SPY SVAR Models

Contents

Setup

Load packages & functions

```
rm(list=ls())
require(tinytex) #LaTeX
require(ggplot2) #plots
require(AEC) #JP-Renne functions
require(AER) #NW formula
require(forecast) #time series stuff
require(expm) #matrix exponents
require(here) #directory finder
require(stringr) # analysis of strings, important for the detection in tweets
require(dplyr) #data management
require(lubridate) #data dates management
require(zoo) #for lagging
require(jtools) #tables
require(huxtable) #tables
require(lmtest) #reg tests
require(vroom) #for loading data
require(data.table) #for data filtering
require(sysid) #for ARMA-X modeling
require(sandwhich) #regression errors
require(stargazer) #nice reg tables
require(tidytext) #text mining
require(textstem) #lemmatization
require(quanteda) #tokenization
require(texreg) #arima tables
require(vars) #VAR models
require(xts) #time series objects
require(tseries) #includes adf test
require(quantmod)
require(TSA)
require(aTSA)
require(tibble)
require(FinTS)
require(kableExtra)
require(writexl)
require(purrr)

getwd()
#setwd("...") -> set wd at base repo folder

#load helper functions
source(here("helperfunctions/data_loaders.R"))
source(here("helperfunctions/date_selector.R"))
source(here("helperfunctions/plotters.R"))
source(here("helperfunctions/quick_arma.R"))
source(here("helperfunctions/r.vol_calculators.R"))
source(here("helperfunctions/truths_cleaning_function.R"))
source(here("helperfunctions/armax_functions.R"))
source(here("helperfunctions/var_irf.R"))
```

Load Data

```
#load final dataset
source(here("helperfunctions/full_data.R"))

#select timeframe
Vdata = filter(data,between(timestamp, as.Date('2014-01-01'), as.Date('2025-05-07')))
```

Some SVAR estimations

Note that this is not an exhaustive list of our VAR estimations, you can find more by going on /modeling/VAR/VAR_SPY_TRUE or VAR_ASHR_TRUE or VAR_VGK_TRUE).

Dummy variable

Here we use a dummy variable which equal to one if Trump has made a post or 0 otherwise, taking into account the closed hour market posts.

```
y = cbind(Vdata$dummy, Vdata$SPY_vol)
colnames(y)[1:2] <- c("dummy", "vol")
est.VAR <- VAR(y,p=6)
mod_vol <- est.VAR$varresult$vol
texreg(mod_vol, digits = 6)
```

```
Omega <- var(residuals(est.VAR))

#make the B matrix
loss <- function(param){
  #Define the restriction
  B <- matrix(c(param[1], param[2], 0, param[3]), ncol = 2)

  #Make BB' approximatively equal to omega
  X <- Omega - B %*% t(B)

  #loss function
  loss <- sum(X^2)
  return(loss)
}

res.opt <- optim(c(1, 0, 1), loss, method = "BFGS")
B.hat <- matrix(c(res.opt$par[1], res.opt$par[2], 0, res.opt$par[3]), ncol = 2)

print(cbind(Omega,B.hat %*% t(B.hat)))
```

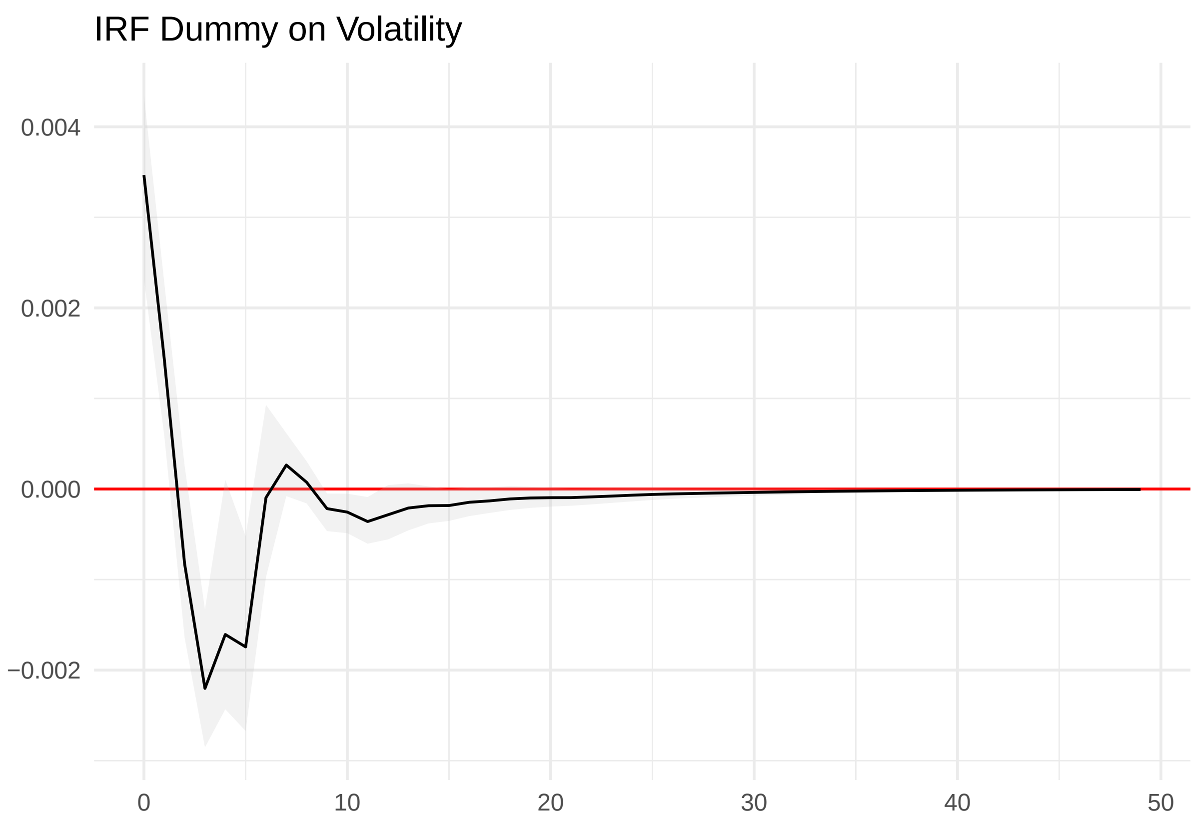
```
##             dummy         vol
## dummy 8.51990313 0.010117308 8.51990217 0.010117313
## vol   0.01011731 0.006077173 0.01011731 0.006076165
```

	Model 1
dummy.l1	0.000083
	(0.000188)
vol.l1	0.344511^{***}
	(0.006992)
dummy.l2	-0.000473^{*}
	(0.000188)
vol.l2	0.023714^{**}
	(0.007402)
dummy.l3	-0.000804^{***}
	(0.000189)
vol.l3	0.082941^{***}
	(0.007372)
dummy.l4	-0.000546^{**}
	(0.000189)
vol.l4	0.096948^{***}
	(0.007371)
dummy.l5	-0.000579^{**}
	(0.000188)
vol.l5	0.022887^{**}
	(0.007403)
dummy.l6	-0.000099
	(0.000188)
vol.l6	0.164034^{***}
	(0.006989)
const	0.008726^{***}
	(0.000849)
R^2	0.285135
Adj. R^2	0.284705
Num. obs.	19965

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

Table 1: Statistical models

```r
#irf creation
irf_res <- irf(est.VAR, impulse = "dummy", response = "vol",
                   bmat=b.hat, n.ahead = 7 * 7, boot = TRUE, ci = 0.95)

#function to extract relevant objects for plotting
single_varirf <- extract_varirf(irf_res)

#the plot
single_varirf %>%
  ggplot(aes(x=period, y=irf_dummy_vol, ymin=lower_dummy_vol, ymax=upper_dummy_vol)) +
  geom_hline(yintercept = 0, color="red") +
  geom_ribbon(fill="grey", alpha=0.2) +
  geom_line() +
  theme_light() +
  ggtitle("IRF Dummy on Volatility")+
  ylab("")+
  xlab("") +
  theme_minimal()
```




```r
#does volatility Granger cause dummy mentions
grangertest(y[,c("vol","dummy")], order = 6)
```

```r
#does dummy mentions Granger cause volatility
grangertest(y[,c("dummy", "vol")], order = 6)
```

Res.Df	Df	F	Pr(>F)
2e+04			
2e+04	-6	4.98	4.19e-05

Res.Df	Df	F	Pr(>F)
2e+04			
2e+04	-6	5.99	2.83e-06

Post Counts

```
y2 = cbind(Vdata$N , Vdata$SPY_vol)
colnames(y2)[1:2] <- c("N", "vol")
est.VAR2 <- VAR(y2,p=6)
mod_vol2 <- est.VAR2$varresult$vol
texreg(mod_vol2, digits = 6)
```

```
Omega2 <- var(residuals(est.VAR2))

#make the B matrix
loss2 <- function(param2){
  #Define the restriction
  B2 <- matrix(c(param2[1], param2[2], 0, param2[3]), ncol = 2)

  #Make BB' approximatively equal to omega
  X2 <- Omega2 - B2 %*% t(B2)

  #loss function
  loss2 <- sum(X2^2)
  return(loss2)
}

res.opt2 <- optim(c(1, 0, 1), loss2, method = "BFGS")
B.hat2 <- matrix(c(res.opt2$par[1], res.opt2$par[2], 0, res.opt2$par[3]), ncol = 2)

print(cbind(Omega2,B.hat2 %*% t(B.hat2)))
```

```
##                 N         vol
## N   79.86723661 0.024691589 79.86723573 0.024691619
## vol  0.02469159 0.006080964  0.02469162 0.006081985
```

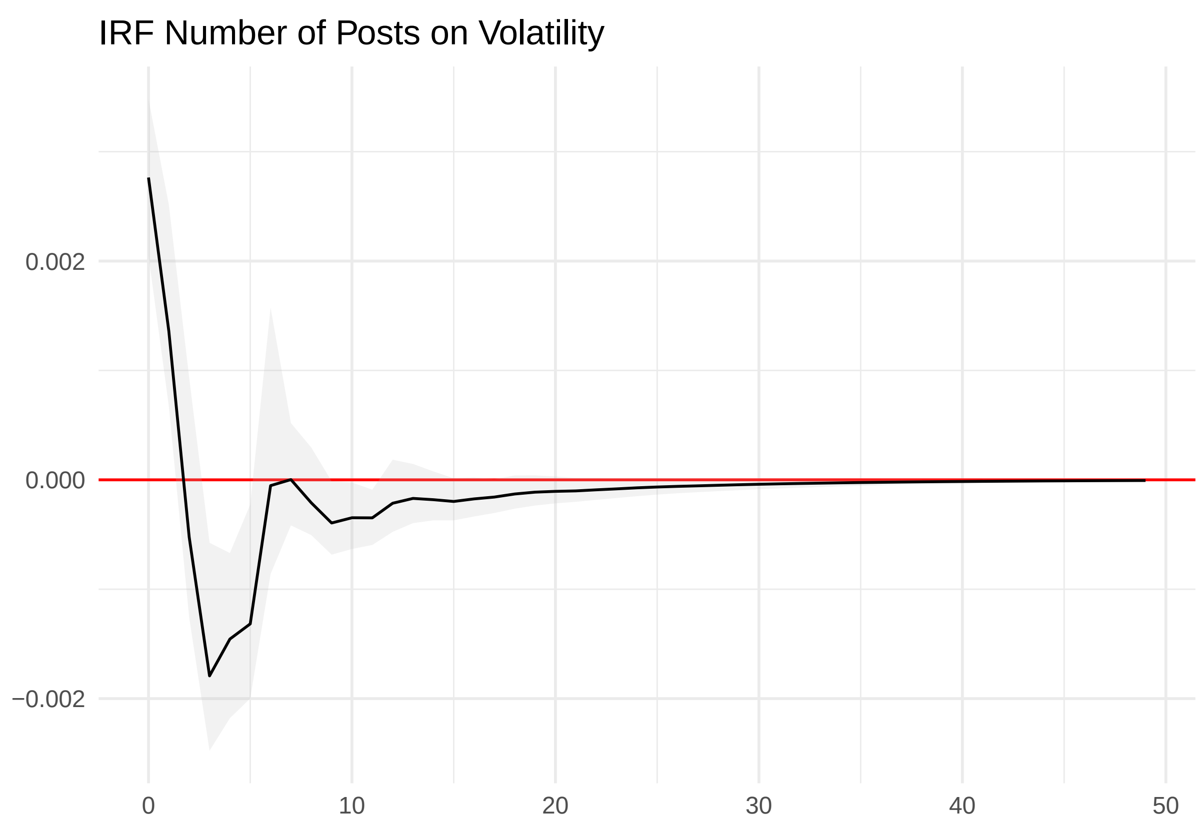
```
#irf creation
irf_res2 <- irf(est.VAR2, impulse = "N", response = "vol",
                  bmat=b.hat2, n.ahead = 7 * 7, boot = TRUE, ci = 0.95)

#function to extract relevant objects for plotting
single_varirf2 <- extract_varirf(irf_res2)
```

	Model 1
N.l1	0.000045
	(0.000062)
vol.l1	0.345011^{***}
	(0.006988)
N.l2	-0.000116
	(0.000062)
vol.l2	0.023575^{**}
	(0.007401)
N.l3	-0.000213^{***}
	(0.000062)
vol.l3	0.082525^{***}
	(0.007370)
N.l4	-0.000147^{*}
	(0.000062)
vol.l4	0.096739^{***}
	(0.007370)
N.l5	-0.000119
	(0.000062)
vol.l5	0.022593^{**}
	(0.007401)
N.l6	0.000000
	(0.000062)
vol.l6	0.164442^{***}
	(0.006986)
const	0.007587^{***}
	(0.000754)
R^2	0.284689
Adj. R^2	0.284259
Num. obs.	19965

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

Table 2: Statistical models

```r
#the plot
single_varirf2 %>%
  ggplot(aes(x=period, y=irf_n_vol, ymin=lower_n_vol, ymax=upper_n_vol)) +
  geom_hline(yintercept = 0, color="red") +
  geom_ribbon(fill="grey", alpha=0.2) +
  geom_line() +
  theme_light() +
  ggtitle("IRF Number of Posts on Volatility")+
  ylab("")+
  xlab("") +
  theme_minimal()
```




```r
#does volatility Granger cause N mentions
grangertest(y2[,c("vol","N")], order = 6)
```

Res.Df	Df	F	Pr(>F)
2e+04			
2e+04	-6	3.89	0.000688

```r
#does N mentions Granger cause volatility
grangertest(y2[,c("N", "vol")], order = 6)
```

Res.Df	Df	F	Pr(>F)
2e+04			
2e+04	-6	3.92	0.000646

Tariff Mention

```r
y3 = cbind(Vdata$tariff , Vdata$SPY_vol)
colnames(y3)[1:2] <- c("tariff", "vol")
est.VAR3 <- VAR(y3,p=6)
mod_vol3 <- est.VAR3$varresult$vol
texreg(mod_vol3, digits = 6)
```

```r
Omega3 <- var(residuals(est.VAR3))

#make the B matrix
loss3 <- function(param3){
  #Define the restriction
  B3 <- matrix(c(param3[1], param3[2], 0, param3[3]), ncol = 2)

  #Make BB' approximatively equal to omega
  X3 <- Omega3 - B3 %*% t(B3)

  #loss function
  loss3 <- sum(X3^2)
  return(loss3)
}

res.opt3 <- optim(c(1, 0, 1), loss3, method = "BFGS")
B.hat3 <- matrix(c(res.opt3$par[1], res.opt3$par[2], 0, res.opt3$par[3]), ncol = 2)

print(cbind(Omega3,B.hat3 %*% t(B.hat3)))
```

```
##              tariff          vol
## tariff 0.1422112842 0.0007678487 0.1422102848 0.0007678501
## vol    0.0007678487 0.0060214190 0.0007678501 0.0060204238
```

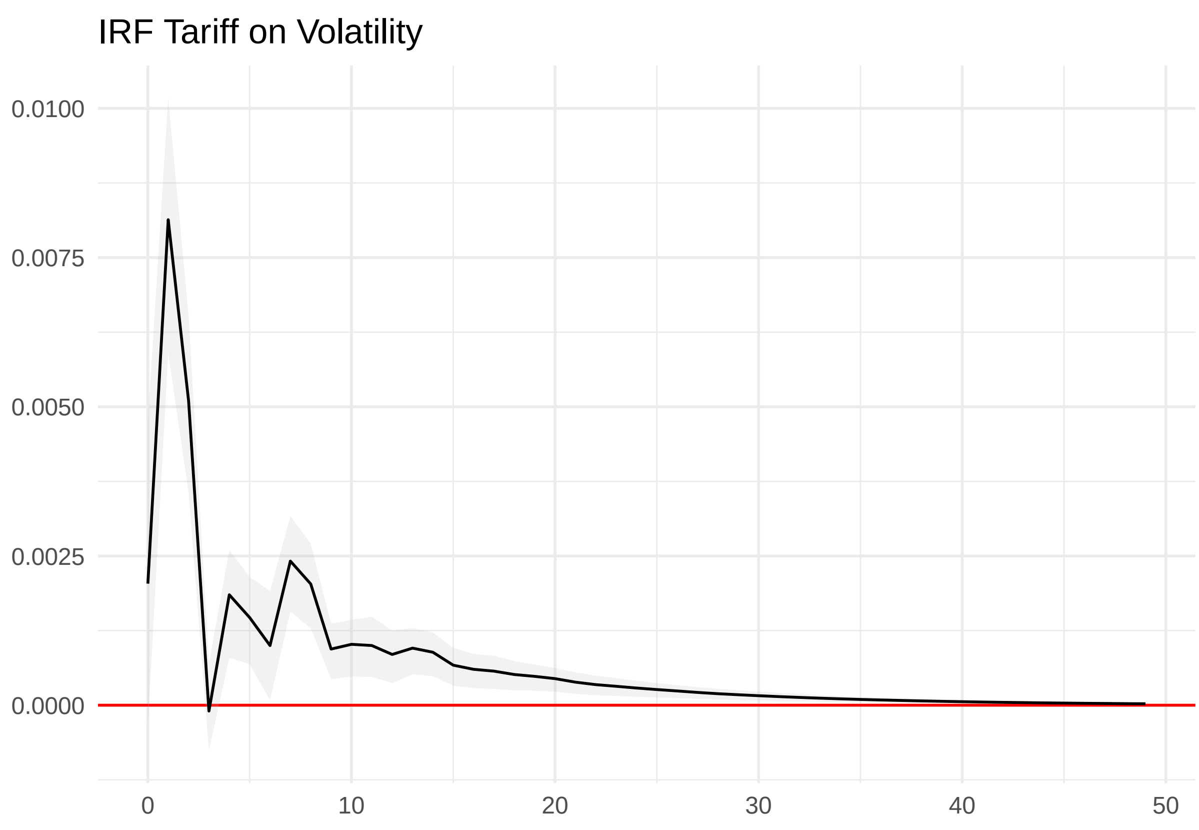
```r
#irf creation
irf_res3 <- irf(est.VAR3, impulse = "tariff", response = "vol",
                  bmat=b.hat3, n.ahead = 7 * 7, boot = TRUE, ci = 0.95)

#function to extract relevant objects for plotting
single_varirf3 <- extract_varirf(irf_res3)
```

	Model 1
tariff.l1	0.019718^{***}
	(0.001454)
vol.l1	0.342081^{***}
	(0.006981)
tariff.l2	0.005269^{***}
	(0.001460)
vol.l2	0.027464^{***}
	(0.007388)
tariff.l3	-0.007797^{***}
	(0.001464)
vol.l3	0.075380^{***}
	(0.007374)
tariff.l4	0.002275
	(0.001463)
vol.l4	0.088777^{***}
	(0.007383)
tariff.l5	-0.001145
	(0.001456)
vol.l5	0.026049^{***}
	(0.007407)
tariff.l6	-0.002750
	(0.001457)
vol.l6	0.167546^{***}
	(0.006969)
const	0.005770^{***}
	(0.000585)
R^2	0.291693
Adj. R^2	0.291267
Num. obs.	19965

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

Table 3: Statistical models

```r
#the plot
single_varirf3 %>%
  ggplot(aes(x=period, y=irf_tariff_vol, ymin=lower_tariff_vol, ymax=upper_tariff_vol)) +
  geom_hline(yintercept = 0, color="red") +
  geom_ribbon(fill="grey", alpha=0.2) +
  geom_line() +
  theme_light() +
  ggtitle("IRF Tariff on Volatility")+
  ylab("")+
  xlab("") +
  theme_minimal()
```




```r
#does volatility Granger cause tariff mentions
grangertest(y3[,c("vol","tariff")], order = 6)
```

Res.Df	Df	F	Pr(>F)
2e+04			
2e+04	-6	37.5	1.54e-45

```r
#does tariff mentions Granger cause volatility
grangertest(y3[,c("tariff", "vol")], order = 6)
```

Res.Df	Df	F	Pr(>F)
2e+04			
2e+04	-6	36.8	1.12e-44

Trade Mention

```
y4 = cbind(Vdata$trade , Vdata$SPY_vol)
colnames(y4)[1:2] <- c("trade", "vol")
est.VAR4 <- VAR(y4,p=6)
mod_vol4 <- est.VAR4$varresult$vol
texreg(mod_vol4, digits = 6)
```

```
Omega4 <- var(residuals(est.VAR4))

#make the B matrix
loss4 <- function(param4){
  #Define the restriction
  B4 <- matrix(c(param4[1], param4[2], 0, param4[3]), ncol = 2)

  #Make BB' approximatively equal to omega
  X4 <- Omega4 - B4 %*% t(B4)

  #loss function
  loss4 <- sum(X4^2)
  return(loss4)
}

res.opt4 <- optim(c(1, 0, 1), loss4, method = "BFGS")
B.hat4 <- matrix(c(res.opt4$par[1], res.opt4$par[2], 0, res.opt4$par[3]), ncol = 2)

print(cbind(Omega4,B.hat4 %*% t(B.hat4)))
```

```
##              trade          vol
## trade 0.0834767755 0.0001006696 0.08347578 0.000100670
## vol   0.0001006696 0.0060826770 0.00010067 0.006081703
```

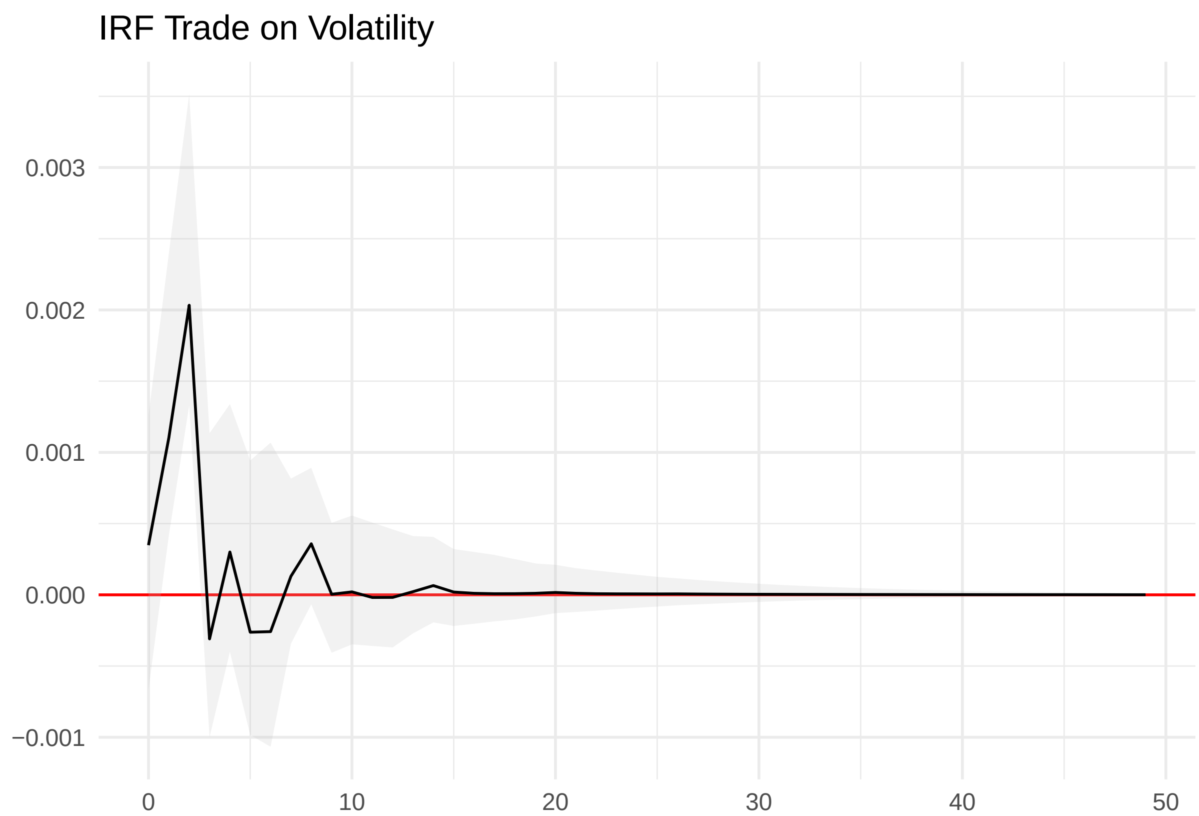
```
#irf creation
irf_res4 <- irf(est.VAR4, impulse = "trade", response = "vol",
                  bmat=b.hat4, n.ahead = 7 * 7, boot = TRUE, ci = 0.95)

#function to extract relevant objects for plotting
single_varirf4 <- extract_varirf(irf_res4)

#the plot
single_varirf4 %>%
  ggplot(aes(x=period, y=irf_trade_vol, ymin=lower_trade_vol, ymax=upper_trade_vol)) +
  geom_hline(yintercept = 0, color="red") +
  geom_ribbon(fill="grey", alpha=0.2) +
```

	Model 1
trade.l1	0.003399
	(0.001910)
vol.l1	0.346107^{***}
	(0.006983)
trade.l2	0.005600^{**}
	(0.001911)
vol.l2	0.022949^{**}
	(0.007398)
trade.l3	-0.003904^{*}
	(0.001911)
vol.l3	0.081148^{***}
	(0.007374)
trade.l4	0.000725
	(0.001913)
vol.l4	0.095797^{***}
	(0.007374)
trade.l5	-0.002363
	(0.001912)
vol.l5	0.023502^{**}
	(0.007401)
trade.l6	-0.001543
	(0.001911)
vol.l6	0.165323^{***}
	(0.006986)
const	0.005939^{***}
	(0.000603)
R^2	0.284487
Adj. R^2	0.284057
Num. obs.	19965

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

Table 4: Statistical models

```
  geom_line() +
  theme_light() +
  ggtitle("IRF Trade on Volatility")+
  ylab("")+
  xlab("") +
  theme_minimal()
```




```
#does volatility Granger cause trade mentions
grangertest(y4[,c("vol","trade")], order = 6)
```

Res.Df	Df	F	Pr(>F)
2e+04			
2e+04	-6	10.6	9.06e-12

```
#does trade mentions Granger cause volatility
grangertest(y4[,c("trade", "vol")], order = 6)
```

Res.Df	Df	F	Pr(>F)
2e+04			
2e+04	-6	2.98	0.00655

China Mention

```
y5 = cbind(Vdata$china , Vdata$SPY_vol)
colnames(y5)[1:2] <- c("china", "vol")
est.VAR5 <- VAR(y5,p=6)
mod_vol5 <- est.VAR5$varresult$vol
texreg(mod_vol5, digits = 6)
```

```
Omega5 <- var(residuals(est.VAR5))

#make the B matrix
loss5 <- function(param5){
  #Define the restriction
  B5 <- matrix(c(param5[1], param5[2], 0, param5[3]), ncol = 2)

  #Make BB' approximatively equal to omega
  X5 <- Omega5 - B5 %*% t(B5)

  #loss function
  loss5 <- sum(X5^2)
  return(loss5)
}

res.opt5 <- optim(c(1, 0, 1), loss5, method = "BFGS")
B.hat5 <- matrix(c(res.opt5$par[1], res.opt5$par[2], 0, res.opt5$par[3]), ncol = 2)

print(cbind(Omega5,B.hat5 %*% t(B.hat5)))
```

```
##              china          vol
## china 0.2019008552 0.0008143567 0.2018998607 0.0008143568
## vol   0.0008143567 0.0060717717 0.0008143568 0.0060707887
```

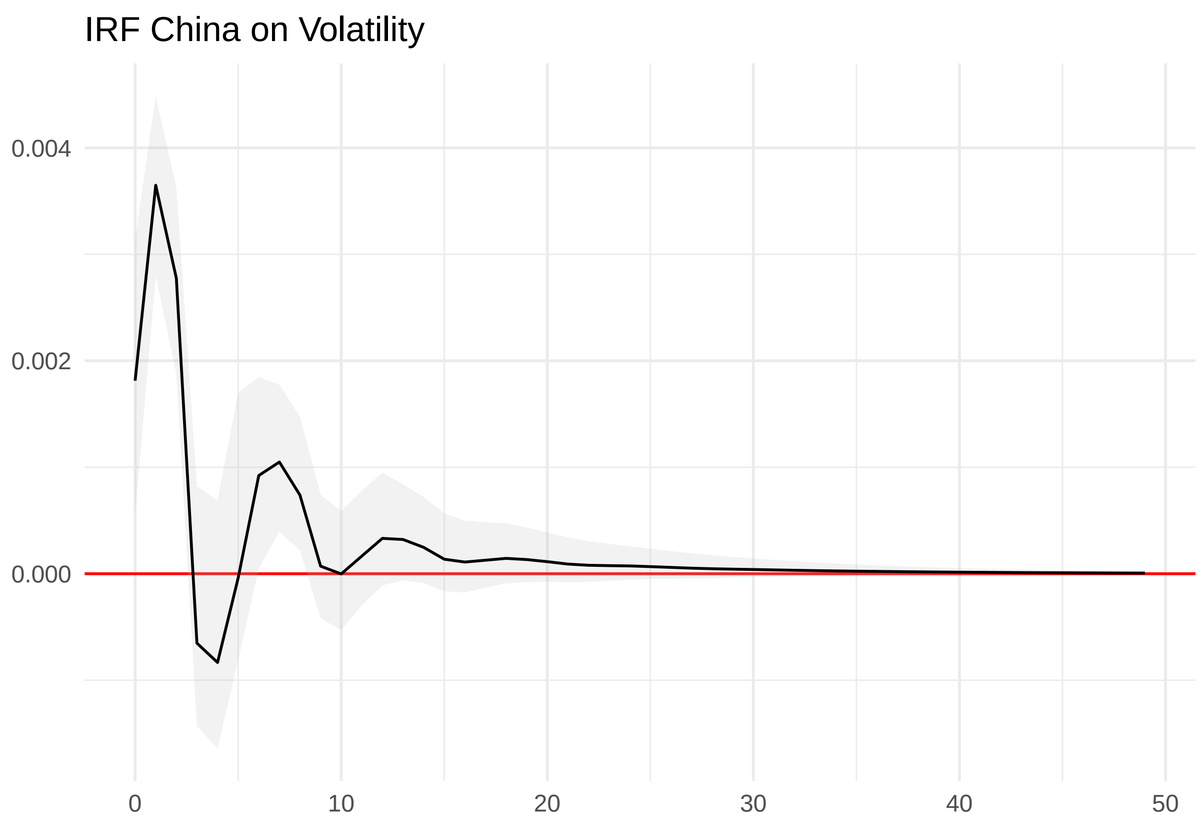
```
#irf creation
irf_res5 <- irf(est.VAR5, impulse = "china", response = "vol",
                  bmat=b.hat5, n.ahead = 7 * 7, boot = TRUE, ci = 0.95)

#function to extract relevant objects for plotting
single_varirf5 <- extract_varirf(irf_res5)

#the plot
single_varirf5 %>%
  ggplot(aes(x=period, y=irf_china_vol, ymin=lower_china_vol, ymax=upper_china_vol)) +
  geom_hline(yintercept = 0, color="red") +
  geom_ribbon(fill="grey", alpha=0.2) +
```

	Model 1
china.l1	0.006729^{***}
	(0.001226)
vol.l1	0.344512^{***}
	(0.006982)
china.l2	0.002778^{*}
	(0.001229)
vol.l2	0.024149^{**}
	(0.007394)
china.l3	-0.004652^{***}
	(0.001229)
vol.l3	0.081646^{***}
	(0.007367)
china.l4	-0.002442^{*}
	(0.001230)
vol.l4	0.094919^{***}
	(0.007368)
china.l5	-0.000607
	(0.001229)
vol.l5	0.022961^{**}
	(0.007397)
china.l6	0.000596
	(0.001227)
vol.l6	0.166695^{***}
	(0.006978)
const	0.005857^{***}
	(0.000603)
R^2	0.285770
Adj. R^2	0.285341
Num. obs.	19965

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

Table 5: Statistical models

```
  geom_line() +
  theme_light() +
  ggtitle("IRF China on Volatility")+
  ylab("")+
  xlab("") +
  theme_minimal()
```




```
#does volatility Granger cause china mentions
grangertest(y5[,c("vol","china")], order = 6)
```

Res.Df	Df	F	Pr(>F)
2e+04			
2e+04	-6	7.43	5.74e-08

```
#does china mentions Granger cause volatility
grangertest(y5[,c("china", "vol")], order = 6)
```

Post Count and Tariff Mention Interaction

Here is an example of adding interaction terms.

Res.Df	Df	F	Pr(>F)
2e+04			
2e+04	-6	8.96	8.55e-10

```r
#interaction
##N and tariff, 2 variables

int1 = Vdata$tariff * Vdata$N

y12 = cbind(int1, Vdata$SPY_vol)
colnames(y12)[1:2] <- c("interaction", "vol")
est.VAR12 <- VAR(y12,p=6)
mod_vol12 <- est.VAR12$varresult$vol
texreg(mod_vol12, digits = 6)
```

```r
Omega12 <- var(residuals(est.VAR12))
#make the B matrix
loss12 <- function(param12){
  #Define the restriction
  B12 <- matrix(c(param12[1], param12[2], 0, param12[3]), ncol = 2)

  #Make BB' approximatively equal to omega
  X12 <- Omega12 - B12 %*% t(B12)

  #loss function
  loss12 <- sum(X12^2)
  return(loss12)
}

res.opt12 <- optim(c(1, 0, 1), loss12, method = "BFGS")
B.hat12 <- matrix(c(res.opt12$par[1], res.opt12$par[2], 0, res.opt12$par[3]), ncol = 2)

print(cbind(Omega12,B.hat12 %*% t(B.hat12)))
```

```
##              interaction        vol
## interaction 708.64123701 0.02468214 708.64123601 0.024682138
## vol           0.02468214 0.00608363   0.02468214 0.006082714
```

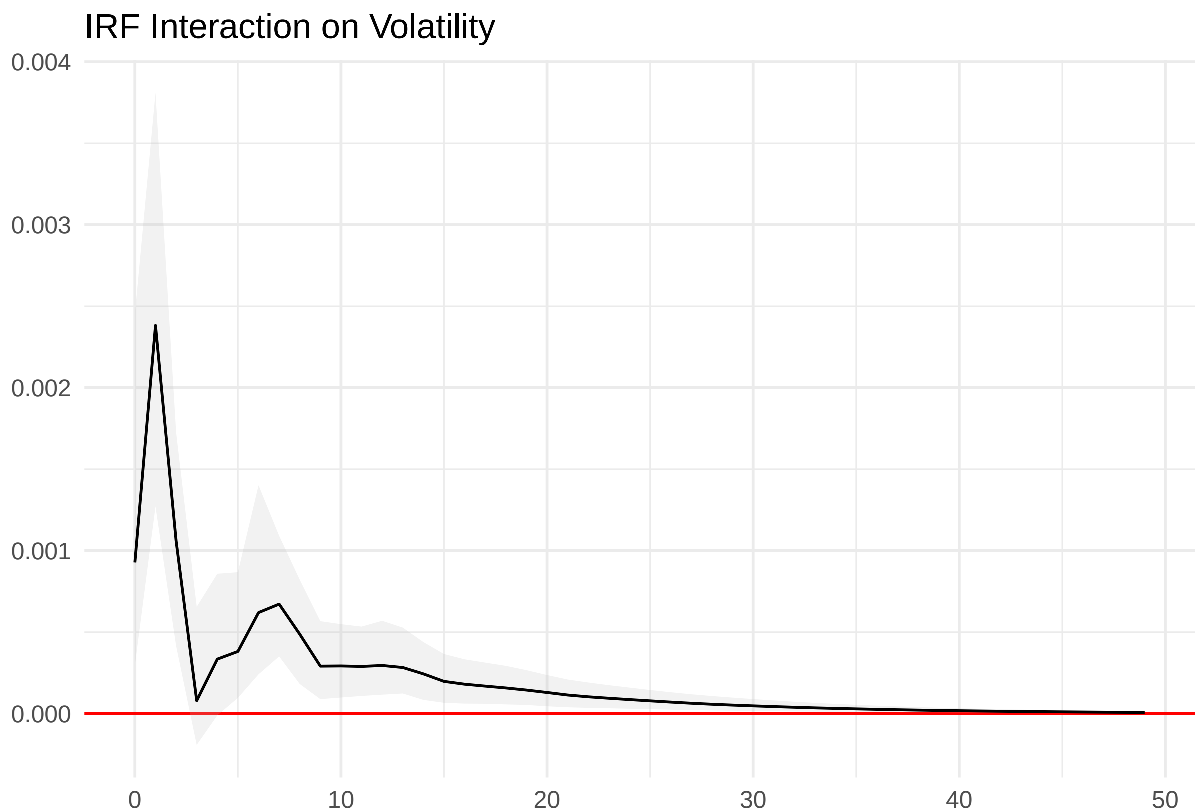
```r
#irf creation
irf_res12 <- irf(est.VAR12, impulse = "interaction", response = "vol",
                 bmat=b.hat12, n.ahead = 7 * 7, boot = TRUE, ci = 0.95)

#function to extract relevant objects for plotting
single_varirf12 <- extract_varirf(irf_res12)

#the plot
single_varirf12 %>%
  ggplot(aes(x=period, y=irf_interaction_vol, ymin=lower_interaction_vol, ymax=upper_interaction_vol)) +
  geom_hline(yintercept = 0, color="red") +
```

	Model 1
interaction.l1	0.000077***
	(0.000021)
vol.l1	0.345775***
	(0.006982)
interaction.l2	0.000008
	(0.000021)
vol.l2	0.023165**
	(0.007398)
interaction.l3	−0.000016
	(0.000021)
vol.l3	0.081682***
	(0.007368)
interaction.l4	−0.000000
	(0.000021)
vol.l4	0.096177***
	(0.007368)
interaction.l5	−0.000004
	(0.000021)
vol.l5	0.022393**
	(0.007397)
interaction.l6	0.000006
	(0.000021)
vol.l6	0.165429***
	(0.006980)
const	0.005964***
	(0.000587)
R^2	0.284375
Adj. R^2	0.283945
Num. obs.	19965

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

Table 6: Statistical models

```
  geom_ribbon(fill="grey", alpha=0.2) +
  geom_line() +
  theme_light() +
  ggtitle("IRF Interaction on Volatility")+
  ylab("")+
  xlab("") +
  theme_minimal()
```



Split Terms

Here we look for the first and second mandate effect of posts. We will use the tariff variable as a proxy for the posts.

First mandate

```
# First and Second Mandate

#first term
Vdata_f = filter(data,between(timestamp, as.Date('2017-01-20'), as.Date('2021-01-20')))

#second term
Vdata_s = filter(data,between(timestamp, as.Date('2025-01-20'), as.Date('2025-05-07')))
```

	Model 1
tariff.l1	−0.000454
	(0.001203)
vol.l1	0.543570***
	(0.011208)
tariff.l2	−0.000289
	(0.001202)
vol.l2	−0.115106***
	(0.012903)
tariff.l3	−0.001007
	(0.001204)
vol.l3	0.053635***
	(0.012788)
tariff.l4	−0.000274
	(0.001204)
vol.l4	0.184183***
	(0.012788)
tariff.l5	−0.000468
	(0.001202)
vol.l5	−0.091496***
	(0.012903)
tariff.l6	0.000240
	(0.001203)
vol.l6	0.343373***
	(0.011207)
const	0.001510***
	(0.000416)
R^2	0.652239
Adj. R^2	0.651645
Num. obs.	7036

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

Table 7: Statistical models

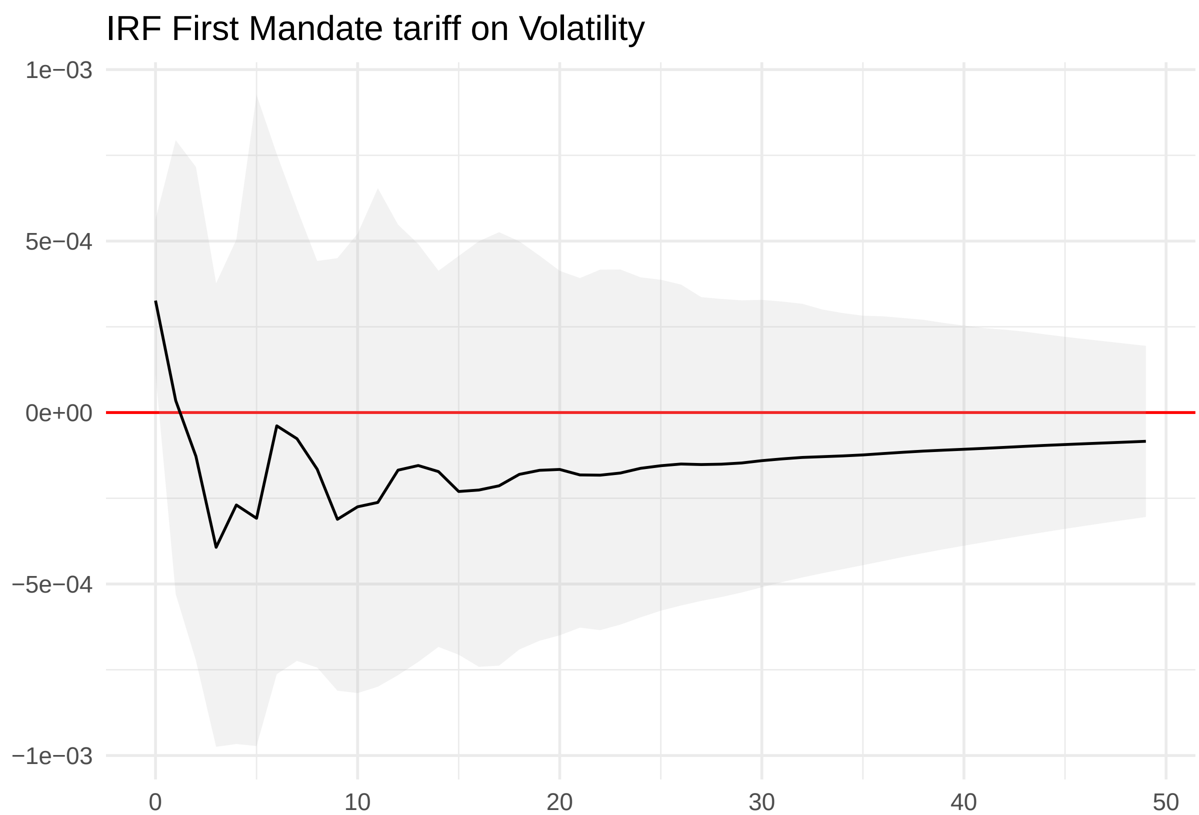
```
y_f_d = cbind(Vdata_f$tariff, Vdata_f$SPY_vol)
colnames(y_f_d)[1:2] <- c("tariff", "vol")
est.VAR_f_d <- VAR(y_f_d,p=6)
mod_vol_f_d <- est.VAR_f_d$varresult$vol
texreg(mod_vol_f_d, digits = 6)
```

```
Omega_f_d <- var(residuals(est.VAR_f_d))
#make the B matrix
loss_f_d <- function(param_f_d){
  #Define the restriction
  B_f_d <- matrix(c(param_f_d[1], param_f_d[2], 0, param_f_d[3]), ncol = 2)

  #Make BB' approximatively equal to omega
  X_f_d <- Omega_f_d - B_f_d %*% t(B_f_d)

  #loss function
  loss_f_d <- sum(X_f_d^2)
```

```r
  return(loss_f_d)
}

res.opt_f_d <- optim(c(1, 0, 1), loss_f_d, method = "BFGS")
B.hat_f_d <- matrix(c(res.opt_f_d$par[1], res.opt_f_d$par[2], 0, res.opt_f_d$par[3]), ncol = 2)

print(cbind(Omega_f_d,B.hat_f_d %*% t(B.hat_f_d)))
```

```
##              tariff          vol
## tariff 0.0983593077 0.0001022935 0.0983584298 0.0001021937
## vol    0.0001022935 0.0010122611 0.0001021937 0.0010121908
```

```r
#irf creation
irf_res_f_d <- irf(est.VAR_f_d, impulse = "tariff", response = "vol",
                  bmat=b.hat_f_d, n.ahead = 7 * 7, boot = TRUE, ci = 0.95)

#function to extract relevant objects for plotting
single_varirf_f_d <- extract_varirf(irf_res_f_d)

#the plot
single_varirf_f_d %>%
  ggplot(aes(x=period, y=irf_tariff_vol, ymin=lower_tariff_vol, ymax=upper_tariff_vol)) +
  geom_hline(yintercept = 0, color="red") +
  geom_ribbon(fill="grey", alpha=0.2) +
  geom_line() +
  theme_light() +
  ggtitle("IRF First Mandate tariff on Volatility")+
  ylab("")+
  xlab("") +
  theme_minimal()
```




```
#does vol granger cause tariff
grangertest(y_f_d[,c("vol","tariff")], order = 6)
```

Res.Df	Df	F	Pr(>F)
7.02e+03			
7.03e+03	-6	0.198	0.978

```
#does tariff granger cause vol
grangertest(y_f_d[,c("tariff", "vol")], order = 6)
```

Res.Df	Df	F	Pr(>F)
7.02e+03			
7.03e+03	-6	0.239	0.964

Second Mandate

	Model 1
tariff.l1	0.027028**
	(0.010236)
vol.l1	0.294752***
	(0.044373)
tariff.l2	0.008588
	(0.010304)
vol.l2	0.020667
	(0.046306)
tariff.l3	−0.010306
	(0.010326)
vol.l3	0.068749
	(0.046301)
tariff.l4	0.002002
	(0.010314)
vol.l4	0.074401
	(0.046412)
tariff.l5	−0.002649
	(0.010258)
vol.l5	0.015342
	(0.046487)
tariff.l6	−0.004279
	(0.010255)
vol.l6	0.132056**
	(0.044283)
const	0.049265*
	(0.023399)
R^2	0.185830
Adj. R^2	0.166251
Num. obs.	512

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

Table 8: Statistical models

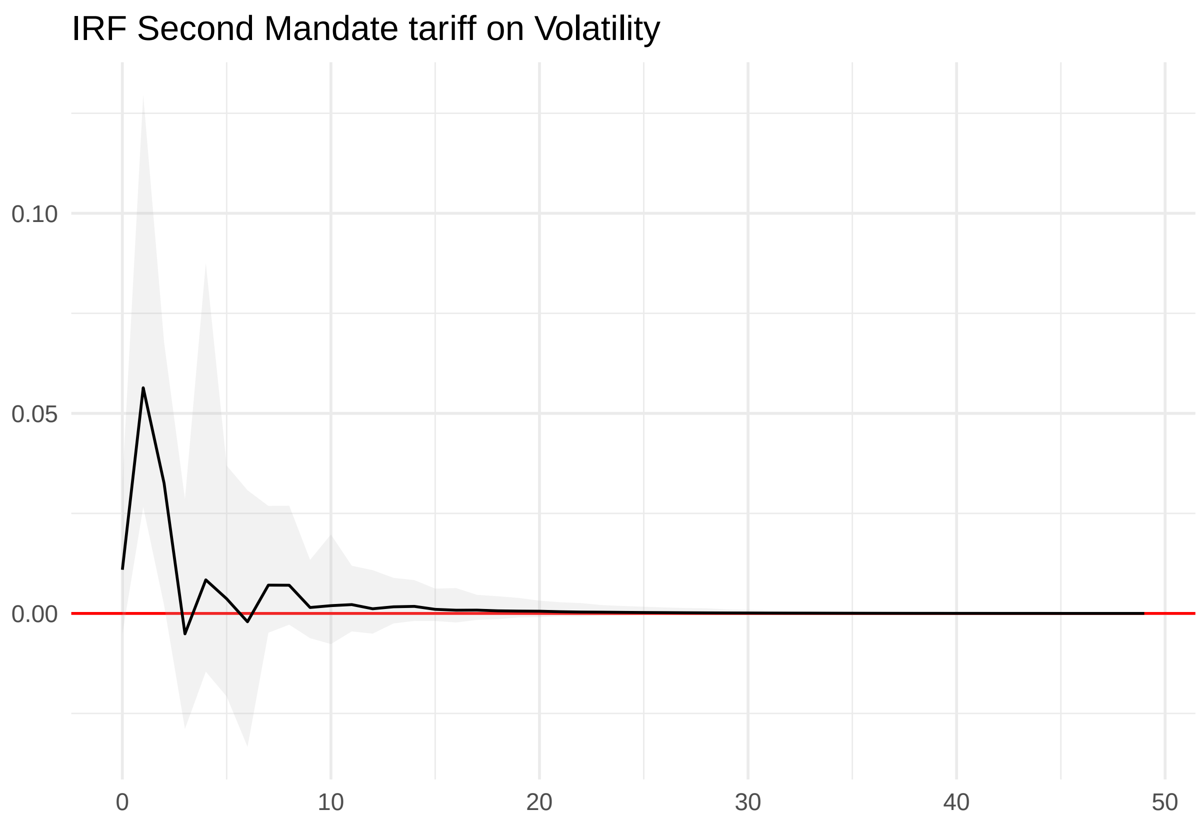
```r
y_s_d = cbind(Vdata_s$tariff, Vdata_s$SPY_vol)
colnames(y_s_d)[1:2] <- c("tariff", "vol")
est.VAR_s_d <- VAR(y_s_d,p=6)
mod_vol_s_d <- est.VAR_s_d$varresult$vol
texreg(mod_vol_s_d, digits = 6)
```

```r
Omega_s_d <- var(residuals(est.VAR_s_d))
#make the B matrix
loss_s_d <- function(param_s_d){
  #Define the restriction
  B_s_d <- matrix(c(param_s_d[1], param_s_d[2], 0, param_s_d[3]), ncol = 2)

  #Make BB' approximatively equal to omega
  X_s_d <- Omega_s_d - B_s_d %*% t(B_s_d)

  #loss function
  loss_s_d <- sum(X_s_d^2)
```

```r
  return(loss_s_d)
}

res.opt_s_d <- optim(c(1, 0, 1), loss_s_d, method = "BFGS")
B.hat_s_d <- matrix(c(res.opt_s_d$par[1], res.opt_s_d$par[2], 0, res.opt_s_d$par[3]), ncol = 2)

print(cbind(Omega_s_d,B.hat_s_d %*% t(B.hat_s_d)))
```

```
##             tariff        vol
## tariff 3.78068588 0.02097243 3.78068489 0.02097242
## vol    0.02097243 0.19766504 0.02097242 0.19766404
```

```r
#irf creation
irf_res_s_d <- irf(est.VAR_s_d, impulse = "tariff", response = "vol",
                   bmat=b.hat_s_d, n.ahead = 7 * 7, boot = TRUE, ci = 0.95)

#function to extract relevant objects for plotting
single_varirf_s_d <- extract_varirf(irf_res_s_d)

#the plot
single_varirf_s_d %>%
  ggplot(aes(x=period, y=irf_tariff_vol, ymin=lower_tariff_vol, ymax=upper_tariff_vol)) +
  geom_hline(yintercept = 0, color="red") +
  geom_ribbon(fill="grey", alpha=0.2) +
  geom_line() +
  theme_light() +
  ggtitle("IRF Second Mandate tariff on Volatility")+
  ylab("")+
  xlab("") +
  theme_minimal()
```




```r
#does vol granger cause tariff
grangertest(y_s_d[,c("vol","tariff")], order = 6)
```

Res.Df	Df	F	Pr(>F)
499			
505	-6	1.36	0.229

```r
#does tariff granger cause vol
grangertest(y_s_d[,c("tariff", "vol")], order = 6)
```

Res.Df	Df	F	Pr(>F)
499			
505	-6	1.42	0.204