VGK 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$dummy, Vdata$VGK_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)))
```

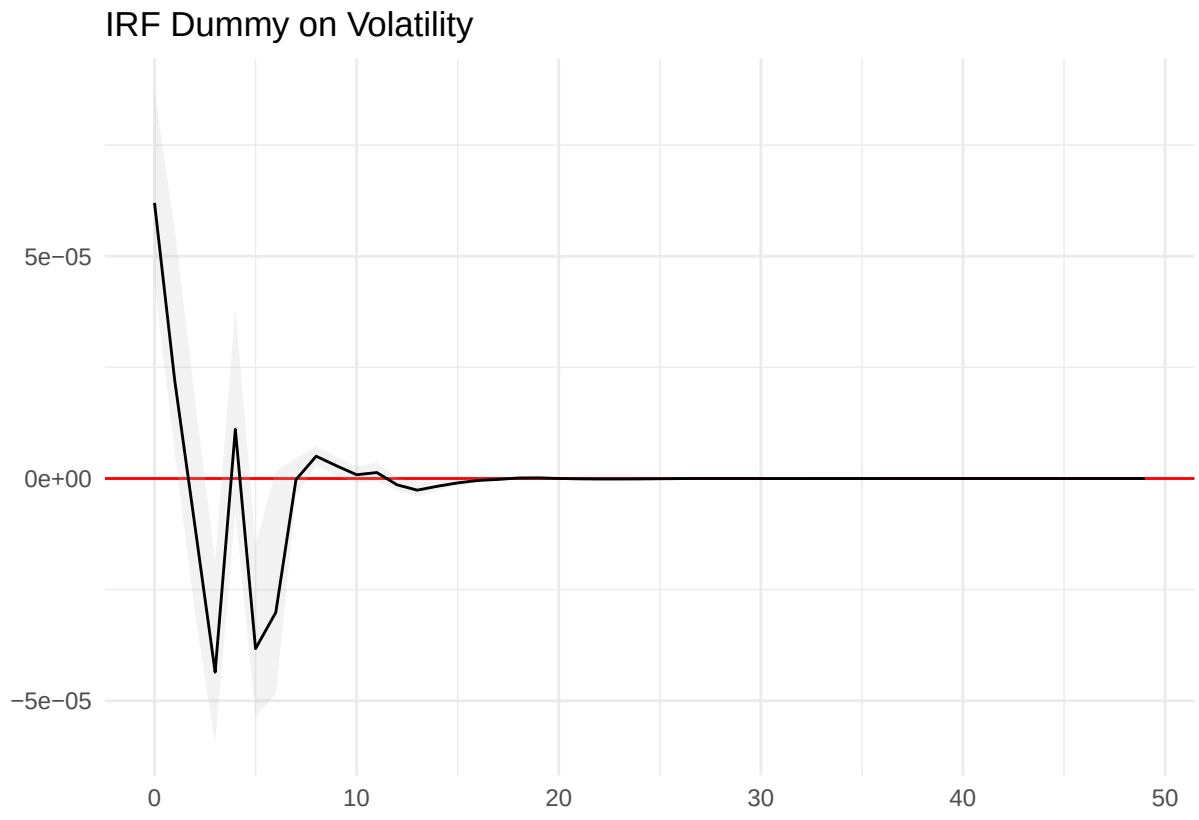
```
##              dummy          vol
## dummy 8.5228910167 1.809484e-04 8.522890588 1.808910e-04
## vol   0.0001809484 2.621563e-06 0.000180891 2.697374e-05
```

	Model 1
dummy.l1	0.000002
	(0.000004)
vol.l1	0.258482***
	(0.007073)
dummy.l2	−0.000006
	(0.000004)
vol.l2	0.021449**
	(0.007302)
dummy.l3	−0.000015***
	(0.000004)
vol.l3	0.028590***
	(0.007297)
dummy.l4	0.000005
	(0.000004)
vol.l4	0.036605***
	(0.007295)
dummy.l5	−0.000016***
	(0.000004)
vol.l5	0.032120***
	(0.007300)
dummy.l6	−0.000010**
	(0.000004)
vol.l6	0.057830***
	(0.007069)
const	0.000267***
	(0.000018)
R^2	0.089824
Adj. R^2	0.089277
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	3.81	0.000846

Res.Df	Df	F	Pr(>F)
2e+04			
2e+04	-6	6.54	6.53e-07

Number of Post

```
y2 = cbind(Vdata$N , Vdata$VGK_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   7.988066e+01 4.527081e-04 7.988066e+01 4.527033e-04
## vol 4.527081e-04 2.623291e-06 4.527033e-04 2.765553e-06
```

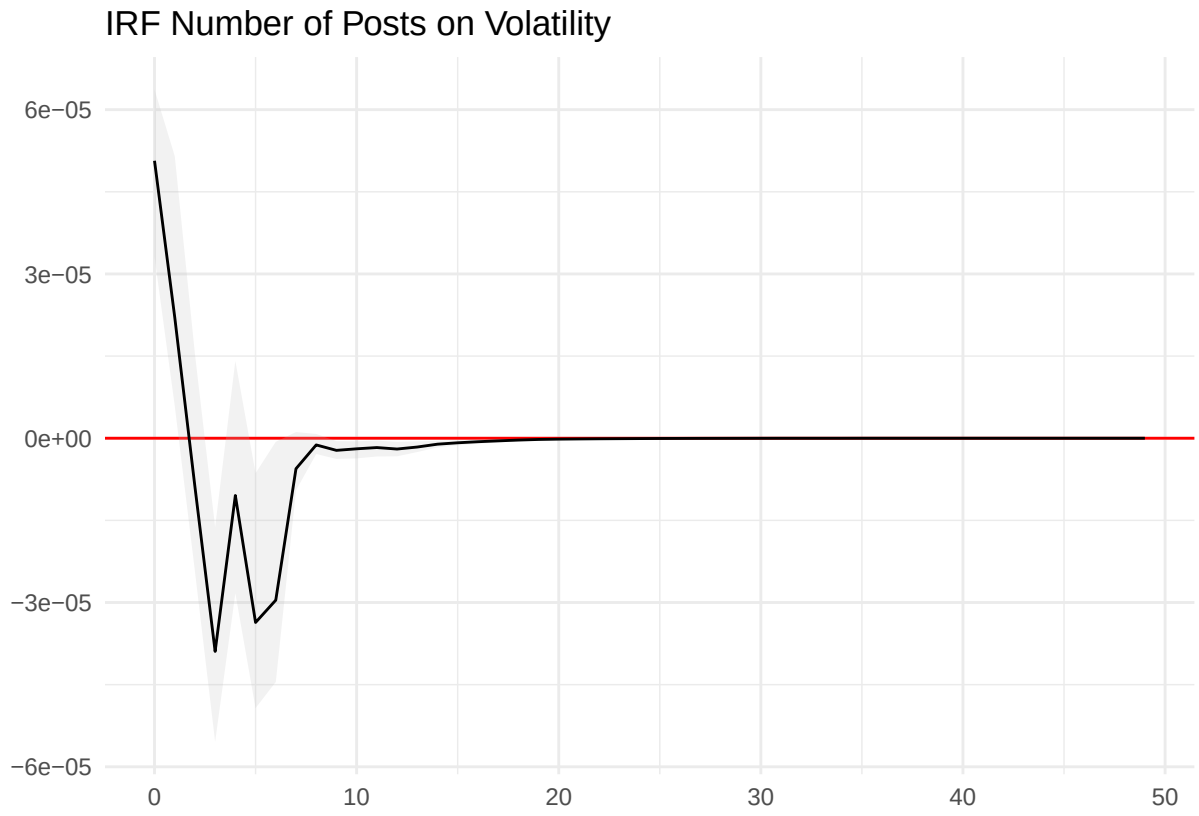
```
#irf creation
irf_res2 <- irf(est.VAR2, impulse = "N", response = "vol",
                bmat=b.hat2, n.ahead = 7 * 7, boot = TRUE, ci = 0.95)

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

	Model 1
N.l1	0.000001
	(0.000001)
vol.l1	0.257940***
	(0.007071)
N.l2	−0.000002
	(0.000001)
vol.l2	0.021295**
	(0.007299)
N.l3	−0.000004***
	(0.000001)
vol.l3	0.028552***
	(0.007296)
N.l4	−0.000001
	(0.000001)
vol.l4	0.037417***
	(0.007295)
N.l5	−0.000004**
	(0.000001)
vol.l5	0.031707***
	(0.007299)
N.l6	−0.000003*
	(0.000001)
vol.l6	0.057719***
	(0.007069)
const	0.000257***
	(0.000016)
R^2	0.089224
Adj. R^2	0.088676
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	3.33	0.00278

```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	4.34	0.000217

Tariff

```r
y3 = cbind(Vdata$tariff , Vdata$VGK_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 1.435590e-01 7.070418e-06 1.435583e-01 7.305006e-06
## vol    7.070418e-06 2.622257e-06 7.305006e-06 9.030517e-06
```

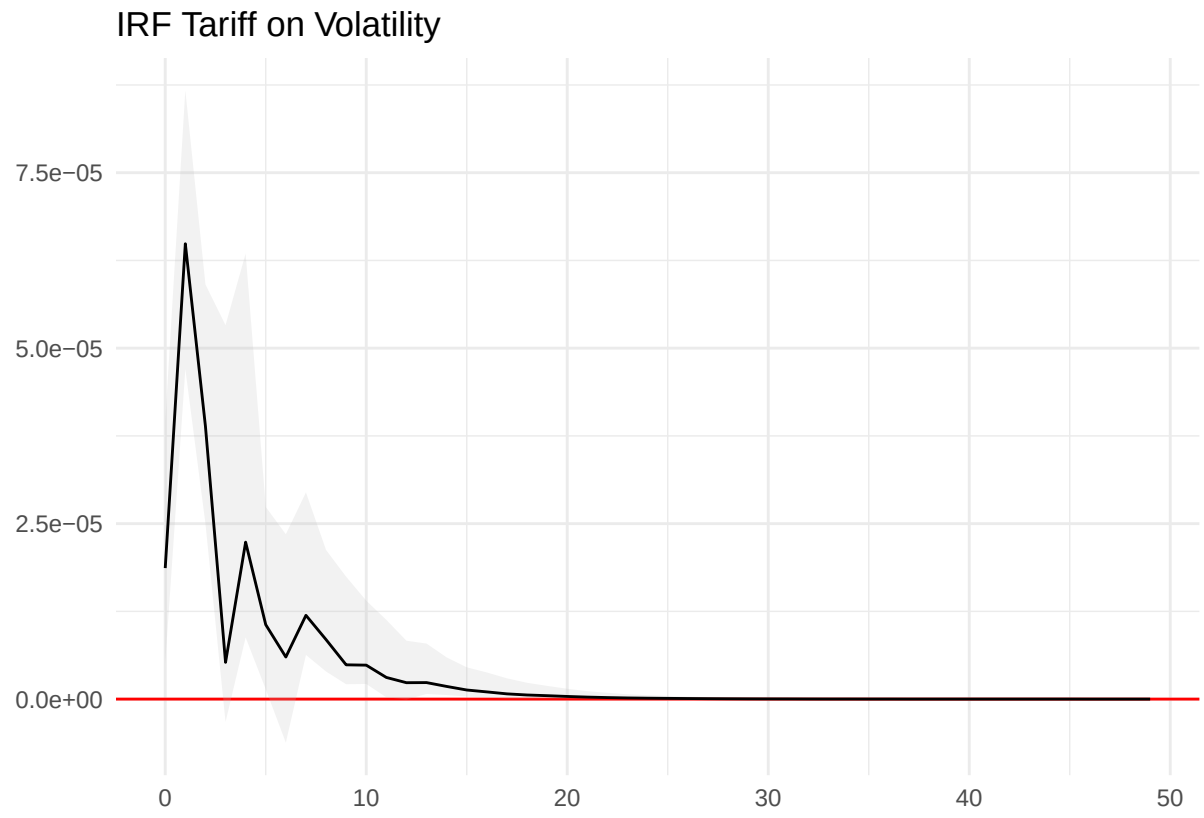
```r
#irf creation
irf_res3 <- irf(est.VAR3, impulse = "tariff", response = "vol",
                  bmat=b.hat3, n.ahead = 7 * 7, boot = TRUE, ci = 0.95)

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

	Model 1
tariff.l1	0.000158***
	(0.000030)
vol.l1	0.257819***
	(0.007068)
tariff.l2	0.000051
	(0.000030)
vol.l2	0.021335**
	(0.007297)
tariff.l3	−0.000034
	(0.000030)
vol.l3	0.027037***
	(0.007296)
tariff.l4	0.000043
	(0.000030)
vol.l4	0.036129***
	(0.007298)
tariff.l5	−0.000004
	(0.000030)
vol.l5	0.031088***
	(0.007301)
tariff.l6	−0.000019
	(0.000030)
vol.l6	0.057889***
	(0.007068)
const	0.000218***
	(0.000013)
R^2	0.089583
Adj. R^2	0.089036
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	5.95	3.19e-06

```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	5.66	6.95e-06

Trade

```
y4 = cbind(Vdata$trade , Vdata$VGK_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  8.349087e-02 -1.622273e-06 8.349086e-02 1.083601e-07
## vol   -1.622273e-06  2.625540e-06 1.083601e-07 3.530968e-05
```

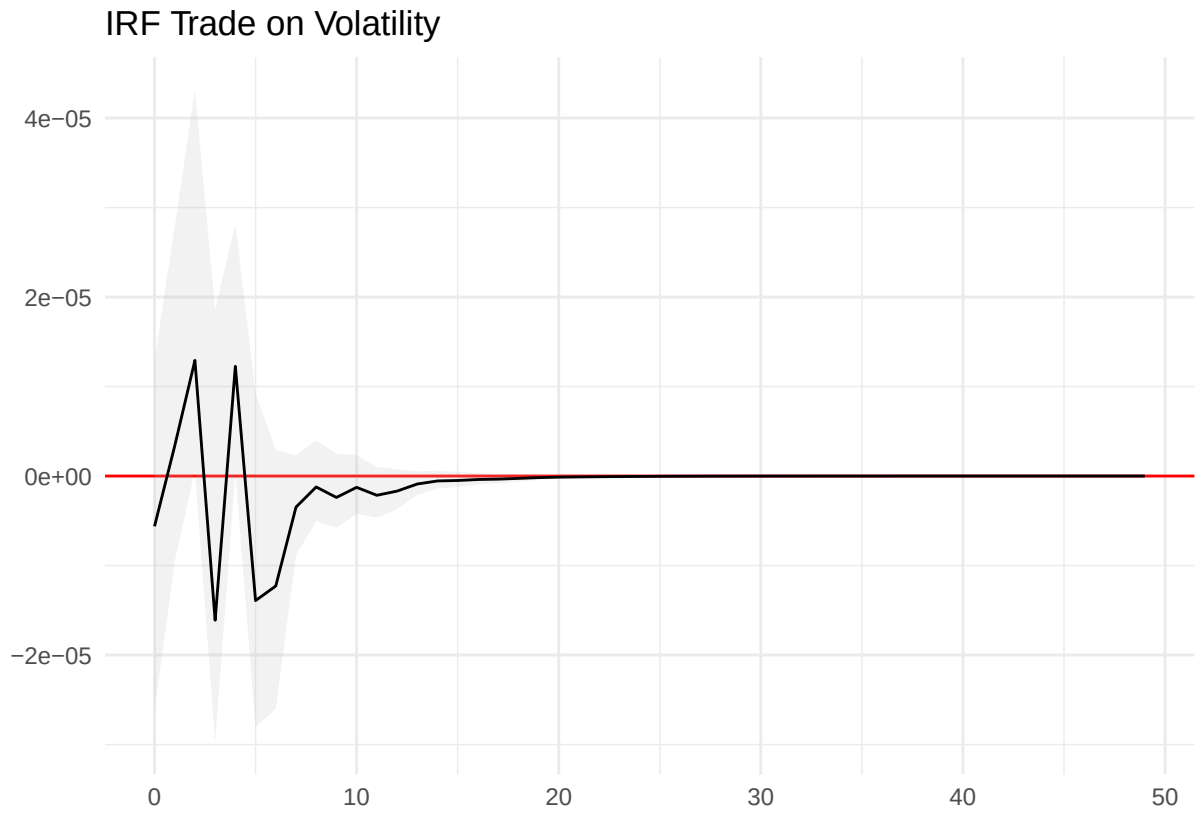
```
#irf creation
irf_res4 <- irf(est.VAR4, impulse = "trade", response = "vol",
                 bmat=b.hat4, n.ahead = 7 * 7, boot = TRUE, ci = 0.95)

#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	0.000017
	(0.000040)
vol.l1	0.258921***
	(0.007067)
trade.l2	0.000042
	(0.000040)
vol.l2	0.020907**
	(0.007301)
trade.l3	−0.000068
	(0.000040)
vol.l3	0.028060***
	(0.007299)
trade.l4	0.000057
	(0.000040)
vol.l4	0.037660***
	(0.007300)
trade.l5	−0.000061
	(0.000040)
vol.l5	0.030651***
	(0.007304)
trade.l6	−0.000030
	(0.000040)
vol.l6	0.058531***
	(0.007076)
const	0.000224***
	(0.000013)
R^2	0.088443
Adj. R^2	0.087895
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	4.39e-11

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

Res.Df	Df	F	Pr(>F)
2e+04			
2e+04	-6	1.49	0.176

China

```
y5 = cbind(Vdata$china , Vdata$VGK_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 2.022300e-01 1.083104e-05 2.022291e-01 1.085325e-05
## vol   1.083104e-05 2.625418e-06 1.085325e-05 1.294700e-05
```

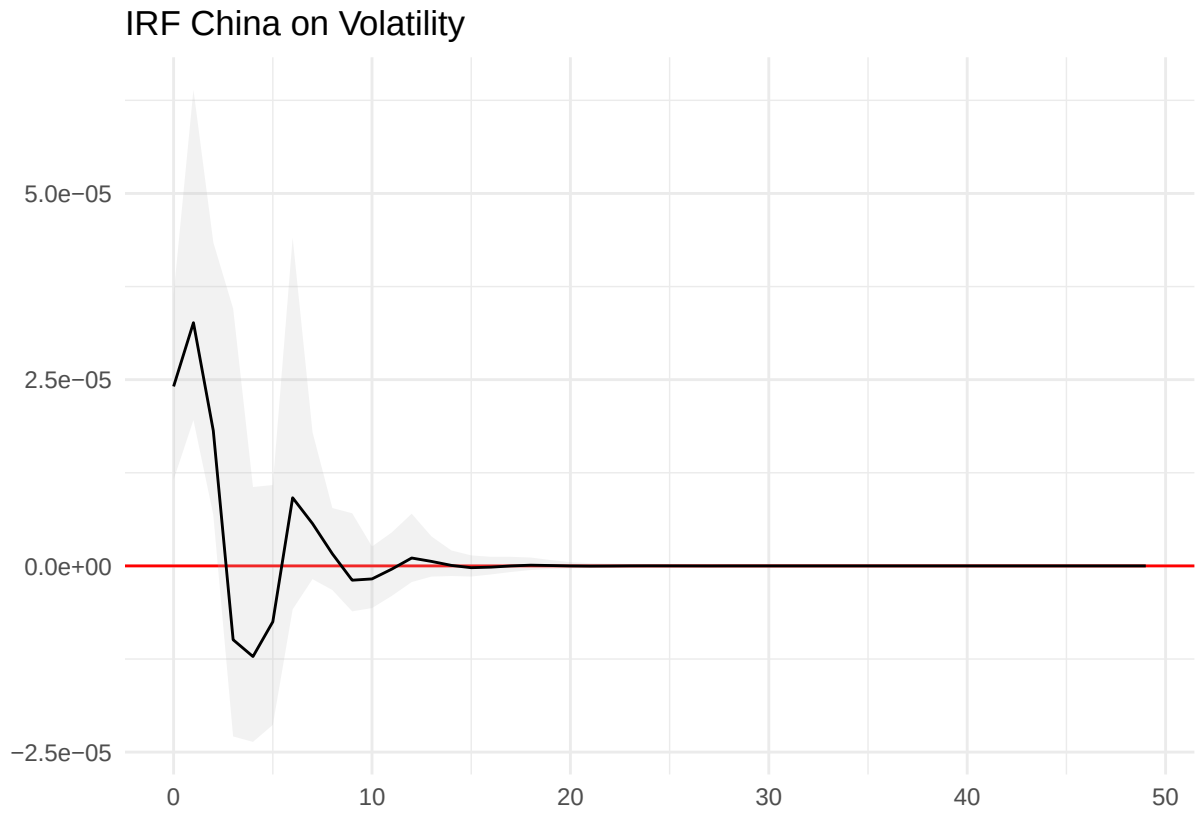
```
#irf creation
irf_res5 <- irf(est.VAR5, impulse = "china", response = "vol",
                  bmat=b.hat5, n.ahead = 7 * 7, boot = TRUE, ci = 0.95)

#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	0.000059*
	(0.000025)
vol.l1	0.258298***
	(0.007068)
china.l2	0.000016
	(0.000026)
vol.l2	0.021287**
	(0.007298)
china.l3	−0.000040
	(0.000026)
vol.l3	0.028374***
	(0.007295)
china.l4	−0.000025
	(0.000026)
vol.l4	0.037333***
	(0.007295)
china.l5	−0.000013
	(0.000026)
vol.l5	0.031020***
	(0.007299)
china.l6	0.000018
	(0.000025)
vol.l6	0.058227***
	(0.007068)
const	0.000221***
	(0.000013)
R^2	0.088486
Adj. R^2	0.087938
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	2.01	0.0609

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

Interaction number of post and tariff

here is an example of our interaction

Res.Df	Df	F	Pr(>F)
2e+04			
2e+04	-6	1.65	0.13

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

int1 = Vdata$tariff * Vdata$N

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

```
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 7.087427e+02 2.261158e-04 7.087427e+02 2.260725e-04
## vol         2.261158e-04 2.626370e-06 2.260725e-04 4.705363e-06
```

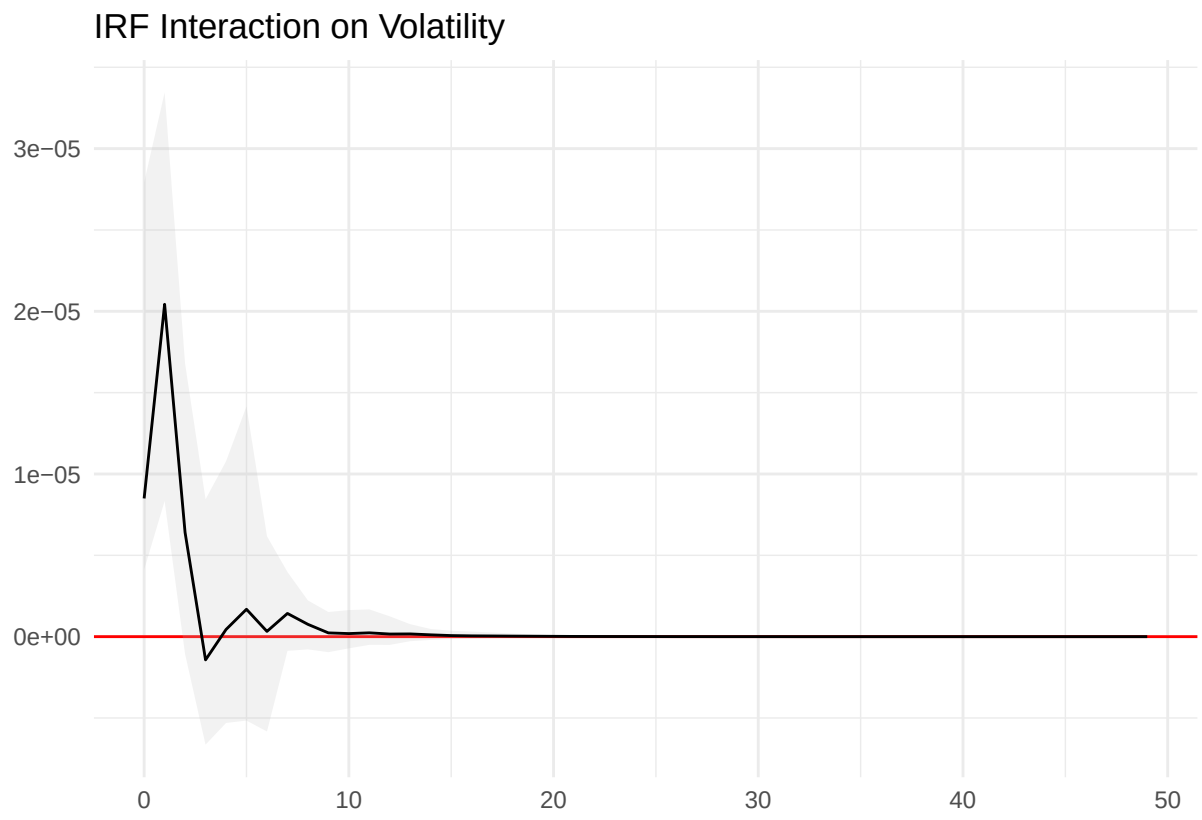
```
#irf creation
irf_res12 <- irf(est.VAR12, impulse = "interaction", response = "vol",
                 bmat=b.hat12, n.ahead = 7 * 7, boot = TRUE, ci = 0.95)

#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	0.000001
	(0.000000)
vol.l1	0.258605***
	(0.007068)
interaction.l2	0.000000
	(0.000000)
vol.l2	0.021145**
	(0.007298)
interaction.l3	−0.000000
	(0.000000)
vol.l3	0.028385***
	(0.007294)
interaction.l4	−0.000000
	(0.000000)
vol.l4	0.037432***
	(0.007294)
interaction.l5	0.000000
	(0.000000)
vol.l5	0.030800***
	(0.007298)
interaction.l6	−0.000000
	(0.000000)
vol.l6	0.058062***
	(0.007067)
const	0.000222***
	(0.000012)
R^2	0.088156
Adj. R^2	0.087607
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()
```



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	0.000002
	(0.000062)
vol.l1	0.096600***
	(0.011897)
tariff.l2	−0.000018
	(0.000062)
vol.l2	0.063067***
	(0.011924)
tariff.l3	−0.000034
	(0.000062)
vol.l3	0.071488***
	(0.011910)
tariff.l4	−0.000032
	(0.000062)
vol.l4	0.078845***
	(0.011910)
tariff.l5	−0.000029
	(0.000062)
vol.l5	0.070102***
	(0.011923)
tariff.l6	−0.000017
	(0.000062)
vol.l6	0.077018***
	(0.011897)
const	0.000189***
	(0.000021)
R^2	0.057712
Adj. R^2	0.056101
Num. obs.	7036

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

Table 7: Statistical models

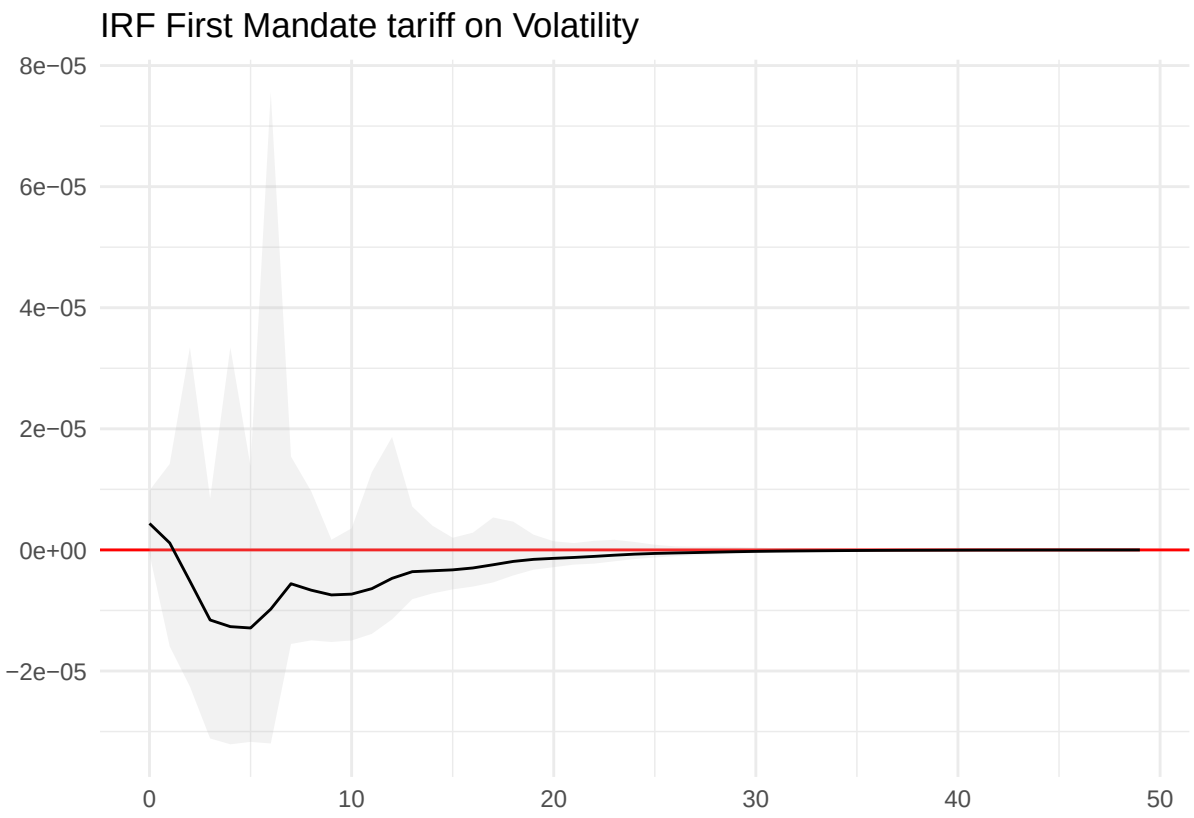
```
y_f_d = cbind(Vdata_f$tariff, Vdata_f$VGK_vol)
colnames(y_f_d)[1:2] <- c("tariff", "vol")
est.VAR_f_d <- VAR(y_f_d,p=6)
mod_vol_f_d <- est.VAR_f_d$varresult$vol
texreg(mod_vol_f_d, digits = 6)
```

```
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 9.836434e-02 1.368161e-06  9.836268e-02 -2.625023e-07
## vol    1.368161e-06 2.699856e-06 -2.625023e-07  3.523707e-05
```

```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 tarif
grangertest(y_f_d[,c("vol","tariff")], order = 6)
```

Res.Df	Df	F	Pr(>F)
7.02e+03			
7.03e+03	-6	0.138	0.991

```
#does tarif 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	0.219	0.971

second mandate

	Model 1
tariff.l1	0.000204*
	(0.000095)
vol.l1	0.187439***
	(0.044443)
tariff.l2	0.000075
	(0.000095)
vol.l2	0.048019
	(0.045174)
tariff.l3	−0.000063
	(0.000095)
vol.l3	0.046386
	(0.045316)
tariff.l4	0.000028
	(0.000095)
vol.l4	0.049858
	(0.045387)
tariff.l5	−0.000020
	(0.000095)
vol.l5	0.056057
	(0.045359)
tariff.l6	−0.000047
	(0.000095)
vol.l6	0.118803**
	(0.044444)
const	0.000478*
	(0.000216)
R^2	0.102630
Adj. R^2	0.081050
Num. obs.	512

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

Table 8: Statistical models

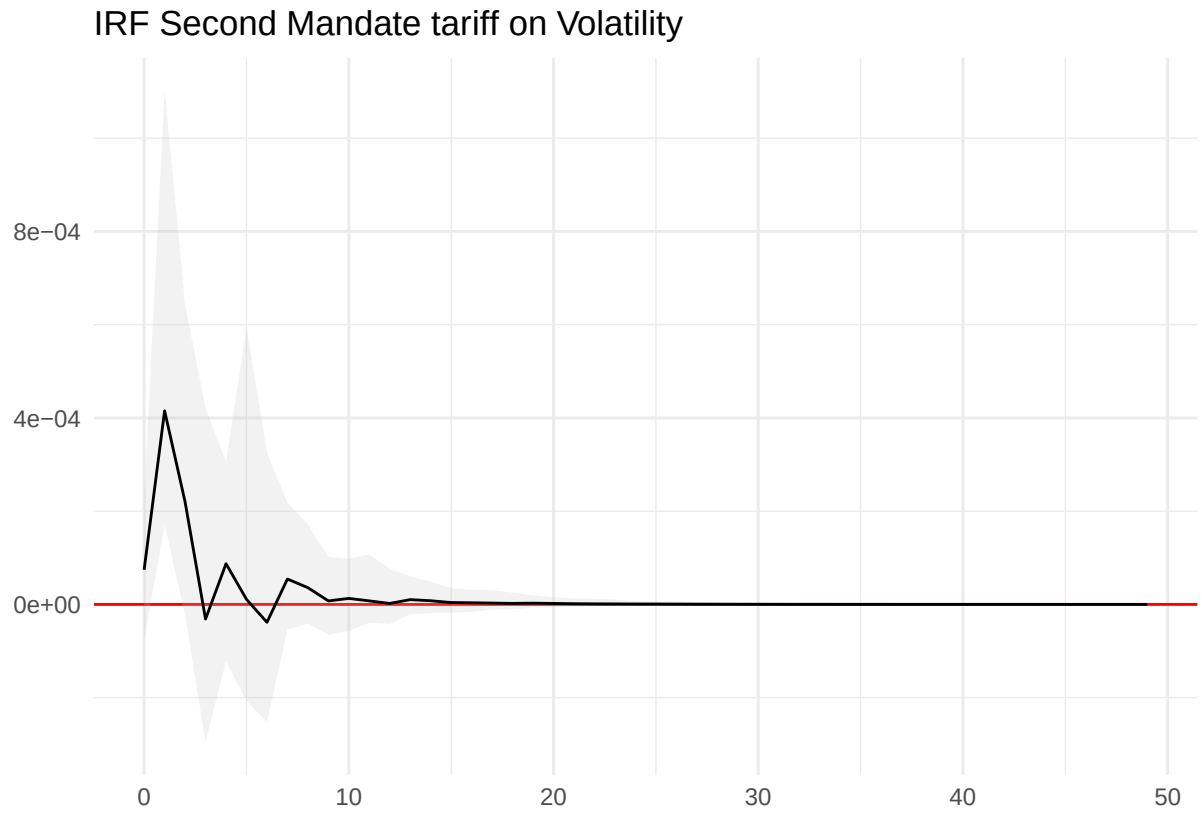
```
y_s_d = cbind(Vdata_s$tariff, Vdata_s$VGK_vol)
colnames(y_s_d)[1:2] <- c("tariff", "vol")
est.VAR_s_d <- VAR(y_s_d,p=6)
mod_vol_s_d <- est.VAR_s_d$varresult$vol
texreg(mod_vol_s_d, digits = 6)
```

```
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 3.7918282529 1.427712e-04 3.791827516 1.429690e-04
## vol    0.0001427712 1.699179e-05 0.000142969 2.519941e-05
```

```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()
```




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

Res.Df	Df	F	Pr(>F)
499			
505	-6	1.11	0.354

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

Res.Df	Df	F	Pr(>F)
499			
505	-6	0.965	0.448