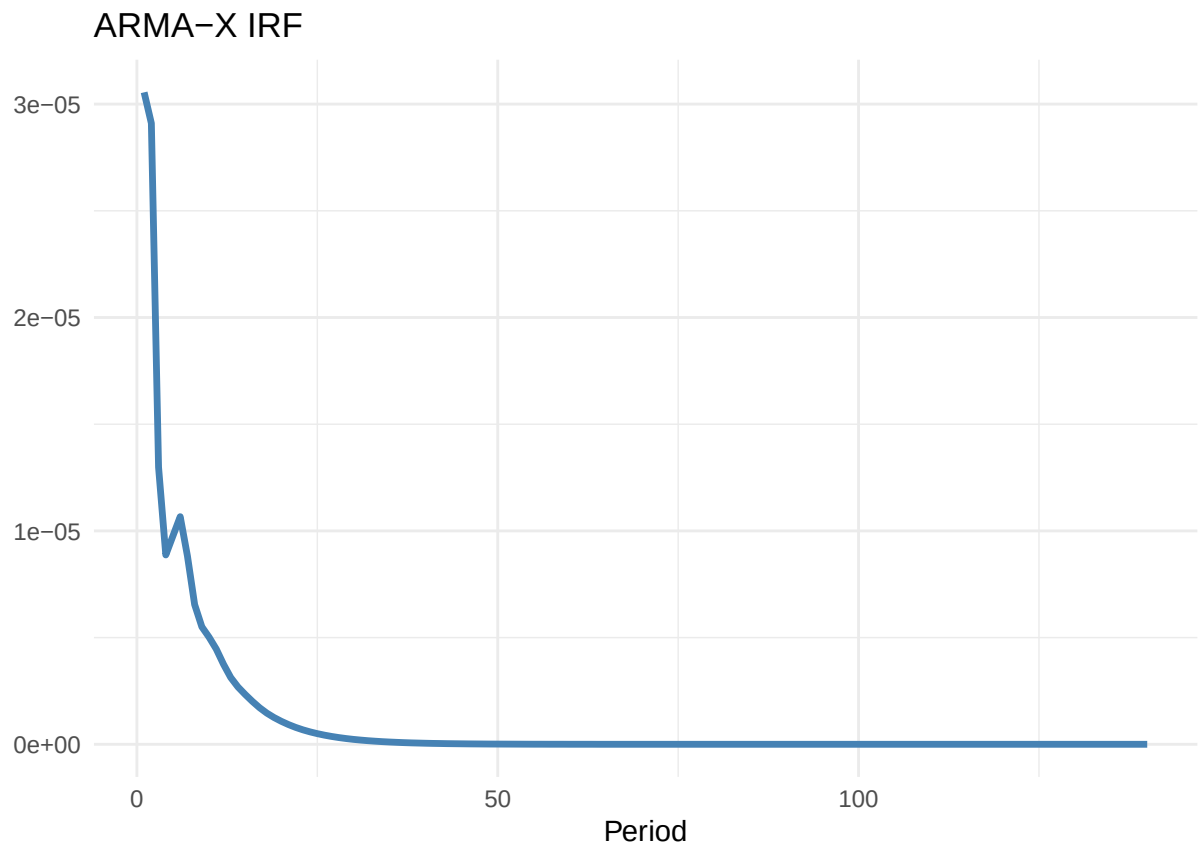
	Model 1
ar1	0.0278
	(0.0510)
ar2	0.7210^{***}
	(0.0399)
ar3	0.2148^{***}
	(0.0284)
ma1	0.2779^{***}
	(0.0496)
ma2	-0.6430^{***}
	(0.0285)
ma3	-0.3563^{***}
	(0.0253)
intercept	0.0211^{***}
	(0.0042)
N_lag_0	0.0004^{***}
	(0.0001)
N_lag_1	0.0002^{**}
	(0.0001)
AIC	−45737.6695
AICc	−45737.6585
BIC	−45658.6497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

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

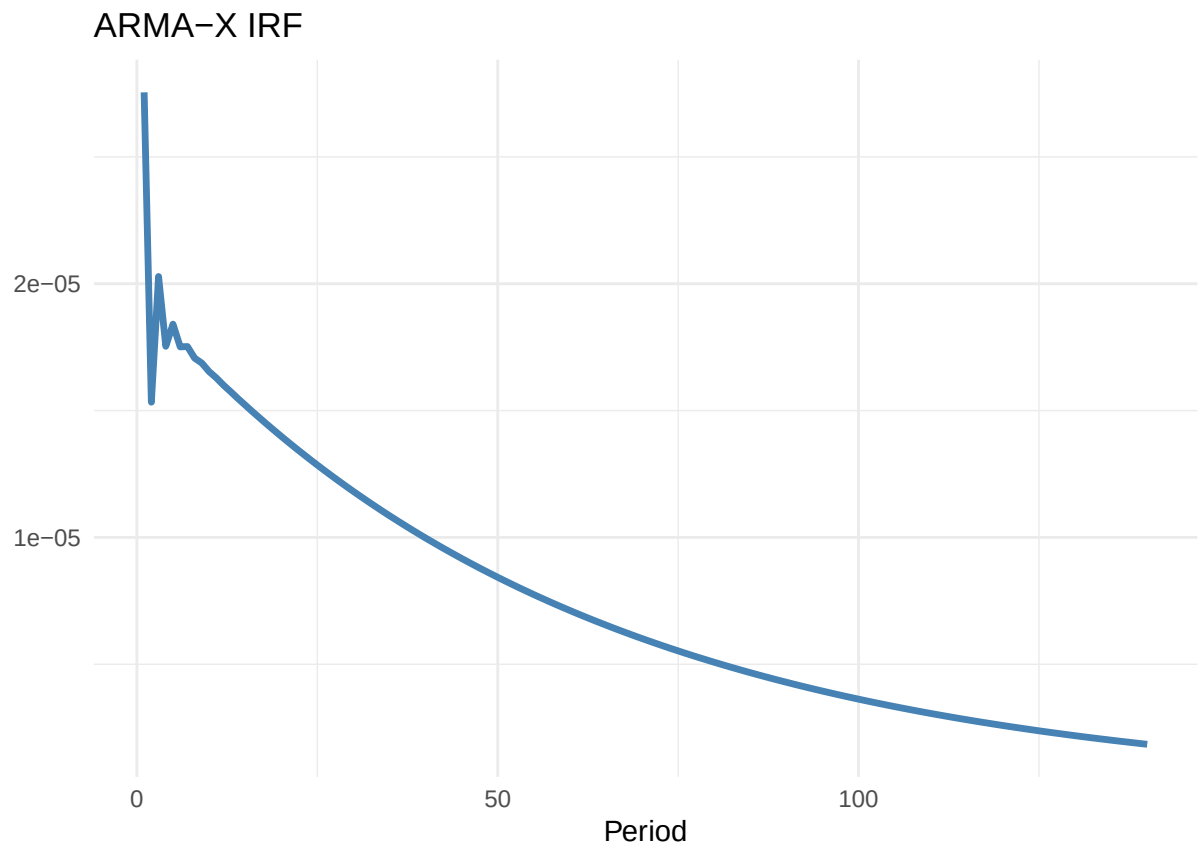
Table 6: ARMAX selected by AIC




```
irf.plot(res2,nb.periods)
```




```
irf.plot(res3$model,nb.periods)
```



Tariff as Exogenous

```
#auto.armax selects the lowest AIC value given r (exogenous variable lags)
res1 = auto.armax(data$SPY_vol,xreg=data$tariff,nb.lags=2,
                  latex=T,max.p = 6, max.q = 6, max.d=0)
```

```
#armax enables a custom armax specification with p,q,r
res2 = armax(data$SPY_vol, xreg=data$tariff, nb.lags=2,
                    p=5, q=0, d=0, latex=T)
```

```
#auto.armax.r selects the lowest AIC checking all 3 p,q,r values
res3 = auto.armax.r(data$SPY_vol, x=data$tariff,
                  max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```

```
#we want to plot the IRFs of these models
nb.periods = 7 * 20

irf.plot(res1,nb.periods)
```

	Model 1
ar1	1.7000***
	(0.1313)
ar2	−0.8772***
	(0.1518)
ar3	0.1689***
	(0.0232)
ma1	−1.3999***
	(0.1327)
ma2	0.4605***
	(0.1192)
intercept	0.0217***
	(0.0040)
tariff_lag_0	0.0042**
	(0.0014)
tariff_lag_1	0.0199***
	(0.0015)
tariff_lag_2	0.0112***
	(0.0014)
AIC	−45860.5245
AICc	−45860.5134
BIC	−45781.5051
Log Likelihood	22940.2622
Num. obs.	19969

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

Table 7: ARMAX Model Results

	Model 1
ar1	0.3572***
	(0.0071)
ar2	0.0427***
	(0.0075)
ar3	0.0903***
	(0.0075)
ar4	0.0978***
	(0.0075)
ar5	0.0859***
	(0.0071)
intercept	0.0217***
	(0.0017)
tariff_lag_0	0.0047**
	(0.0015)
tariff_lag_1	0.0201***
	(0.0015)
tariff_lag_2	0.0109***
	(0.0015)
AIC	−44818.4470
AICc	−44818.4359
BIC	−44739.4276
Log Likelihood	22419.2235
Num. obs.	19969

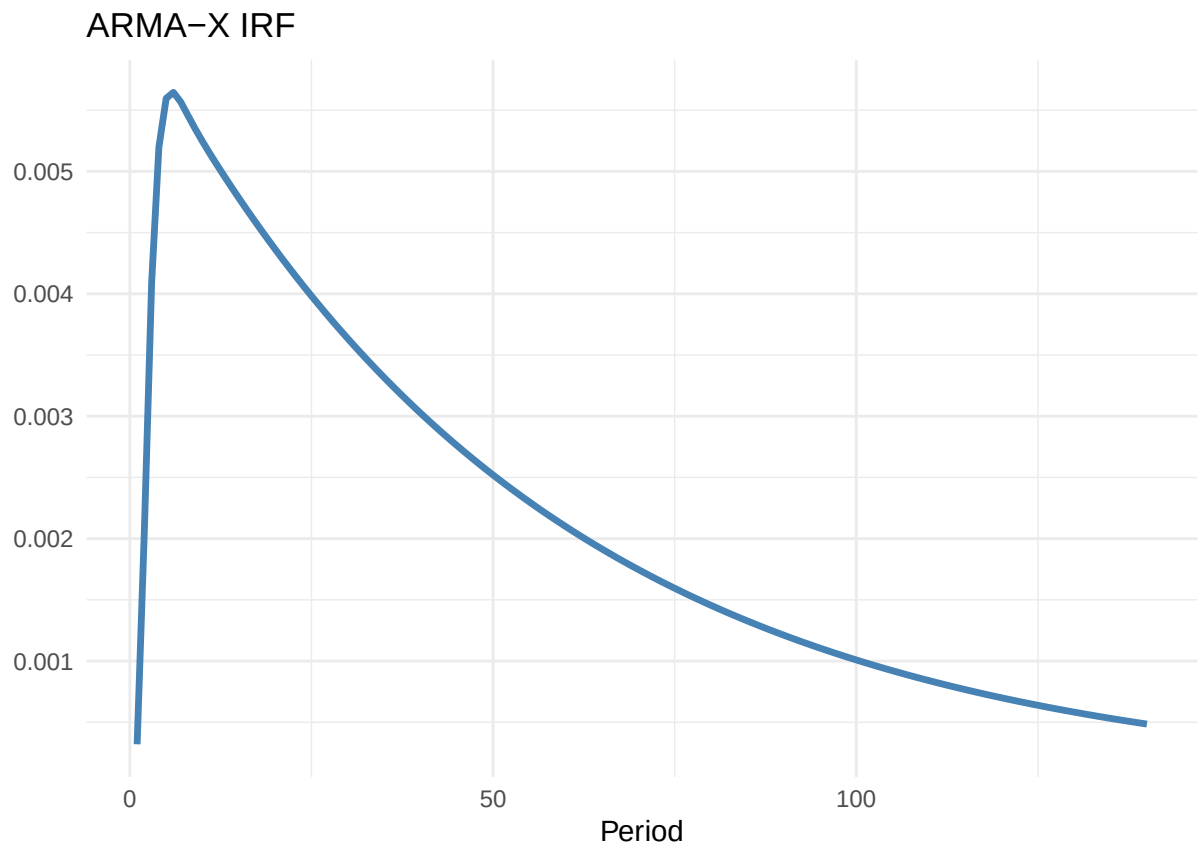
***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

Table 8: ARMAX Model Results

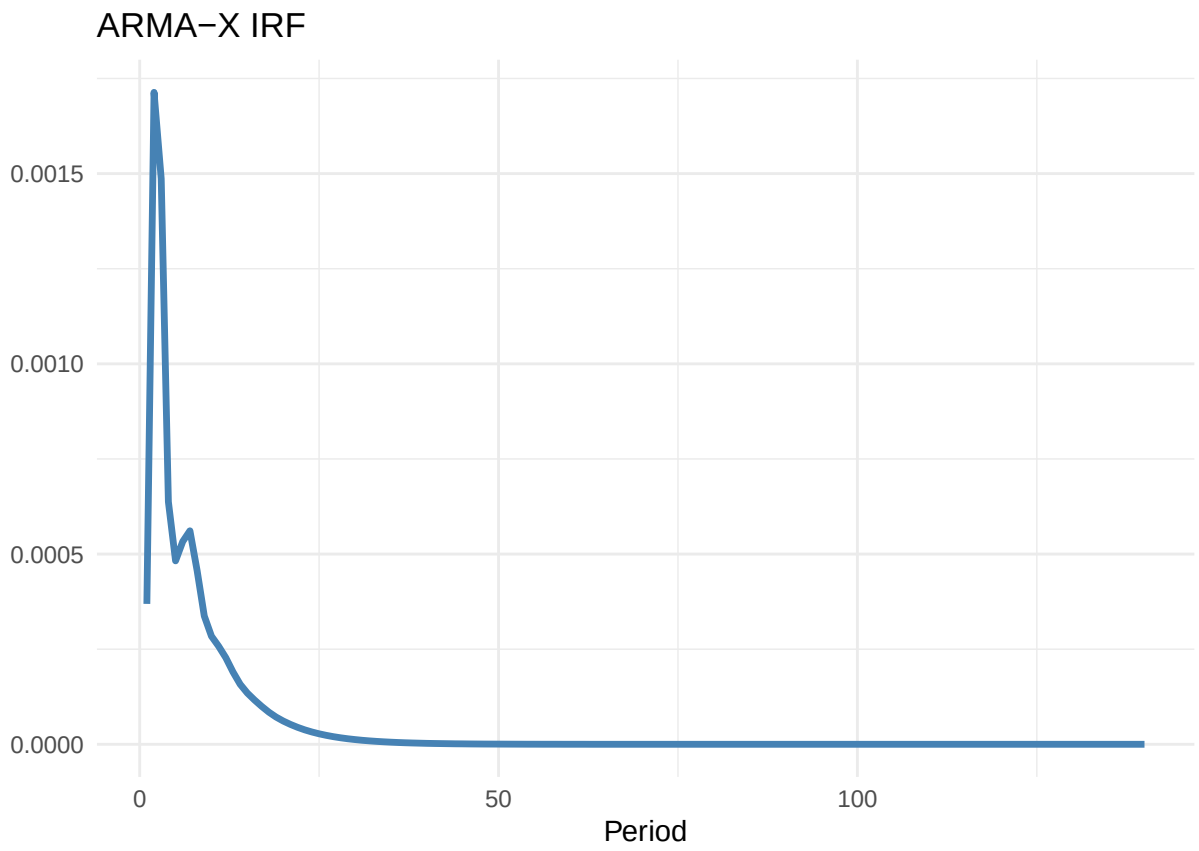
	Model 1
ar1	0.2200^{***}
	(0.0084)
ar2	0.9388^{***}
	(0.0037)
ar3	-0.1837^{***}
	(0.0079)
ma1	0.0870^{***}
	(0.0042)
ma2	-0.8960^{***}
	(0.0042)
intercept	0.0219^{***}
	(0.0042)
tariff_lag_0	0.0035^{*}
	(0.0014)
tariff_lag_1	0.0191^{***}
	(0.0015)
tariff_lag_2	0.0103^{***}
	(0.0015)
tariff_lag_3	-0.0045^{**}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

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

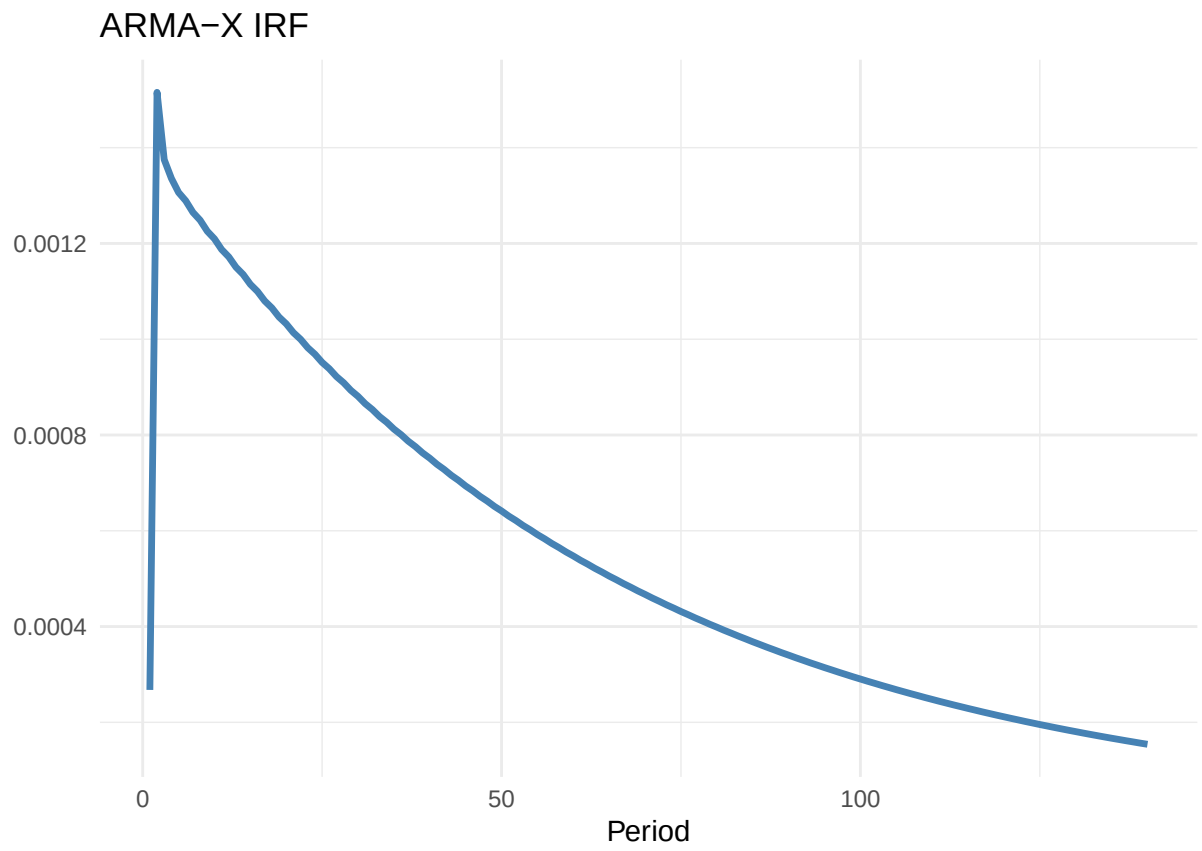
Table 9: ARMAX selected by AIC




```
irf.plot(res2,nb.periods)
```




```
irf.plot(res3$model,nb.periods)
```



Trade Mention as Exogenous

```
#auto.armax selects the lowest AIC value given r (exogenous variable lags)
res1 = auto.armax(data$SPY_vol,xreg=data$trade,nb.lags=2,
                  latex=T,max.p = 6, max.q = 6, max.d=0)
```

```
#armax enables a custom armax specification with p,q,r
res2 = armax(data$SPY_vol, xreg=data$trade, nb.lags=2,
                    p=5, q=0, d=0, latex=T)
```

```
#auto.armax.r selects the lowest AIC checking all 3 p,q,r values
res3 = auto.armax.r(data$SPY_vol, x=data$trade,
                  max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```

```
#we want to plot the IRFs of these models
nb.periods = 7 * 20

irf.plot(res1,nb.periods)
```

	Model 1
ar1	0.9828^{***}
	(0.0017)
ma1	-0.6774^{***}
	(0.0073)
ma2	-0.2149^{***}
	(0.0087)
ma3	-0.0126
	(0.0080)
ma4	0.0352^{***}
	(0.0071)
intercept	0.0222^{***}
	(0.0041)
trade_lag_0	0.0019
	(0.0019)
trade_lag_1	0.0042^{*}
	(0.0019)
trade_lag_2	0.0071^{***}
	(0.0019)
AIC	−45677.4427
AICc	−45677.4317
BIC	−45598.4233
Log Likelihood	22848.7213
Num. obs.	19969

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

Table 10: ARMAX Model Results

	Model 1
ar1	0.3598***
	(0.0071)
ar2	0.0395***
	(0.0075)
ar3	0.0974***
	(0.0074)
ar4	0.1024***
	(0.0075)
ar5	0.0827***
	(0.0071)
intercept	0.0221***
	(0.0018)
trade_lag_0	0.0027
	(0.0019)
trade_lag_1	0.0045*
	(0.0020)
trade_lag_2	0.0075***
	(0.0019)
AIC	−44647.3628
AICc	−44647.3518
BIC	−44568.3435
Log Likelihood	22333.6814
Num. obs.	19969

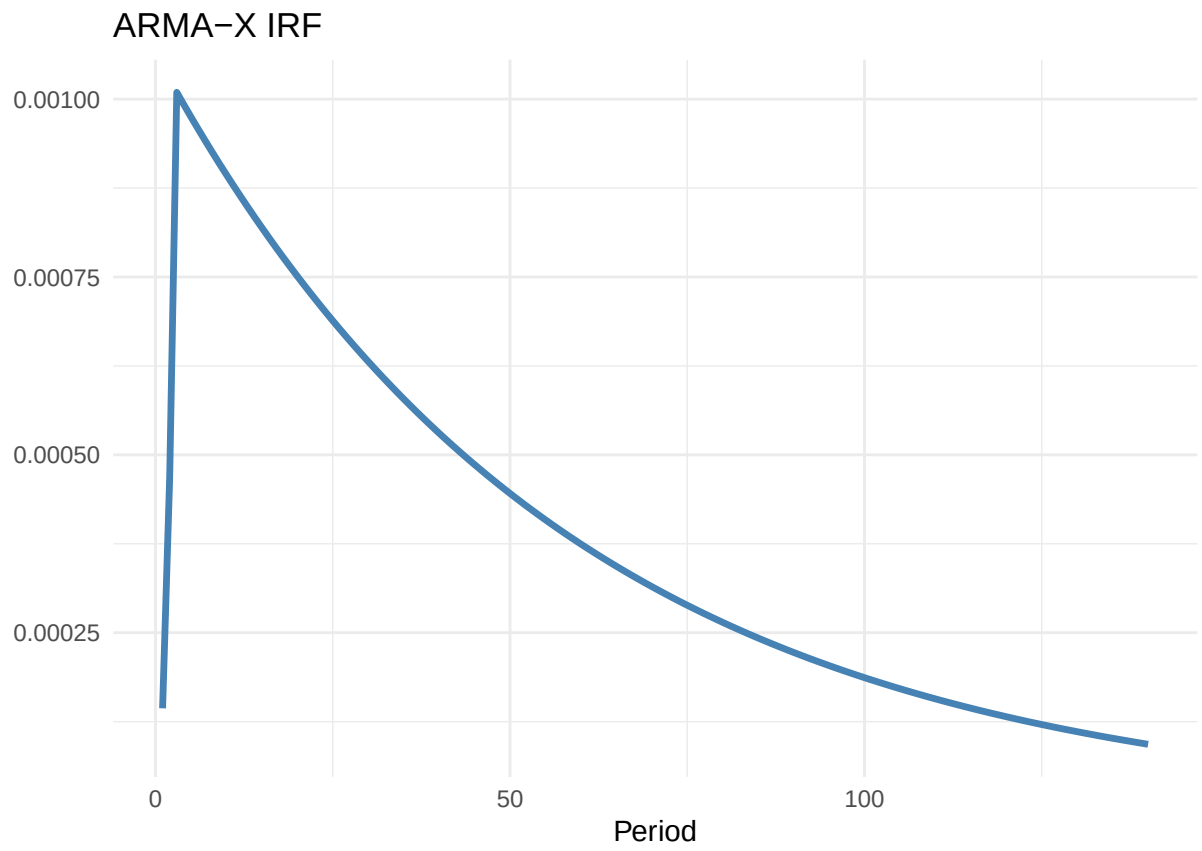
***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

Table 11: ARMAX Model Results

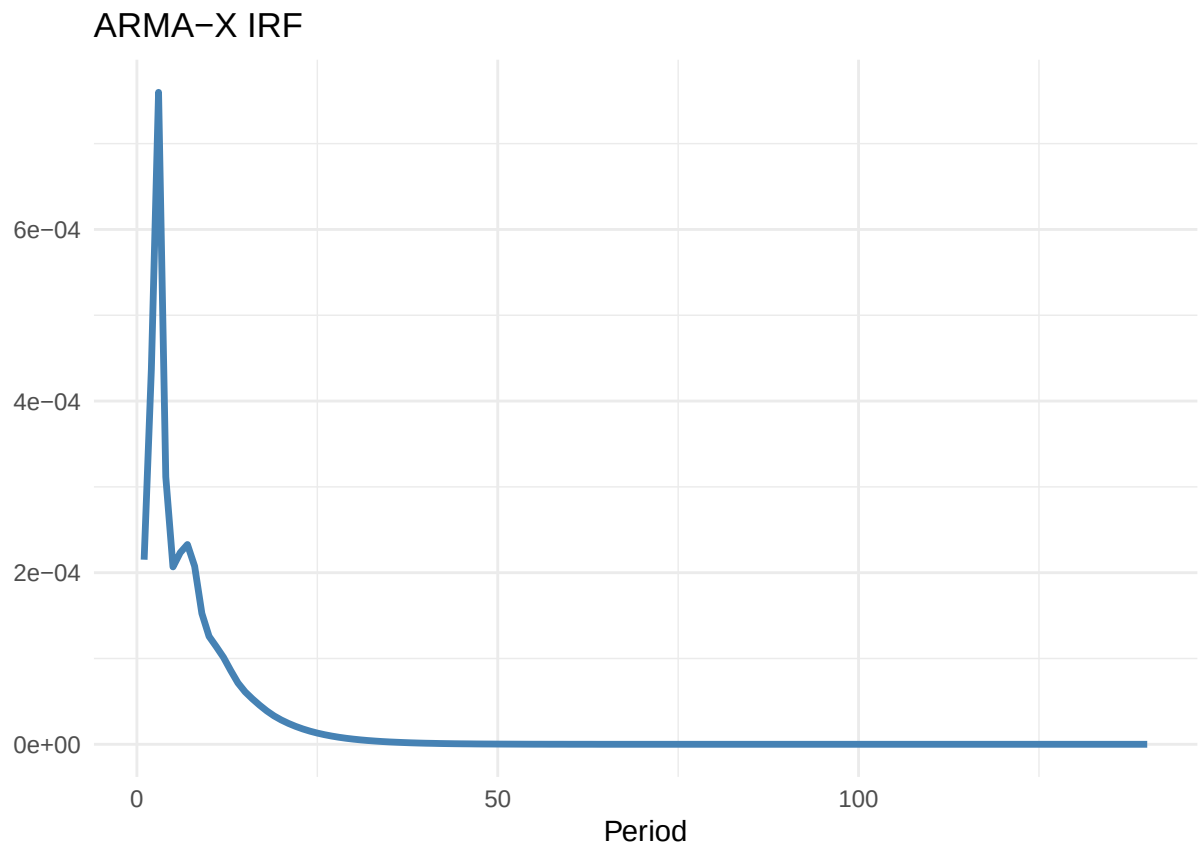
	Model 1
ar1	2.1903***
	(0.0096)
ar2	−1.4727***
	(0.0173)
ar3	0.2784***
	(0.0082)
ma1	−1.8955***
	(0.0062)
ma2	0.9165***
	(0.0063)
intercept	0.0225***
	(0.0028)
trade_lag_0	0.0032
	(0.0018)
trade_lag_1	0.0016
	(0.0018)
AIC	−45816.1540
AICc	−45816.1449
BIC	−45745.0361
Log Likelihood	22917.0770
Num. obs.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

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

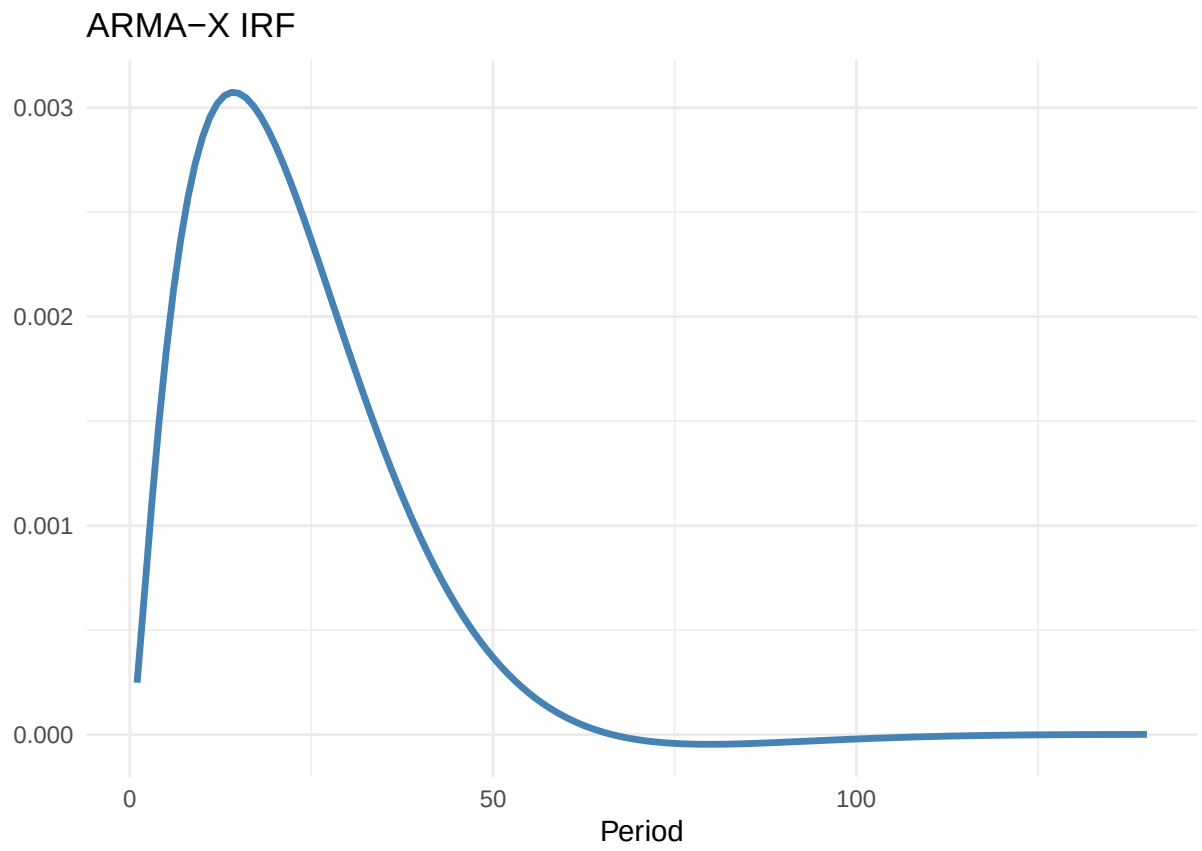
Table 12: ARMAX selected by AIC




```
irf.plot(res2,nb.periods)
```




```
irf.plot(res3$model,nb.periods)
```



China Mention as Exogenous

```
#auto.armax selects the lowest AIC value given r (exogenous variable lags)
res1 = auto.armax(data$SPY_vol,xreg=data$china,nb.lags=2,
                  latex=T,max.p = 6, max.q = 6, max.d=0)
```

```
#armax enables a custom armax specification with p,q,r
res2 = armax(data$SPY_vol, xreg=data$china, nb.lags=2,
                    p=5, q=0, d=0, latex=T)
```

```
#auto.armax.r selects the lowest AIC checking all 3 p,q,r values
res3 = auto.armax.r(data$SPY_vol, x=data$china,
                  max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```

```
#we want to plot the IRFs of these models
nb.periods = 7 * 20

irf.plot(res1,nb.periods)
```

	Model 1
ar1	0.9828^{***}
	(0.0017)
ma1	-0.6793^{***}
	(0.0073)
ma2	-0.2139^{***}
	(0.0087)
ma3	-0.0126
	(0.0080)
ma4	0.0355^{***}
	(0.0071)
intercept	0.0215^{***}
	(0.0041)
china_lag_0	0.0047^{***}
	(0.0012)
china_lag_1	0.0084^{***}
	(0.0012)
china_lag_2	0.0054^{***}
	(0.0012)
AIC	-45721.8164
AICc	-45721.8054
BIC	-45642.7971
Log Likelihood	22870.9082
Num. obs.	19969

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

Table 13: ARMAX Model Results

	Model 1
ar1	0.3584***
	(0.0071)
ar2	0.0405***
	(0.0075)
ar3	0.0972***
	(0.0074)
ar4	0.1022***
	(0.0075)
ar5	0.0825***
	(0.0071)
intercept	0.0215***
	(0.0018)
china_lag_0	0.0047***
	(0.0012)
china_lag_1	0.0079***
	(0.0013)
china_lag_2	0.0051***
	(0.0012)
AIC	−44680.9095
AICc	−44680.8985
BIC	−44601.8902
Log Likelihood	22350.4548
Num. obs.	19969

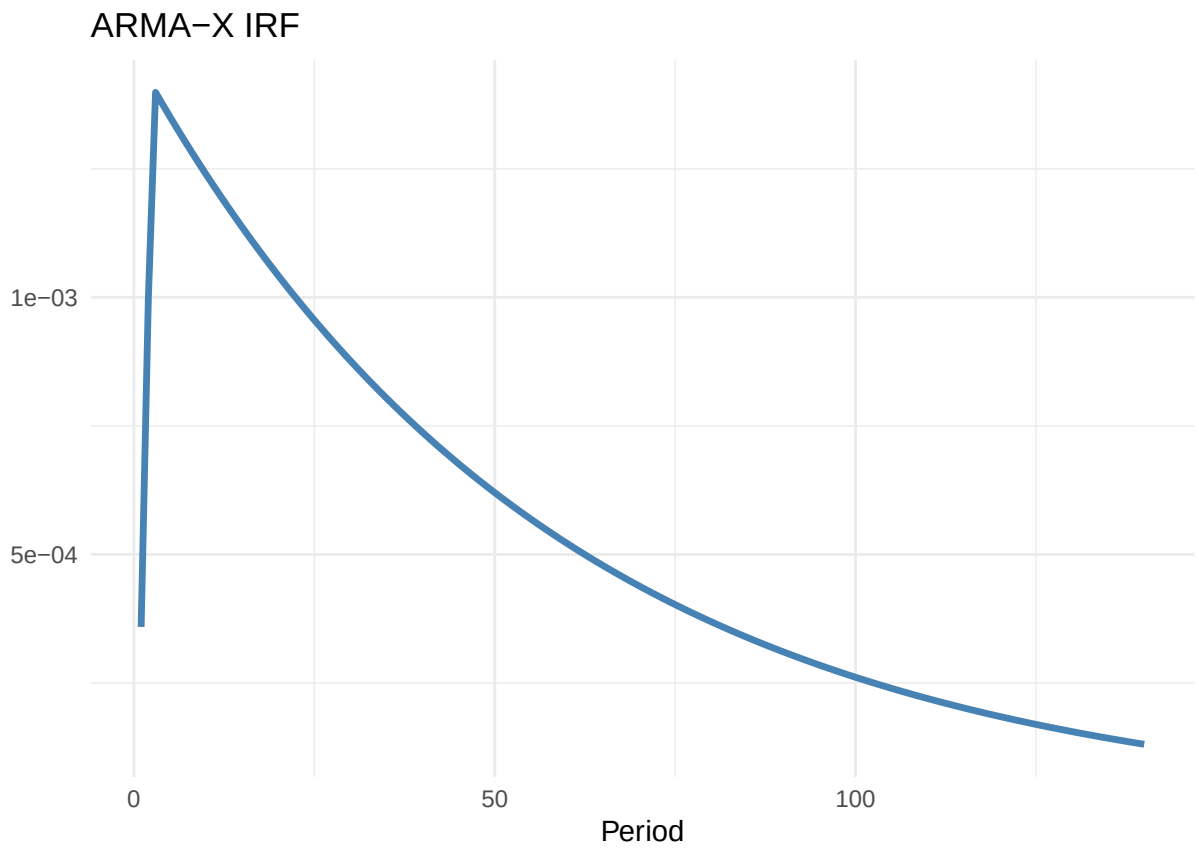
$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table 14: ARMAX Model Results

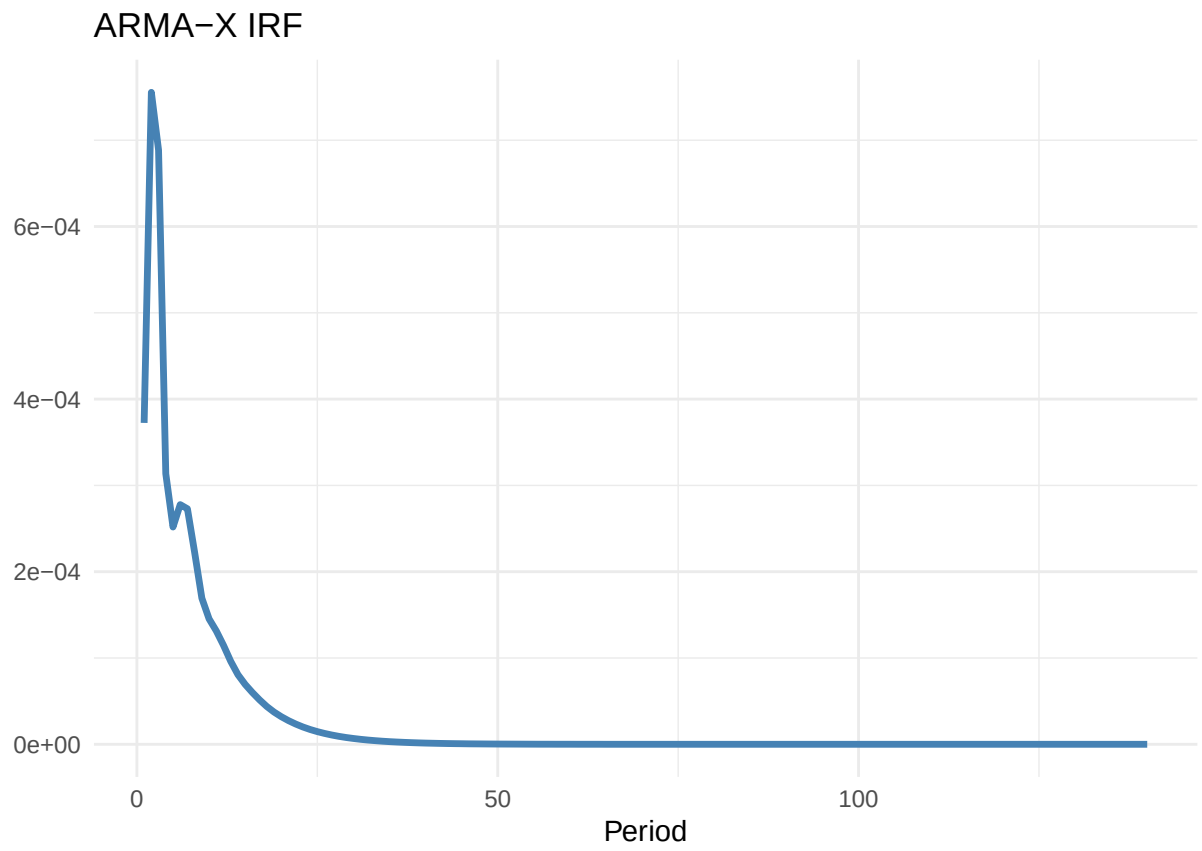
	Model 1
ar1	0.2209***
	(0.0084)
ar2	0.9382***
	(0.0037)
ar3	−0.1837***
	(0.0079)
ma1	0.0878***
	(0.0042)
ma2	−0.8950***
	(0.0042)
intercept	0.0225***
	(0.0042)
china_lag_0	0.0026*
	(0.0012)
AIC	−45840.5349
AICc	−45840.5277
BIC	−45777.3186
Log Likelihood	22928.2675
Num. obs.	19971

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

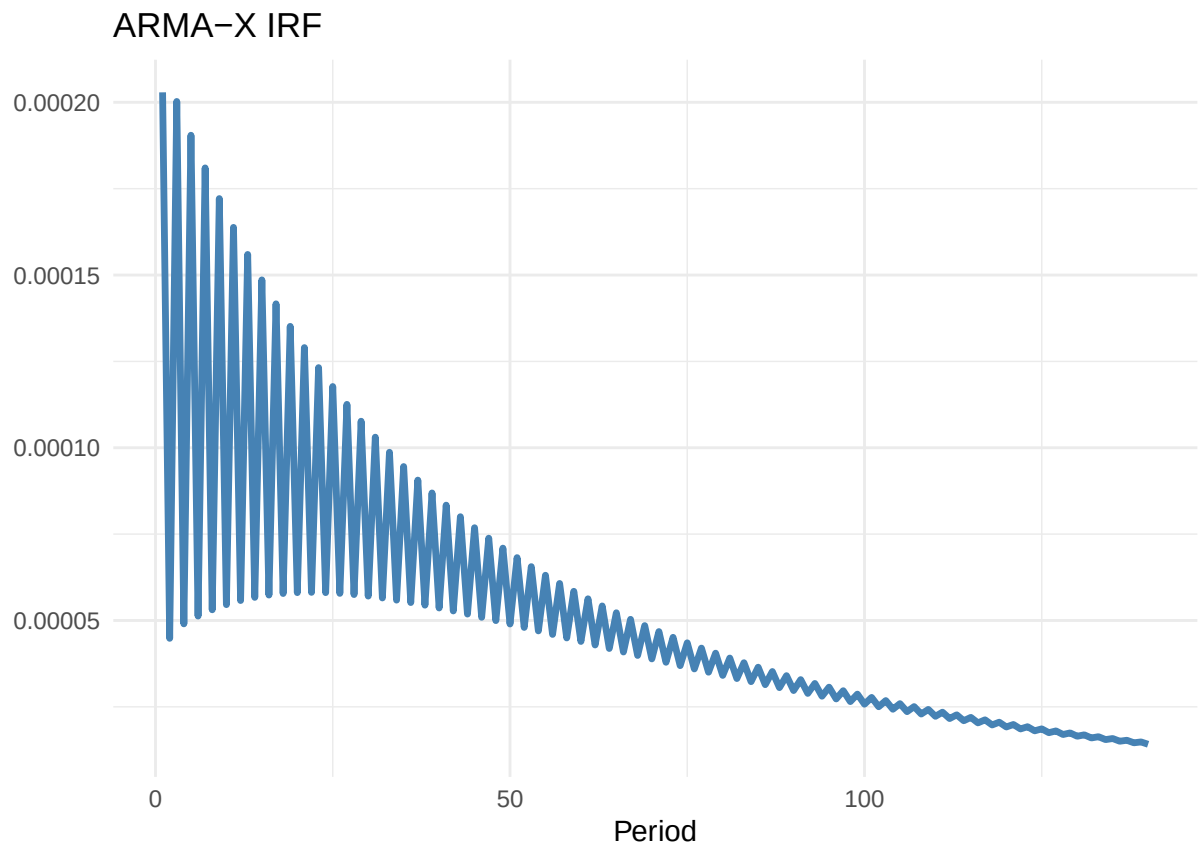
Table 15: ARMAX selected by AIC




```
irf.plot(res2,nb.periods)
```




```
irf.plot(res3$model,nb.periods)
```



Positive Vibe as Exogenous

```
#auto.armax selects the lowest AIC value given r (exogenous variable lags)
res1 = auto.armax(data$SPY_vol,xreg=data$prop_positive,nb.lags=2,
                  latex=T,max.p = 6, max.q = 6, max.d=0)
```

```
#armax enables a custom armax specification with p,q,r
res2 = armax(data$SPY_vol, xreg=data$prop_positive, nb.lags=2,
                    p=5, q=0, d=0, latex=T)
```

```
#auto.armax.r selects the lowest AIC checking all 3 p,q,r values
res3 = auto.armax.r(data$SPY_vol, x=data$prop_positive,
                  max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```

```
#we want to plot the IRFs of these models
nb.periods = 7 * 20

irf.plot(res1,nb.periods)
```

	Model 1
ar1	0.9828***
	(0.0017)
ma1	−0.6777***
	(0.0073)
ma2	−0.2146***
	(0.0087)
ma3	−0.0117
	(0.0080)
ma4	0.0345***
	(0.0071)
intercept	0.0195***
	(0.0042)
prop_positive_lag_0	0.0068***
	(0.0017)
prop_positive_lag_1	0.0027
	(0.0017)
prop_positive_lag_2	0.0045**
	(0.0017)
AIC	−45686.3386
AICc	−45686.3275
BIC	−45607.3192
Log Likelihood	22853.1693
Num. obs.	19969

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

Table 16: ARMAX Model Results

	Model 1
ar1	0.3594***
	(0.0071)
ar2	0.0398***
	(0.0075)
ar3	0.0987***
	(0.0074)
ar4	0.1032***
	(0.0075)
ar5	0.0820***
	(0.0071)
intercept	0.0194***
	(0.0019)
prop_positive_lag_0	0.0073***
	(0.0017)
prop_positive_lag_1	0.0030
	(0.0017)
prop_positive_lag_2	0.0045**
	(0.0017)
AIC	−44656.4789
AICc	−44656.4679
BIC	−44577.4595
Log Likelihood	22338.2394
Num. obs.	19969

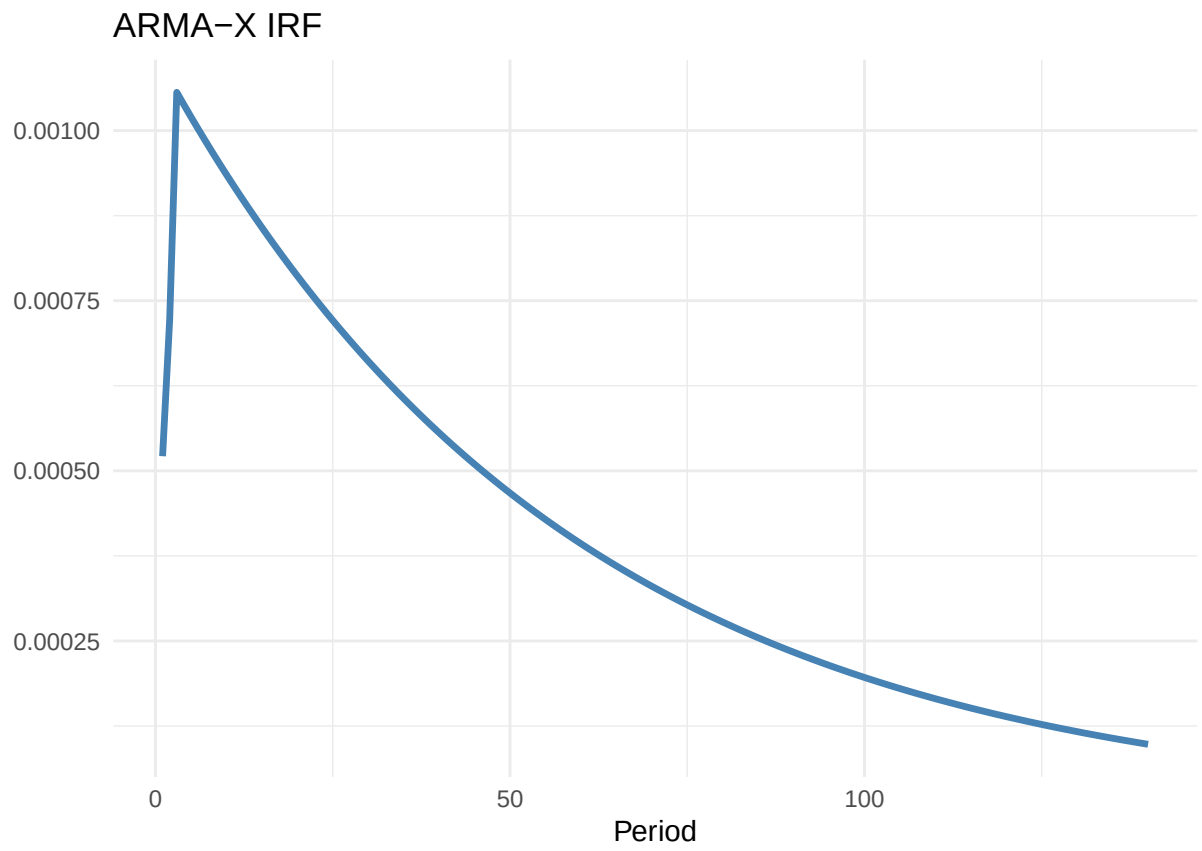
***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

Table 17: ARMAX Model Results

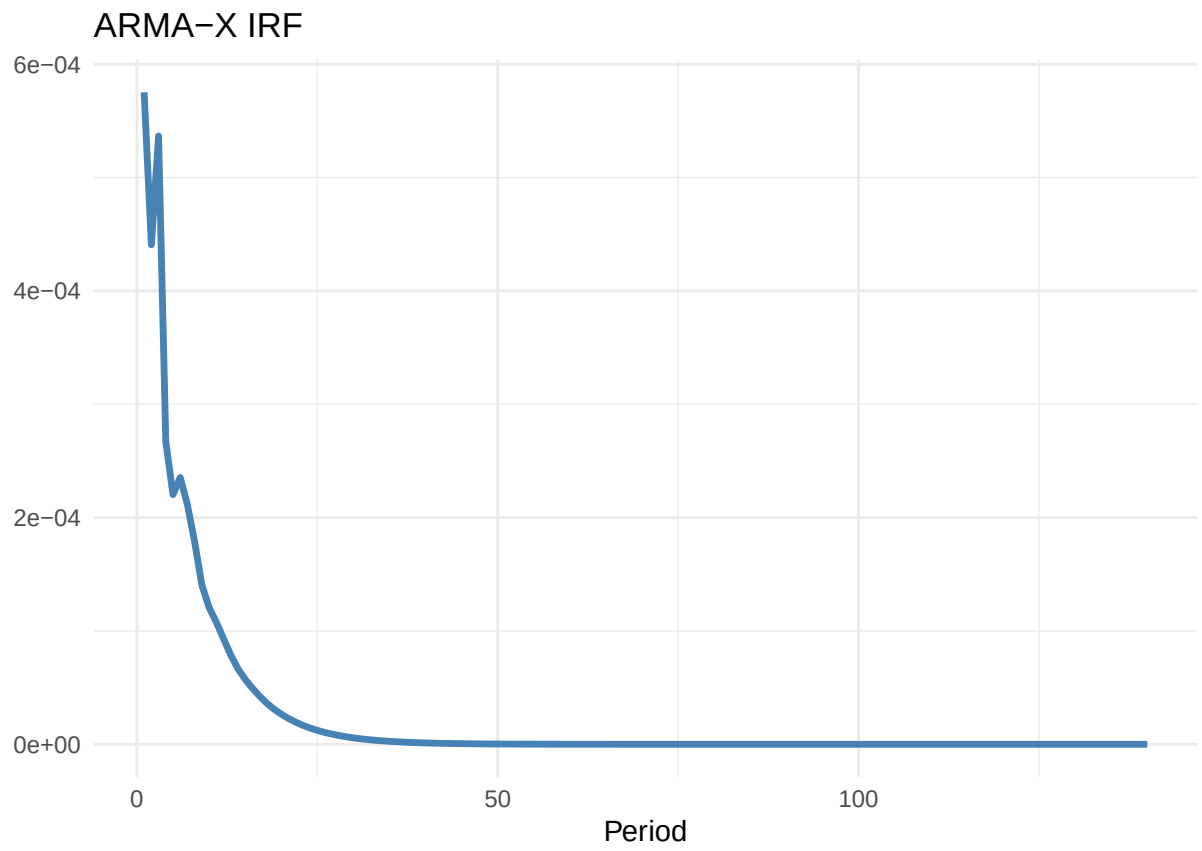
	Model 1
ar1	0.0262
	(0.0503)
ar2	0.7230***
	(0.0390)
ar3	0.2146***
	(0.0283)
ma1	0.2800***
	(0.0489)
ma2	−0.6451***
	(0.0277)
ma3	−0.3571***
	(0.0252)
intercept	0.0212***
	(0.0042)
prop_positive_lag_0	0.0063***
	(0.0016)
AIC	−45722.7625
AICc	−45722.7534
BIC	−45651.6441
Log Likelihood	22870.3812
Num.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

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

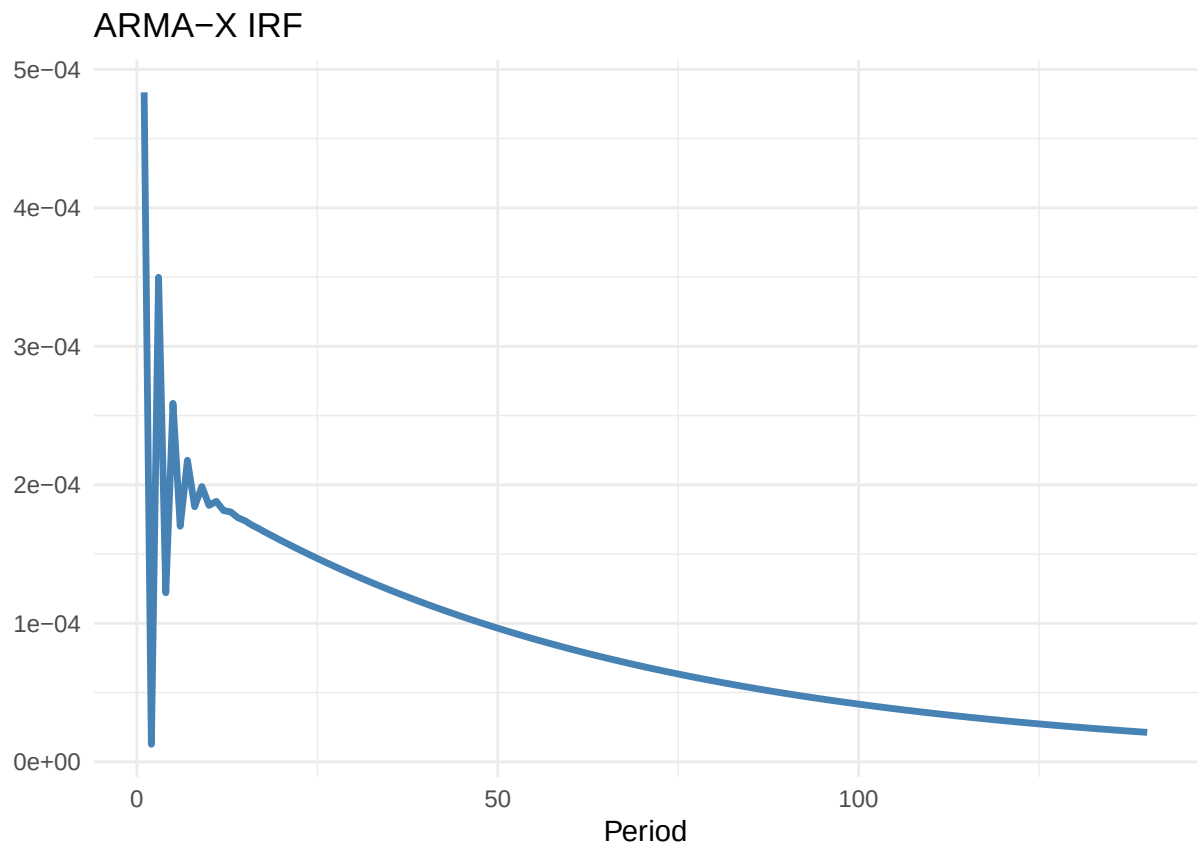
Table 18: ARMAX selected by AIC




```
irf.plot(res2,nb.periods)
```




```
irf.plot(res3$model,nb.periods)
```



Negative Vibe as Exogenous

```
#auto.armax selects the lowest AIC value given r (exogenous variable lags)
res1 = auto.armax(data$SPY_vol,xreg=data$prop_negative,nb.lags=2,
                  latex=T,max.p = 6, max.q = 6, max.d=0)
```

```
#armax enables a custom armax specification with p,q,r
res2 = armax(data$SPY_vol, xreg=data$prop_negative, nb.lags=2,
                    p=5, q=0, d=0, latex=T)
```

```
#auto.armax.r selects the lowest AIC checking all 3 p,q,r values
res3 = auto.armax.r(data$SPY_vol, x=data$prop_negative,
                  max_p = 3, max_q = 3, max_r = 3, criterion = "AIC", latex=T)
```

```
#we want to plot the IRFs of these models
nb.periods = 7 * 20

irf.plot(res1,nb.periods)
```

	Model 1
ar1	0.9828^{***}
	(0.0017)
ma1	-0.6776^{***}
	(0.0073)
ma2	-0.2142^{***}
	(0.0087)
ma3	−0.0126
	(0.0080)
ma4	0.0348^{***}
	(0.0071)
intercept	0.0213^{***}
	(0.0042)
prop_negative_lag_0	0.0068^{**}
	(0.0023)
prop_negative_lag_1	0.0030
	(0.0023)
prop_negative_lag_2	−0.0007
	(0.0023)
AIC	−45673.0125
AICc	−45673.0015
BIC	−45593.9932
Log Likelihood	22846.5063
Num. obs.	19969

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

Table 19: ARMAX Model Results

	Model 1
ar1	0.3594***
	(0.0071)
ar2	0.0403***
	(0.0075)
ar3	0.0978***
	(0.0074)
ar4	0.1033***
	(0.0075)
ar5	0.0819***
	(0.0071)
intercept	0.0212***
	(0.0019)
prop_negative_lag_0	0.0075**
	(0.0023)
prop_negative_lag_1	0.0036
	(0.0023)
prop_negative_lag_2	−0.0012
	(0.0023)
AIC	−44643.1033
AICc	−44643.0923
BIC	−44564.0840
Log Likelihood	22331.5517
Num. obs.	19969

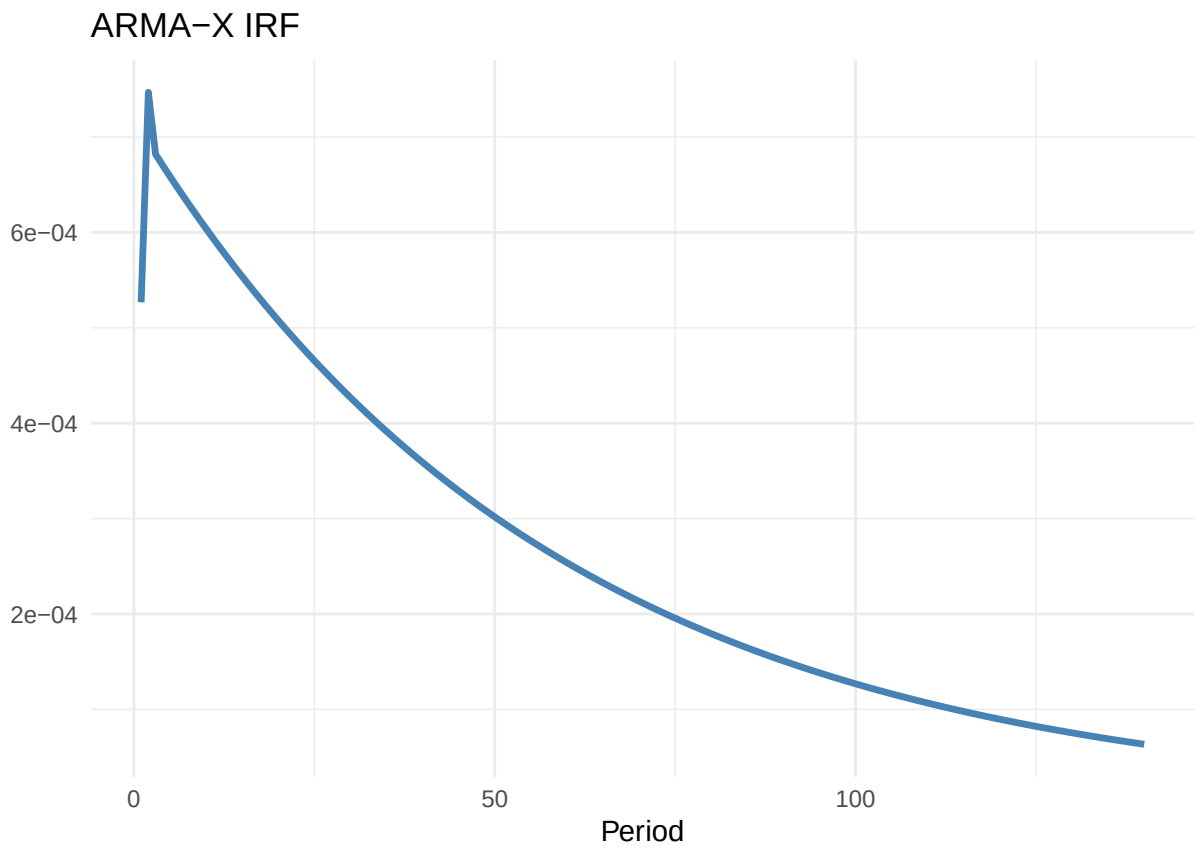
***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

Table 20: ARMAX Model Results

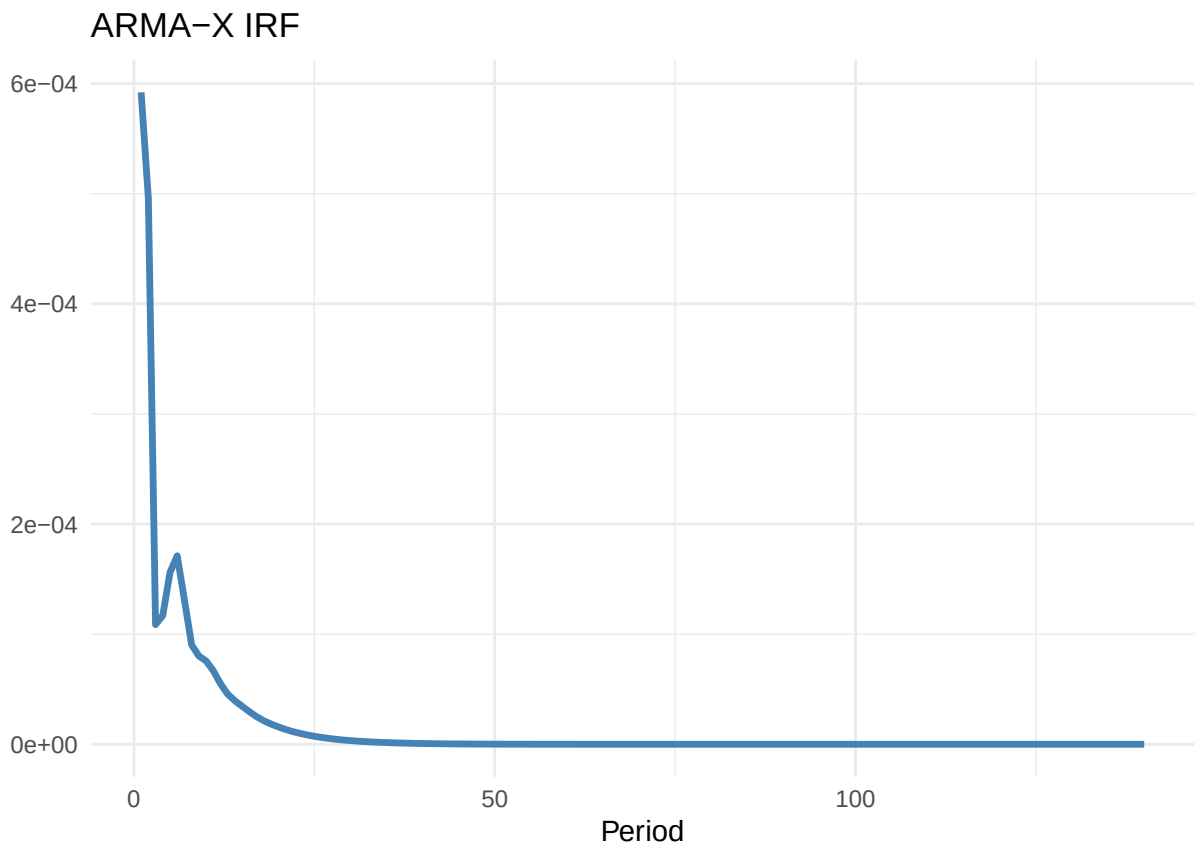
	Model 1
ar1	0.0237
	(0.0495)
ar2	0.7250***
	(0.0379)
ar3	0.2150***
	(0.0283)
ma1	0.2824***
	(0.0481)
ma2	−0.6460***
	(0.0270)
ma3	−0.3581***
	(0.0251)
intercept	0.0216***
	(0.0042)
prop_negative_lag_0	0.0070**
	(0.0022)
AIC	−45716.8054
AICc	−45716.7964
BIC	−45645.6871
Log Likelihood	22867.4027
Num. obs.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

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

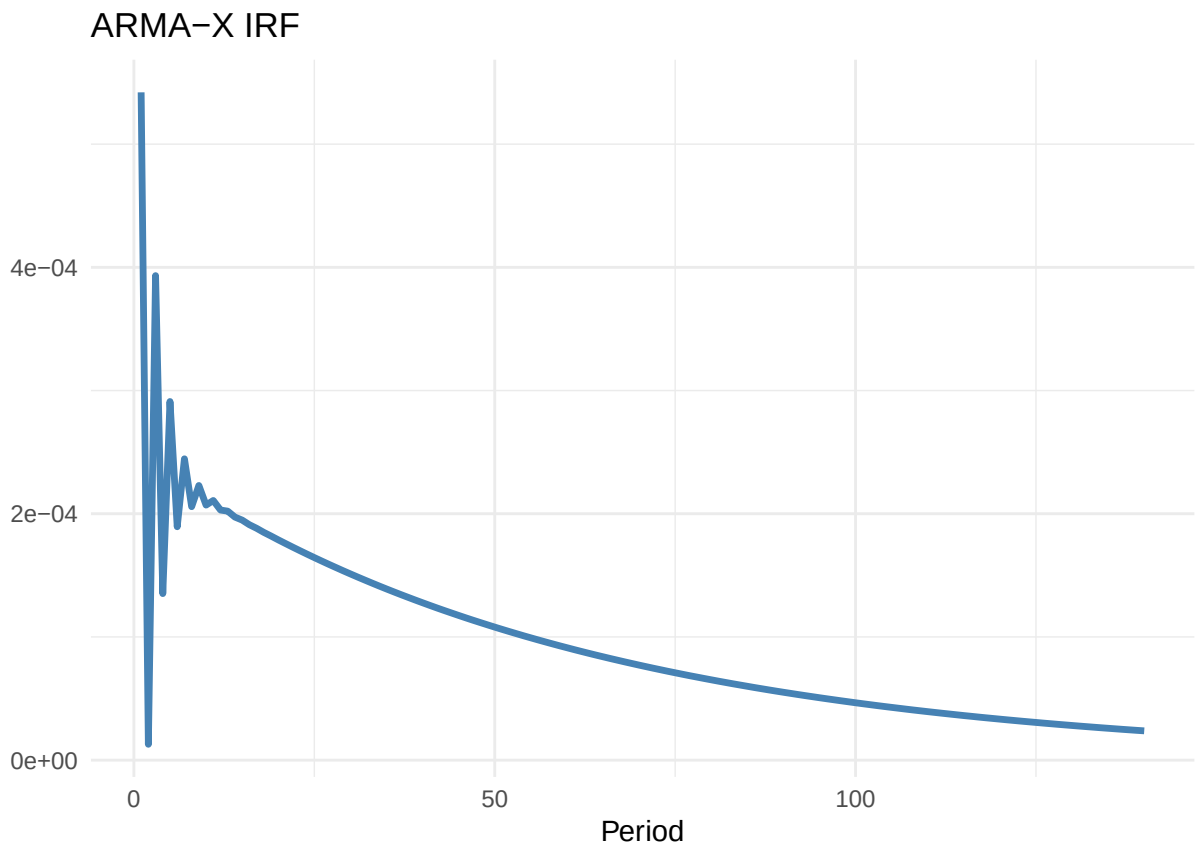
Table 21: ARMAX selected by AIC




```
irf.plot(res2,nb.periods)
```




```
irf.plot(res3$model,nb.periods)
```


ARMA−X IRF
4e−04
2e−04
0e+00
0
50
100
Period