paper_test

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Contents

```
# load packages
library("data.table")
library("tidyverse")
```

```
## -- Attaching core tidyverse packages ------------------------ tidyverse 2.0.0 --
## v dplyr     1.1.4     v readr     2.1.5
## v forcats   1.0.0     v stringr   1.5.1
## v ggplot2   4.0.0     v tibble    3.2.1
## v lubridate 1.9.4     v tidyr     1.3.1
## v purrr     1.0.4
## -- Conflicts ------------------------------------------ tidyverse_conflicts() --
## x dplyr::between()     masks data.table::between()
## x dplyr::filter()      masks stats::filter()
## x dplyr::first()       masks data.table::first()
## x lubridate::hour()    masks data.table::hour()
## x lubridate::isoweek() masks data.table::isoweek()
## x dplyr::lag()         masks stats::lag()
## x dplyr::last()        masks data.table::last()
## x lubridate::mday()    masks data.table::mday()
## x lubridate::minute()  masks data.table::minute()
## x lubridate::month()   masks data.table::month()
## x lubridate::quarter() masks data.table::quarter()
## x lubridate::second()  masks data.table::second()
## x purrr::transpose()   masks data.table::transpose()
## x lubridate::wday()    masks data.table::wday()
## x lubridate::week()    masks data.table::week()
## x lubridate::yday()    masks data.table::yday()
## x lubridate::year()    masks data.table::year()
## i Use the conflicted package (<http://conflicted.r-lib.org/>) to force all conflicts to become errors
```

```
library("tseries")
```

```
## Registered S3 method overwritten by 'quantmod':
##   method            from
##   as.zoo.data.frame zoo
```

```r
library("quantmod")
```

```
## Loading required package: xts
## Loading required package: zoo
##
## Attaching package: 'zoo'
##
## The following objects are masked from 'package:data.table':
##
##     yearmon, yearqtr
##
## The following objects are masked from 'package:base':
##
##     as.Date, as.Date.numeric
##
##
## ######################### Warning from 'xts' package ##########################
## #                                                                             #
## # The dplyr lag() function breaks how base R's lag() function is supposed to  #
## # work, which breaks lag(my_xts). Calls to lag(my_xts) that you type or       #
## # source() into this session won't work correctly.                            #
## #                                                                             #
## # Use stats::lag() to make sure you're not using dplyr::lag(), or you can add #
## # conflictRules('dplyr', exclude = 'lag') to your .Rprofile to stop           #
## # dplyr from breaking base R's lag() function.                                #
## #                                                                             #
## # Code in packages is not affected. It's protected by R's namespace mechanism #
## # Set `options(xts.warn_dplyr_breaks_lag = FALSE)` to suppress this warning.  #
## #                                                                             #
## ###############################################################################
##
## Attaching package: 'xts'
##
## The following objects are masked from 'package:dplyr':
##
##     first, last
##
## The following objects are masked from 'package:data.table':
##
##     first, last
##
## Loading required package: TTR
```

```r
library('Rsolnp')
library('msos')
```

```
## Loading required package: mclust
## Package 'mclust' version 6.1.1
## Type 'citation("mclust")' for citing this R package in publications.
##
## Attaching package: 'mclust'
##
```

```
## The following object is masked from 'package:purrr':
##
##     map
##
## Loading required package: tree
##
## Attaching package: 'msos'
##
## The following object is masked from 'package:datasets':
##
##     cars
```

```
library('tikzDevice')
library('xtable')

# set working directory
setwd("/Users/wangqiyang/Desktop/postshock-main1/inst")

## Conoco Phillips
getSymbols('COP', from = "2000-01-01")
```

```
## [1] "COP"
```

```
COP <- as.data.frame(COP)
COP <- COP %>% mutate(Date = rownames(COP))

## S&P 500
getSymbols('^GSPC', from = "1970-01-01")
```

```
## [1] "GSPC"
```

```
GSPC <- as.data.frame(GSPC)
GSPC <- GSPC %>% mutate(Date = rownames(GSPC))

## Brent Crude prices
Brent_Crude <- read.csv("https://pkgstore.datahub.io/core/oil-prices/brent-daily_csv/data/d93216330ab2c
  rename(Oil_Close = Price)

## WTI Crude prices
WTI_Crude <- read.csv("https://pkgstore.datahub.io/core/oil-prices/wti-daily_csv/data/c414c9d375ec3c8f9
  rename(WTI_Close = Price)

## Gold Price
getSymbols('GC=F', from = "2000-01-01")
```

```
## Warning: GC=F contains missing values. Some functions will not work if objects
## contain missing values in the middle of the series. Consider using na.omit(),
## na.approx(), na.fill(), etc to remove or replace them.
```

```
## [1] "GC=F"
```

```r
gold <- as.data.frame(`GC=F`)
gold <- na.omit(gold)
gold <- gold %>% mutate(Date = rownames(gold))

## Dollar Index
getSymbols('DX-Y.NYB', from = "2000-01-01")
```

```
## Warning: DX-Y.NYB contains missing values. Some functions will not work if
## objects contain missing values in the middle of the series. Consider using
## na.omit(), na.approx(), na.fill(), etc to remove or replace them.
```

```
## [1] "DX-Y.NYB"
```

```r
USD <- as.data.frame(`DX-Y.NYB`)
USD <- na.omit(USD)
USD <- USD %>% mutate(Date = rownames(USD))

TB_xts <- getSymbols("^IRX", src = "yahoo", from = "2000-01-01", auto.assign = FALSE)
```

```
## Warning: ^IRX contains missing values. Some functions will not work if objects
## contain missing values in the middle of the series. Consider using na.omit(),
## na.approx(), na.fill(), etc to remove or replace them.
```

```r
TB <- data.frame(
  Date = as.Date(index(TB_xts)),
  TB_Close = as.numeric(Cl(TB_xts))   #
)

## Volatility Index
getSymbols('^VIX', from = "2000-01-01")
```

```
## Warning: ^VIX contains missing values. Some functions will not work if objects
## contain missing values in the middle of the series. Consider using na.omit(),
## na.approx(), na.fill(), etc to remove or replace them.
```

```
## [1] "VIX"
```

```r
VIX <- as.data.frame(VIX)
VIX <- na.omit(VIX)
VIX <- VIX %>% mutate(Date = rownames(VIX))


## inflation adjustment
# === inflation adjustment (works without quantmod/FRED backend) ===
library(curl)
```

```
## Using libcurl 8.11.1 with OpenSSL/3.3.2
##
## Attaching package: 'curl'
##
## The following object is masked from 'package:readr':
##
##     parse_date
```

```r
#    CPIAUCSL   CSV
u <- "https://fred.stlouisfed.org/graph/fredgraph.csv?id=CPIAUCSL"
raw <- curl_fetch_memory(u)$content
cpi <- read.csv(text = rawToChar(raw), stringsAsFactors = FALSE)  #  DATE, CPIAUCSL

#   + 2020
library(curl)

# 1)    CPIAUCSL CSV
txt <- rawToChar(curl_fetch_memory("https://fred.stlouisfed.org/graph/fredgraph.csv?id=CPIAUCSL")$conte
cpi <- read.csv(text = txt, stringsAsFactors = FALSE)   #  1 = ,  2 =

# 2)    + 2020   → inflation_adj(year, dollars_2020)
inflation_adj <- aggregate(cpi[[2]], list(year = as.integer(substr(cpi[[1]], 1, 4))), mean, na.rm = TRU
names(inflation_adj) <- c("year","cpi")
inflation_adj <- transform(inflation_adj, dollars_2020 = cpi[year == 2020]/cpi)[, c("year","dollars_202




COP_close  <- COP  %>% dplyr::transmute(Date = as.Date(Date), COP_Close  = COP.Close)
GSPC_close <- GSPC %>% dplyr::transmute(Date = as.Date(Date), GSPC_Close = GSPC.Close)
USD_close  <- USD  %>% dplyr::transmute(Date = as.Date(Date), USD_Close  = `DX-Y.NYB.Close`)  #    DX=F
TB_close   <- TB   %>% dplyr::select(Date, TB_Close)  #
VIX_close  <- VIX  %>% dplyr::transmute(Date = as.Date(Date), VIX_Close = VIX.Close)


tom <- list(GSPC_close, WTI_Crude, USD_close, TB_close, VIX_close)
for (i in 1:length(tom)) {
  COP_close <- merge(COP_close, tom[[i]])
}


# response
Y <- COP_close$COP_Close[-1]

# data frame
COP_close <- data.frame(COP_close[-nrow(COP_close), ], Y)

#### Monday, March 17th, 2008

## March 17th; 1 day nowcast

# shock effect date
start <- which(COP_close$Date == "2008-03-14")
start_day_20080317 <- as.numeric(1:nrow(COP_close) == start)
COP_close <- COP_close %>% mutate(start_day_20080317 = start_day_20080317)
TS2 <- COP_close[(start - 30):start, ]
# inflation adjustment
TS2[, 2:8] <- TS2[, 2:8] * inflation_adj$dollars_2020[inflation_adj$year == 2008]
m_COP_3_17 <- lm(Y ~ COP_Close + start_day_20080317 + GSPC_Close + WTI_Close +
                   USD_Close + TB_Close,
                 data = TS2)
```

```r
alpha_3_17 <- summary(m_COP_3_17)$coef[3,1:2]
# shock-effects
alpha_3_17
```

```
##   Estimate Std. Error
##  -0.925979   1.697907
```

```r
#### 2008 shock effects

# shock effect date
start_09_08_08 <- which(COP_close$Date == "2008-09-08")
start_09_12_08 <- which(COP_close$Date == "2008-09-12")
start_09_26_08 <- which(COP_close$Date == "2008-09-26")
# three shocks
start_day_09_08_08 <- as.numeric(1:nrow(COP_close) %in% start_09_08_08)
start_day_09_12_08 <- as.numeric(1:nrow(COP_close) %in% start_09_12_08)
start_day_09_26_08 <- as.numeric(1:nrow(COP_close) %in% start_09_26_08)
COP_close <- COP_close %>% mutate(start_day_09_08_08 = start_day_09_08_08,
                                  start_day_09_12_08 = start_day_09_12_08,
                                  start_day_09_26_08 = start_day_09_26_08)
# time window
TS3 <- COP_close[which(COP_close$Date == "2008-08-26"):which(COP_close$Date == "2008-09-26"), ]
# adjust for inflation
TS3[, 2:8] <- TS3[, 2:8] * inflation_adj$dollars_2020[inflation_adj$year == 2008]
# AR(1)
m_COP_Sept_08 <- lm(Y ~ COP_Close + start_day_09_08_08 + start_day_09_12_08 +
                    start_day_09_26_08 + GSPC_Close + WTI_Close + USD_Close + TB_Close, data = TS3)
alpha_Sept_08 <- summary(m_COP_Sept_08)$coef[3:5,1:2]
cov2cor(vcov(m_COP_Sept_08)[3:5, 3:5])
```

```
##                    start_day_09_08_08 start_day_09_12_08 start_day_09_26_08
## start_day_09_08_08         1.00000000         0.09189711        -0.12282810
## start_day_09_12_08         0.09189711         1.00000000         0.03808604
## start_day_09_26_08        -0.12282810         0.03808604         1.00000000
```

```r
# shock-effects
alpha_Sept_08
```

```
##                      Estimate Std. Error
## start_day_09_08_08 -7.096613   2.209606
## start_day_09_12_08 -5.804833   2.075966
## start_day_09_26_08 -6.425133   2.051642
```

```r
# test independence

# test independence of a sequence of covariance matrices
lrindcov <- function(cov, cols, v){
  # cols is the sub-columns (in list) you want to test
  # est is the sample covariance matrix
  # v is the degrees of freedom of the sample covariance matrix under H0
  # test
```

```
  # H0: Sigmaij = 0; HA: Sigmaij != 0

  # sub sample covariance matrix
  est <- cov[unlist(cols), unlist(cols)]
  # multiple sub
  subest <- lapply(cols, function(x) cov[x, x])
  # dimensions
  q <- length(unlist(cols))
  # dimensions of sub sample covariance matrices
  qs <- sapply(cols, FUN = function(x) length(x))
  # calculate test statistics: 2log(LR)
  teststat <- v * (sum(sapply(subest,
                              FUN = function(x) if (length(x) == 1) log(x) else logdet(x)))
                   - logdet(est))
  # output result
  list(tlogLR = teststat, pvalue = 1 - pchisq(q = teststat, df = prod(qs)))
}

# not significant => Independence
lrindcov(vcov(m_COP_Sept_08)[3:5, 3:5], cols = list(1, 2, 3), v = df.residual(m_COP_Sept_08))
```

```
## $tlogLR
## [1] 0.3665472
##
## $pvalue
## [1] 0.5448924
```

```
xtable(vcov(m_COP_Sept_08)[3:5, 3:5], digits = 3)
```

```
## % latex table generated in R 4.4.2 by xtable 1.8-4 package
## % Mon Nov 17 14:57:51 2025
## \begin{table}[ht]
## \centering
## \begin{tabular}{rrrr}
##   \hline
##  & start\_day\_09\_08\_08 & start\_day\_09\_12\_08 & start\_day\_09\_26\_08 \\
##   \hline
## start\_day\_09\_08\_08 & 4.882 & 0.422 & -0.557 \\
##   start\_day\_09\_12\_08 & 0.422 & 4.310 & 0.162 \\
##   start\_day\_09\_26\_08 & -0.557 & 0.162 & 4.209 \\
##    \hline
## \end{tabular}
## \end{table}
```

```
#### Thursday, November 27, 2014

# shock effect date
start <- which(COP_close$Date == "2014-11-26")
start_day_20141127 <- as.numeric(1:nrow(COP_close) == start)
COP_close <- COP_close %>% mutate(start_day_20141127 = start_day_20141127)
# time window
TS4 <- COP_close[(start - 30):start,]
```

```r
# adjust for inflation
TS4[, 2:8] <- TS4[, 2:8] * inflation_adj$dollars_2020[inflation_adj$year == 2014]
# AR(1)
m_COP_11_27_14 <- lm(Y ~ COP_Close + start_day_20141127 + GSPC_Close + WTI_Close + USD_Close + TB_Close
                     data = TS4)
alpha_11_27_14 <- summary(m_COP_11_27_14)$coef[3,1:2]
# shock-effects
alpha_11_27_14
```

```
##   Estimate Std. Error
##  -6.085747   1.093611
```

```r
#### The March 9th, 2020 shock effect:

# shock effect date
start <- which(COP_close$Date == "2020-03-06")
start_day_20200309 <- as.numeric(1:nrow(COP_close) == start)
COP_close <- COP_close %>% mutate(start_day_20200309 = start_day_20200309)
# time window
TS1 <- COP_close[(start-30):(start), ]

# shock-effect estimate
m_COP_03_09_20 <- lm(Y ~ COP_Close + start_day_20200309 + GSPC_Close + WTI_Close +
                       USD_Close + TB_Close,
                     data = TS1)
alpha_03_09_20 <- summary(m_COP_03_09_20)$coef[3,1:2]
# shock-effects
alpha_03_09_20
```

```
##   Estimate Std. Error
## -10.227449   2.044689
```

```r
## Shock effect estimators
estimates <- rbind(alpha_3_17, alpha_Sept_08, alpha_11_27_14)
estimates[, 2] <- estimates[, 2] ^ 2
colnames(estimates) <- c("alpha_hat", "var")
rownames(estimates) <- c("m2008","s8y2008","s12y2008","s26y2008","y2014")


# adjustment estimator
alpha_adj <- mean(estimates[, 1])

# IVW estimator
weights <- (1 / estimates[,2]) / sum(1 / estimates[, 2])
alpha_IVW <- sum(weights * estimates[, 1])

# weighted adjustment estimator
Tstar.Date <- c("2020-03-05", "2008-03-13", "2008-09-05", "2008-09-11", "2008-09-25",  "2014-11-25")
Tstar <- sapply(Tstar.Date, function(x) which(COP_close$Date == x))
# X1
X1 <- as.matrix(TS1[nrow(TS1), 3:7])
# X1 <- as.matrix(COP_close[c(Tstar[1], Tstar[1] + 1), c(3, 4)])
```

```r
# X0
X0 <- c()
for (i in 1:5) {
  X0[[i]] <- as.matrix(COP_close[Tstar[i + 1] + 1, 3:7])
}

# SCM

dat <- scale(rbind(X1, do.call('rbind', X0)), center = T, scale = T)
X1 <- dat[1, , drop = FALSE]
X0 <- c()
for (i in 1:5) {
  X0[[i]] <- dat[i + 1, , drop = FALSE]
}

# Euclidean metric
# objective function

scmm <- function(X1, X0) {
  weightedX0 <- function(W) {
    # W is a vector of weight of the same length of X0
    n <- length(W)
    p <- ncol(X1)
    XW <- matrix(0, nrow = 1, ncol = p)
    for (i in 1:n) {
      XW <- XW + W[i] * X0[[i]]
    }
    norm <- as.numeric(crossprod(matrix(X1 - XW)))
    return(norm)
  }
  # constraint for W
  Wcons <- function(W) sum(W) - 1
  n <- length(X0)
  # optimization
  outs <- solnp(par = rep(1/n, n), fun = weightedX0, eqfun = Wcons, eqB = 0, LB = rep(0, n), UB = rep(1

  # output weights
  Wstar <- outs$pars

  return(Wstar)
}

# objective function is not 0; the fit may not be good
Wstar <- scmm(X1 = X1, X0 = X0)
```

```
##
## Iter: 1 fn: 11.8359   Pars:  0.0000000032701 0.0000000004513 0.0000000115022 0.2732475033069 0.72675
## Iter: 2 fn: 11.8359   Pars:  0.0000000029329 0.0000000001664 0.0000000110123 0.2732475055956 0.72675
## solnp--> Completed in 2 iterations
```

```r
weightedX0 <- function(W) {
  # W is a vector of weight of the same length of X0
  n <- length(W)
```

```
  p <- ncol(X1)
  XW <- matrix(0, nrow = 1, ncol = p)
  for (i in 1:n) {
    XW <- XW + W[i] * X0[[i]]
  }
  norm <- as.numeric(crossprod(matrix(X1 - XW)))
  return(norm)
}
# constraint for W
Wcons <- function(W) sum(W) - 1
n <- length(X0)
# optimization
outs <- solnp(par = rep(1/n, n), fun = weightedX0, eqfun = Wcons, eqB = 0, LB = rep(0, n), UB = rep(1, n
```

```
##
## Iter: 1 fn: 11.8359   Pars:  0.0000000032701 0.0000000004513 0.0000000115022 0.2732475033069 0.72675
## Iter: 2 fn: 11.8359   Pars:  0.0000000029329 0.0000000001664 0.0000000110123 0.2732475055956 0.72675
## solnp--> Completed in 2 iterations
```

```
# output weights
Wstar <- outs$pars
weightedX0(round(outs$pars, digits = 3))
```

```
## [1] 11.83593
```

```
devtools::load_all(".")
```

```
## i Loading postshock
```

```
library(postshock)
```

```
# make_window():
#   - center_date: date of the shock (e.g. "2008-03-17")
#   - pre:   number of days before the shock to include in the window
#   - post:  number of days after (including the shock day as the first post day)
#   - year_adj: calendar year used for CPI-based inflation adjustment
make_window <- function(center_date, pre = 30, post = 30, year_adj) {
  # Locate the index of the shock date in COP_close
  idx_c <- which(COP_close$Date == center_date)
  if (length(idx_c) != 1) {
    stop("Date not found or found more than once: ", center_date)
  }

  # Compute start and end row indices of the window
  idx_start <- idx_c - pre
  idx_end   <- idx_c + post - 1

  # Subset COP_close to obtain the time window
  TS <- COP_close[idx_start:idx_end, ]

  # Inflation adjustment:
```

```r
  # assume columns 2:7 are the six price / covariate columns to be scaled
  factor <- inflation_adj$dollars_2020[inflation_adj$year == year_adj]
  TS[, 2:7] <- TS[, 2:7] * factor

  # Return the inflation-adjusted time window
  return(TS)
}
```

```r
## ================== Build target and donor windows ==================

# Target window around 2020-03-09 (COVID + oil price war episode)
# pre = 30, post = 30 → 30 days before the shock + shock day + 29 days after
TS_target <- make_window("2020-03-09", pre = 30, post = 30, year_adj = 2020)

# Donor 1: 2008-03-17 (March 2008 financial crisis shock)
TS_2008_03_17 <- make_window("2008-03-17", pre = 30, post = 30, year_adj = 2008)

# Donor 2: 2014-11-28 (OPEC supply shock episode)
TS_2014_11_28 <- make_window("2014-11-28", pre = 30, post = 30, year_adj = 2014)

# Donor 3: 2008-09-09 (first September 2008 shock around the Lehman crisis)
TS_2008_09_09 <- make_window("2008-09-09", pre = 30, post = 30, year_adj = 2008)

# Donor 4: 2008-09-15 (Lehman Brothers bankruptcy filing date)
TS_2008_09_15 <- make_window("2008-09-15", pre = 30, post = 30, year_adj = 2008)

# Donor 5: 2008-09-29 (first rejection of the U.S. bailout plan; another large drop)
TS_2008_09_29 <- make_window("2008-09-29", pre = 30, post = 30, year_adj = 2008)

## ================== Quick sanity check ==================

print(TS_target)       # target window
```

```
##            Date COP_Close GSPC_Close WTI_Close USD_Close TB_Close VIX_Close
## 5025 2020-01-24     62.62    3295.47     54.09     97.85    1.490     14.56
## 5026 2020-01-27     61.04    3243.63     53.09     97.96    1.505     18.23
## 5027 2020-01-28     61.18    3276.24     53.33     98.02    1.530     16.28
## 5028 2020-01-29     60.49    3273.40     53.29     97.99    1.520     16.39
## 5029 2020-01-30     60.89    3283.66     52.19     97.87    1.528     15.49
## 5030 2020-01-31     59.43    3225.52     51.58     97.39    1.510     18.84
## 5031 2020-02-03     59.18    3248.92     50.06     97.80    1.518     17.97
## 5032 2020-02-04     56.49    3297.59     49.59     97.96    1.538     16.05
## 5033 2020-02-05     58.78    3334.69     50.87     98.27    1.520     15.15
## 5034 2020-02-06     58.41    3345.78     50.94     98.50    1.530     14.96
## 5035 2020-02-07     57.99    3327.71     50.34     98.68    1.518     15.47
## 5036 2020-02-10     57.87    3352.09     49.59     98.83    1.520     15.04
## 5037 2020-02-11     58.71    3357.75     50.00     98.72    1.538     15.18
## 5038 2020-02-12     59.76    3379.45     51.13     99.05    1.535     13.74
## 5039 2020-02-13     58.82    3373.94     51.41     99.07    1.545     14.15
## 5040 2020-02-14     58.62    3380.16     52.03     99.12    1.535     13.68
## 5041 2020-02-18     58.30    3370.29     52.10     99.46    1.535     14.83
## 5042 2020-02-19     59.26    3386.15     53.31     99.60    1.543     14.38
## 5043 2020-02-20     58.88    3373.23     53.77     99.87    1.538     15.56
```

```
## 5044 2020-02-21     58.44    3337.75     53.36     99.26    1.518     17.08
## 5045 2020-02-24     56.38    3225.89     51.36     99.29    1.503     25.03
## 5046 2020-02-25     53.83    3128.21     49.78     98.97    1.490     27.85
## 5047 2020-02-26     51.17    3116.39     48.67     99.00    1.478     27.56
## 5048 2020-02-27     47.13    2978.76     47.17     98.44    1.395     39.16
## 5049 2020-02-28     48.42    2954.22     44.83     98.13    1.230     40.11
## 5050 2020-03-02     49.23    3090.23     46.78     97.36    1.135     33.42
## 5051 2020-03-03     48.12    3003.37     47.27     97.15    0.918     36.82
## 5052 2020-03-04     49.43    3130.12     46.78     97.34    0.675     31.99
## 5053 2020-03-05     47.70    3023.94     45.90     96.82    0.595     39.62
## 5054 2020-03-06     45.33    2972.37     41.14     95.95    0.415     41.94
## 5055 2020-03-09     34.07    2746.56     31.05     94.90    0.330     54.46
## 5056 2020-03-10     34.88    2882.23     34.47     96.41    0.390     47.30
## 5057 2020-03-11     32.56    2741.38     33.13     96.51    0.368     53.90
## 5058 2020-03-12     28.20    2480.64     31.56     97.47    0.273     75.47
## 5059 2020-03-13     31.38    2711.02     31.72     98.75    0.243     57.83
## 5060 2020-03-16     26.08    2386.13     28.96     98.09    0.185     82.69
## 5061 2020-03-17     26.25    2529.19     26.96     99.58    0.165     75.91
## 5062 2020-03-18     22.67    2398.10     20.48    101.16    0.003     76.45
## 5063 2020-03-19     25.59    2409.39     25.09    102.76   -0.028     72.00
## 5064 2020-03-20     26.84    2304.92     19.48    102.82   -0.033     66.04
## 5065 2020-03-23     24.55    2237.40     23.33    102.49   -0.040     61.59
## 5066 2020-03-24     30.74    2447.33     21.03    101.74   -0.033     61.67
## 5067 2020-03-25     30.94    2475.56     20.75    101.05   -0.070     63.95
## 5068 2020-03-26     32.09    2630.07     16.60     99.42   -0.105     61.00
## 5069 2020-03-27     29.25    2541.47     15.48     98.37   -0.058     65.54
## 5070 2020-03-30     29.29    2626.65     14.10     99.18    0.013     57.08
## 5071 2020-03-31     30.80    2584.59     20.51     99.05    0.030     53.54
## 5072 2020-04-01     29.62    2470.50     20.28     99.67    0.063     57.06
## 5073 2020-04-02     33.86    2526.90     25.18    100.18    0.065     50.91
## 5074 2020-04-03     32.91    2488.65     28.36    100.58    0.058     46.80
## 5075 2020-04-06     32.80    2663.68     26.21    100.69    0.060     45.24
## 5076 2020-04-07     33.27    2659.41     23.54     99.98    0.128     46.70
## 5077 2020-04-08     35.68    2749.98     24.97    100.12    0.185     43.35
## 5078 2020-04-09     34.73    2789.82     22.90     99.52    0.210     41.67
## 5079 2020-04-13     34.30    2761.63     22.36     99.35    0.200     41.17
## 5080 2020-04-14     34.08    2846.06     20.15     98.89    0.165     37.76
## 5081 2020-04-15     32.20    2783.36     19.96     99.46    0.115     40.84
## 5082 2020-04-16     31.07    2799.55     19.82    100.03    0.110     40.11
## 5083 2020-04-17     35.26    2874.56     18.31     99.78    0.103     38.15
## 5084 2020-04-20     34.57    2823.16    -36.98     99.96    0.070     43.83
##          Y start_day_20080317 start_day_09_08_08 start_day_09_12_08
## 5025 61.04                  0                  0                  0
## 5026 61.18                  0                  0                  0
## 5027 60.49                  0                  0                  0
## 5028 60.89                  0                  0                  0
## 5029 59.43                  0                  0                  0
## 5030 59.18                  0                  0                  0
## 5031 56.49                  0                  0                  0
## 5032 58.78                  0                  0                  0
## 5033 58.41                  0                  0                  0
## 5034 57.99                  0                  0                  0
## 5035 57.87                  0                  0                  0
## 5036 58.71                  0                  0                  0
```

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## 5037 59.76                 0                 0                 0
## 5038 58.82                 0                 0                 0
## 5039 58.62                 0                 0                 0
## 5040 58.30                 0                 0                 0
## 5041 59.26                 0                 0                 0
## 5042 58.88                 0                 0                 0
## 5043 58.44                 0                 0                 0
## 5044 56.38                 0                 0                 0
## 5045 53.83                 0                 0                 0
## 5046 51.17                 0                 0                 0
## 5047 47.13                 0                 0                 0
## 5048 48.42                 0                 0                 0
## 5049 49.23                 0                 0                 0
## 5050 48.12                 0                 0                 0
## 5051 49.43                 0                 0                 0
## 5052 47.70                 0                 0                 0
## 5053 45.33                 0                 0                 0
## 5054 34.07                 0                 0                 0
## 5055 34.88                 0                 0                 0
## 5056 32.56                 0                 0                 0
## 5057 28.20                 0                 0                 0
## 5058 31.38                 0                 0                 0
## 5059 26.08                 0                 0                 0
## 5060 26.25                 0                 0                 0
## 5061 22.67                 0                 0                 0
## 5062 25.59                 0                 0                 0
## 5063 26.84                 0                 0                 0
## 5064 24.55                 0                 0                 0
## 5065 30.74                 0                 0                 0
## 5066 30.94                 0                 0                 0
## 5067 32.09                 0                 0                 0
## 5068 29.25                 0                 0                 0
## 5069 29.29                 0                 0                 0
## 5070 30.80                 0                 0                 0
## 5071 29.62                 0                 0                 0
## 5072 33.86                 0                 0                 0
## 5073 32.91                 0                 0                 0
## 5074 32.80                 0                 0                 0
## 5075 33.27                 0                 0                 0
## 5076 35.68                 0                 0                 0
## 5077 34.73                 0                 0                 0
## 5078 34.30                 0                 0                 0
## 5079 34.08                 0                 0                 0
## 5080 32.20                 0                 0                 0
## 5081 31.07                 0                 0                 0
## 5082 35.26                 0                 0                 0
## 5083 34.57                 0                 0                 0
## 5084 33.19                 0                 0                 0
##      start_day_09_26_08 start_day_20141127 start_day_20200309
## 5025                  0                 0                 0
## 5026                  0                 0                 0
## 5027                  0                 0                 0
## 5028                  0                 0                 0
## 5029                  0                 0                 0
```

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## 5030                0                0                0
## 5031                0                0                0
## 5032                0                0                0
## 5033                0                0                0
## 5034                0                0                0
## 5035                0                0                0
## 5036                0                0                0
## 5037                0                0                0
## 5038                0                0                0
## 5039                0                0                0
## 5040                0                0                0
## 5041                0                0                0
## 5042                0                0                0
## 5043                0                0                0
## 5044                0                0                0
## 5045                0                0                0
## 5046                0                0                0
## 5047                0                0                0
## 5048                0                0                0
## 5049                0                0                0
## 5050                0                0                0
## 5051                0                0                0
## 5052                0                0                0
## 5053                0                0                0
## 5054                0                0                1
## 5055                0                0                0
## 5056                0                0                0
## 5057                0                0                0
## 5058                0                0                0
## 5059                0                0                0
## 5060                0                0                0
## 5061                0                0                0
## 5062                0                0                0
## 5063                0                0                0
## 5064                0                0                0
## 5065                0                0                0
## 5066                0                0                0
## 5067                0                0                0
## 5068                0                0                0
## 5069                0                0                0
## 5070                0                0                0
## 5071                0                0                0
## 5072                0                0                0
## 5073                0                0                0
## 5074                0                0                0
## 5075                0                0                0
## 5076                0                0                0
## 5077                0                0                0
## 5078                0                0                0
## 5079                0                0                0
## 5080                0                0                0
## 5081                0                0                0
## 5082                0                0                0
## 5083                0                0                0
```

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## 5084                  0                  0                  0
```

```
print(TS_2008_03_17)   # donor 1
```

```
##            Date COP_Close GSPC_Close WTI_Close USD_Close  TB_Close VIX_Close
## 2018 2008-02-01  73.66842   1678.074  107.0638  90.73301 2.4652441  28.88545
## 2019 2008-02-04  73.11838   1660.516  108.3144  90.63681 2.6095513  31.25449
## 2020 2008-02-05  69.75398   1607.387  106.2099  91.53873 2.5794872  33.96024
## 2021 2008-02-06  67.35215   1595.133  104.8150  91.56278 2.4532186  34.83811
## 2022 2008-02-07  68.31472   1607.712  105.9093  92.52483 2.5253720  33.26276
## 2023 2008-02-08  69.10310   1600.954  110.3588  92.20013 2.5975257  33.68365
## 2024 2008-02-11  70.56071   1610.382  112.5113  92.09190 2.6336024  33.19061
## 2025 2008-02-12  70.03817   1622.083  111.6214  91.77924 2.7057558  31.66336
## 2026 2008-02-13  72.10081   1644.149  112.1746  91.87544 2.6576535  29.91965
## 2027 2008-02-14  72.38500   1622.083  114.7481  91.57480 2.6696791  30.71334
## 2028 2008-02-15  72.46750   1623.441  114.9285  91.51467 2.5614490  30.08801
## 2029 2008-02-19  73.92510   1621.986  120.2438  91.39442 2.6095513  30.77346
## 2030 2008-02-20  74.80517   1635.515  121.2900  91.53873 2.6155639  29.34242
## 2031 2008-02-21  73.16422   1614.470  118.5362  90.91339 2.5734745  30.20826
## 2032 2008-02-22  73.89760   1627.193  119.0893  90.81719 2.5734745  28.93355
## 2033 2008-02-25  75.41021   1649.669  119.5343  90.82921 2.5373975  27.69491
## 2034 2008-02-26  77.55536   1661.082  121.2539  89.90325 2.4953082  26.33602
## 2035 2008-02-27  77.12449   1659.554  119.7628  89.24184 2.3209371  27.28604
## 2036 2008-02-28  78.10540   1644.715  123.3825  88.65259 2.2307454  28.29619
## 2037 2008-02-29  75.82274   1600.160  122.3964  88.64056 2.1465662  31.91589
## 2038 2008-03-03  76.49195   1601.014  123.1660  88.62853 1.9661825  31.60323
## 2039 2008-03-04  74.71349   1595.494  119.9191  88.58044 1.9180803  30.68928
## 2040 2008-03-05  75.74940   1603.852  125.6072  88.36398 1.7797861  29.58293
## 2041 2008-03-06  73.46674   1568.545  126.8819  87.78674 1.6414919  33.13048
## 2042 2008-03-07  71.83496   1555.353  126.4129  87.82282 1.6835814  33.05832
## 2043 2008-03-10  70.90907   1531.301  129.7560  87.77472 1.5633255  35.33116
## 2044 2008-03-11  72.88003   1588.158  130.7541  88.12346 1.7316838  31.69943
## 2045 2008-03-12  71.79829   1573.872  132.1130  87.06521 1.7316838  32.73363
## 2046 2008-03-13  71.52327   1581.941  132.5339  86.66836 1.5633255  32.81781
## 2047 2008-03-14  71.03741   1549.063  132.3175  86.17532 1.3468651  37.47171
## 2048 2008-03-17  69.56147   1535.186  127.1585  85.93480 1.1905326  38.77048
## 2049 2008-03-18  71.75245   1600.292  131.7643  86.06709 1.0823023  31.01398
## 2050 2008-03-19  67.48049   1561.426  124.1641  86.75254 0.7816628  35.88434
## 2051 2008-03-20  68.59890   1598.813  123.3464  87.48610 0.6012791  32.01210
## 2052 2008-03-24  69.30478   1623.309  122.3002  87.72661 1.2205965  30.94182
## 2053 2008-03-25  68.32388   1627.049  122.3964  86.92090 1.5092105  30.92979
## 2054 2008-03-26  69.95567   1612.787  127.2667  85.99493 1.5272488  31.36272
## 2055 2008-03-27  69.42396   1594.303  129.3472  86.17532 1.5031977  31.12220
## 2056 2008-03-28  69.36896   1581.628  126.9781  86.19937 1.6234535  30.91777
## 2057 2008-03-31  69.86399   1590.624  122.1078  86.34368 1.5332616  30.79751
## 2058 2008-04-01  71.24825   1647.721  121.3622  87.25762 1.6294663  27.27402
## 2059 2008-04-02  72.21082   1644.534  126.0642  86.89685 1.6414919  28.17594
## 2060 2008-04-03  71.85330   1646.675  124.9698  86.84875 1.6354791  27.91137
## 2061 2008-04-04  72.24749   1647.986  127.5794  86.60823 1.5873768  26.99743
## 2062 2008-04-07  72.32999   1650.559  130.9706  86.82469 1.6354791  26.96135
## 2063 2008-04-08  72.85253   1642.141  130.5257  86.86078 1.6234535  26.88920
## 2064 2008-04-09  72.81586   1628.853  133.3517  86.37975 1.5332616  27.43035
## 2065 2008-04-10  72.71502   1636.141  132.3656  86.72850 1.4851593  26.43223
## 2066 2008-04-11  72.04581   1602.806  132.4498  86.35570 1.3949674  28.21201
```

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## 2067 2008-04-14  73.16422   1597.382  134.3378  86.43988 1.2927501  28.64493
## 2068 2008-04-15  74.47514   1604.730  136.8150  86.60823 1.3228140  27.39428
## 2069 2008-04-16  75.91441   1641.143  138.0537  85.87468 1.3408523  24.68852
## 2070 2008-04-17  75.91441   1642.165  138.0537  86.19937 1.4550954  24.49611
## 2071 2008-04-18  76.90448   1671.953  140.1702  86.59621 1.5873768  24.20749
## 2072 2008-04-21  77.31701   1669.355  141.2765  86.16329 1.5272488  24.65244
## 2073 2008-04-22  77.82121   1654.648  143.3089  85.77847 1.5092105  25.09739
## 2074 2008-04-23  77.44535   1659.446  143.4411  86.36773 1.4430698  24.36383
## 2075 2008-04-24  75.98775   1670.137  140.8196  87.23357 1.4671210  24.12332
## 2076 2008-04-25  76.61112   1680.984  143.8741  87.53421 1.5452872  23.55811
## 2077 2008-04-28  77.40868   1679.216  142.8399  87.53421 1.5994024  23.61824
##             Y start_day_20080317 start_day_09_08_08 start_day_09_12_08
## 2018 60.80237                  0                  0                  0
## 2019 58.00467                  0                  0                  0
## 2020 56.00740                  0                  0                  0
## 2021 56.80783                  0                  0                  0
## 2022 57.46342                  0                  0                  0
## 2023 58.67551                  0                  0                  0
## 2024 58.24099                  0                  0                  0
## 2025 59.95620                  0                  0                  0
## 2026 60.19252                  0                  0                  0
## 2027 60.26112                  0                  0                  0
## 2028 61.47321                  0                  0                  0
## 2029 62.20503                  0                  0                  0
## 2030 60.84048                  0                  0                  0
## 2031 61.45034                  0                  0                  0
## 2032 62.70816                  0                  0                  0
## 2033 64.49198                  0                  0                  0
## 2034 64.13369                  0                  0                  0
## 2035 64.94937                  0                  0                  0
## 2036 63.05120                  0                  0                  0
## 2037 63.60769                  0                  0                  0
## 2038 62.12880                  0                  0                  0
## 2039 62.99022                  0                  0                  0
## 2040 61.09205                  0                  0                  0
## 2041 59.73513                  0                  0                  0
## 2042 58.96519                  0                  0                  0
## 2043 60.60416                  0                  0                  0
## 2044 59.70463                  0                  0                  0
## 2045 59.47594                  0                  0                  0
## 2046 59.07191                  0                  0                  0
## 2047 57.84458                  1                  0                  0
## 2048 59.66652                  0                  0                  0
## 2049 56.11412                  0                  0                  0
## 2050 57.04415                  0                  0                  0
## 2051 57.63113                  0                  0                  0
## 2052 56.81545                  0                  0                  0
## 2053 58.17238                  0                  0                  0
## 2054 57.73023                  0                  0                  0
## 2055 57.68449                  0                  0                  0
## 2056 58.09615                  0                  0                  0
## 2057 59.24724                  0                  0                  0
## 2058 60.04768                  0                  0                  0
## 2059 59.75037                  0                  0                  0
```

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## 2060 60.07817                 0                 0                 0
## 2061 60.14677                 0                 0                 0
## 2062 60.58130                 0                 0                 0
## 2063 60.55080                 0                 0                 0
## 2064 60.46695                 0                 0                 0
## 2065 59.91046                 0                 0                 0
## 2066 60.84048                 0                 0                 0
## 2067 61.93060                 0                 0                 0
## 2068 63.12743                 0                 0                 0
## 2069 63.12743                 0                 0                 0
## 2070 63.95074                 0                 0                 0
## 2071 64.29378                 0                 0                 0
## 2072 64.71305                 0                 0                 0
## 2073 64.40051                 0                 0                 0
## 2074 63.18842                 0                 0                 0
## 2075 63.70679                 0                 0                 0
## 2076 64.37001                 0                 0                 0
## 2077 65.13995                 0                 0                 0
##      start_day_09_26_08 start_day_20141127 start_day_20200309
## 2018                  0                 0                 0
## 2019                  0                 0                 0
## 2020                  0                 0                 0
## 2021                  0                 0                 0
## 2022                  0                 0                 0
## 2023                  0                 0                 0
## 2024                  0                 0                 0
## 2025                  0                 0                 0
## 2026                  0                 0                 0
## 2027                  0                 0                 0
## 2028                  0                 0                 0
## 2029                  0                 0                 0
## 2030                  0                 0                 0
## 2031                  0                 0                 0
## 2032                  0                 0                 0
## 2033                  0                 0                 0
## 2034                  0                 0                 0
## 2035                  0                 0                 0
## 2036                  0                 0                 0
## 2037                  0                 0                 0
## 2038                  0                 0                 0
## 2039                  0                 0                 0
## 2040                  0                 0                 0
## 2041                  0                 0                 0
## 2042                  0                 0                 0
## 2043                  0                 0                 0
## 2044                  0                 0                 0
## 2045                  0                 0                 0
## 2046                  0                 0                 0
## 2047                  0                 0                 0
## 2048                  0                 0                 0
## 2049                  0                 0                 0
## 2050                  0                 0                 0
## 2051                  0                 0                 0
## 2052                  0                 0                 0
```

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## 2053                  0                  0                  0
## 2054                  0                  0                  0
## 2055                  0                  0                  0
## 2056                  0                  0                  0
## 2057                  0                  0                  0
## 2058                  0                  0                  0
## 2059                  0                  0                  0
## 2060                  0                  0                  0
## 2061                  0                  0                  0
## 2062                  0                  0                  0
## 2063                  0                  0                  0
## 2064                  0                  0                  0
## 2065                  0                  0                  0
## 2066                  0                  0                  0
## 2067                  0                  0                  0
## 2068                  0                  0                  0
## 2069                  0                  0                  0
## 2070                  0                  0                  0
## 2071                  0                  0                  0
## 2072                  0                  0                  0
## 2073                  0                  0                  0
## 2074                  0                  0                  0
## 2075                  0                  0                  0
## 2076                  0                  0                  0
## 2077                  0                  0                  0
```

```
print(TS_2014_11_28)   # donor 2
```

```
##            Date COP_Close GSPC_Close WTI_Close USD_Close    TB_Close VIX_Close
## 3707 2014-10-16  73.19019   2036.990  90.03060  92.95034 0.021870667  27.55704
## 3708 2014-10-17  74.44775   2063.235  90.54456  93.15811 0.024057734  24.04680
## 3709 2014-10-20  75.26790   2082.098  90.50082  92.89566 0.021870667  20.30691
## 3710 2014-10-21  77.19252   2122.854  91.03665  93.28933 0.019683600  17.58402
## 3711 2014-10-22  75.93496   2107.359  88.05131  93.75955 0.016403000  19.54144
## 3712 2014-10-23  76.54734   2133.287  90.55550  93.86890 0.016403000  18.07611
## 3713 2014-10-24  76.62388   2148.334  88.87146  93.74862 0.005467667  17.61682
## 3714 2014-10-27  75.26790   2145.108  88.86052  93.49710 0.005467667  17.54028
## 3715 2014-10-28  76.78791   2170.718  88.96987  93.39869 0.016403000  15.73595
## 3716 2014-10-29  77.36749   2167.711  89.94312  93.98919 0.016403000  16.56703
## 3717 2014-10-30  78.02360   2181.216  88.64181  94.20790 0.003280600  15.87810
## 3718 2014-10-31  78.89843   2206.805  88.06224  95.00618 0.003280600  15.34227
## 3719 2014-11-03  77.15971   2206.543  86.13762  95.47640 0.003280600  16.10775
## 3720 2014-11-04  75.20229   2200.298  84.36610  95.11554 0.024057734  16.28271
## 3721 2014-11-05  76.41611   2212.841  86.07201  95.61856 0.021870667  15.49537
## 3722 2014-11-06  77.99080   2221.196  85.15344  96.24187 0.019683600  14.94860
## 3723 2014-11-07  78.90937   2221.972  86.07201  95.83726 0.019683600  14.34716
## 3724 2014-11-10  78.29699   2228.905  84.67229  96.02316 0.016403000  13.85507
## 3725 2014-11-11  78.46102   2230.458  85.13157  95.71697 0.016403000  14.12845
## 3726 2014-11-12  77.85957   2228.894  84.37703  96.03410 0.014215934  14.23780
## 3727 2014-11-13  76.93007   2230.075  81.06363  95.87007 0.005467667  15.07983
## 3728 2014-11-14  78.08922   2230.611  83.01012  95.71697 0.003280600  14.55493
## 3729 2014-11-17  78.10015   2232.251  82.71486  96.15439 0.010935333  15.29853
## 3730 2014-11-18  78.37353   2243.712  81.52291  95.77165 0.016403000  15.15637
## 3731 2014-11-19  78.87656   2240.344  81.52291  95.84820 0.016403000  15.26573
```

```
## 3732 2014-11-20  80.05758   2244.751  82.70393  95.78258 0.016403000  14.85018
## 3733 2014-11-21  80.52780   2256.506  83.67717  96.56993 0.003280600  14.10658
## 3734 2014-11-24  80.18880   2262.969  82.82422  96.39497 0.005467667  13.80039
## 3735 2014-11-25  78.43915   2260.366  80.96521  96.14345 0.019683600  13.39578
## 3736 2014-11-26  77.45497   2266.709  80.59341  95.80446 0.010935333  13.19895
## 3737 2014-11-28  72.24975   2260.946  72.10759  96.62461 0.005467667  14.57680
## 3738 2014-12-01  74.10875   2245.505  75.43193  96.17626 0.007654734  15.48443
## 3739 2014-12-02  75.68344   2259.841  73.25580  96.94173 0.016403000  14.05190
## 3740 2014-12-03  77.42217   2268.349  73.59480  97.28073 0.005467667  13.66917
## 3741 2014-12-04  75.79279   2265.714  72.97148  96.99641 0.014215934  13.53794
## 3742 2014-12-05  74.19624   2269.486  72.05291  97.68534 0.010935333  13.00211
## 3743 2014-12-08  71.11247   2253.018  69.03476  97.36821 0.005467667  15.53911
## 3744 2014-12-09  71.03593   2252.482  69.70182  96.98548 0.030618935  16.78574
## 3745 2014-12-10  69.48311   2215.652  66.69460  96.52619 0.027338334  20.26317
## 3746 2014-12-11  69.55966   2225.701  65.62294  96.95267 0.024057734  21.95815
## 3747 2014-12-12  68.29116   2189.615  63.21716  96.62461 0.016403000  23.05168
## 3748 2014-12-15  67.46007   2175.727  61.19413  96.73396 0.010935333  22.32995
## 3749 2014-12-16  69.13318   2157.257  61.20506  96.37309 0.032806000  25.77458
## 3750 2014-12-17  73.20113   2201.162  61.70809  97.46663 0.021870667  21.25829
## 3751 2014-12-18  76.27395   2254.024  59.24764  97.58691 0.036086601  18.38230
## 3752 2014-12-19  77.61900   2264.325  62.23298  97.98059 0.027338334  18.03236
## 3753 2014-12-22  76.02244   2272.953  60.41772  98.16649 0.016403000  16.67638
## 3754 2014-12-23  77.69555   2276.922  62.09082  98.48361 0.021870667  16.18429
## 3755 2014-12-24  76.68949   2276.605  60.90981  98.38520 0.021870667  15.71407
## 3756 2014-12-26  76.41611   2284.140  59.69599  98.45081 0.010935333  15.85623
## 3757 2014-12-29  76.66762   2286.108  58.46029  98.62578 0.003280600  16.46861
## 3758 2014-12-30  76.47079   2274.932  59.20390  98.40706 0.021870667  17.40905
## 3759 2014-12-31  75.51941   2251.476  58.44936  98.71325 0.040460735  20.99584
## 3760 2015-01-02  75.36632   2250.710  57.65108  99.59902 0.016403000  19.45396
## 3761 2015-01-05  71.77953   2209.572  54.73134  99.92708 0.003280600  21.78318
## 3762 2015-01-06  68.81605   2189.921  52.46773 100.05830 0.021870667  23.09543
## 3763 2015-01-07  69.27534   2215.389  53.24414 100.48478 0.021870667  21.11613
## 3764 2015-01-08  71.00312   2255.019  53.36443 101.00968 0.019683600  18.60100
## 3765 2015-01-09  70.99218   2236.068  52.87234 100.53946 0.016403000  19.19151
## 3766 2015-01-12  68.96915   2217.970  50.36815 100.58320 0.014215934  21.43325
##          Y start_day_20080317 start_day_09_08_08 start_day_09_12_08
## 3707 68.08                   0                  0                  0
## 3708 68.83                   0                  0                  0
## 3709 70.59                   0                  0                  0
## 3710 69.44                   0                  0                  0
## 3711 70.00                   0                  0                  0
## 3712 70.07                   0                  0                  0
## 3713 68.83                   0                  0                  0
## 3714 70.22                   0                  0                  0
## 3715 70.75                   0                  0                  0
## 3716 71.35                   0                  0                  0
## 3717 72.15                   0                  0                  0
## 3718 70.56                   0                  0                  0
## 3719 68.77                   0                  0                  0
## 3720 69.88                   0                  0                  0
## 3721 71.32                   0                  0                  0
## 3722 72.16                   0                  0                  0
## 3723 71.60                   0                  0                  0
## 3724 71.75                   0                  0                  0
```

```
## 3725 71.20                 0                 0                 0
## 3726 70.35                 0                 0                 0
## 3727 71.41                 0                 0                 0
## 3728 71.42                 0                 0                 0
## 3729 71.67                 0                 0                 0
## 3730 72.13                 0                 0                 0
## 3731 73.21                 0                 0                 0
## 3732 73.64                 0                 0                 0
## 3733 73.33                 0                 0                 0
## 3734 71.73                 0                 0                 0
## 3735 70.83                 0                 0                 0
## 3736 66.07                 0                 0                 0
## 3737 67.77                 0                 0                 0
## 3738 69.21                 0                 0                 0
## 3739 70.80                 0                 0                 0
## 3740 69.31                 0                 0                 0
## 3741 67.85                 0                 0                 0
## 3742 65.03                 0                 0                 0
## 3743 64.96                 0                 0                 0
## 3744 63.54                 0                 0                 0
## 3745 63.61                 0                 0                 0
## 3746 62.45                 0                 0                 0
## 3747 61.69                 0                 0                 0
## 3748 63.22                 0                 0                 0
## 3749 66.94                 0                 0                 0
## 3750 69.75                 0                 0                 0
## 3751 70.98                 0                 0                 0
## 3752 69.52                 0                 0                 0
## 3753 71.05                 0                 0                 0
## 3754 70.13                 0                 0                 0
## 3755 69.88                 0                 0                 0
## 3756 70.11                 0                 0                 0
## 3757 69.93                 0                 0                 0
## 3758 69.06                 0                 0                 0
## 3759 68.92                 0                 0                 0
## 3760 65.64                 0                 0                 0
## 3761 62.93                 0                 0                 0
## 3762 63.35                 0                 0                 0
## 3763 64.93                 0                 0                 0
## 3764 64.92                 0                 0                 0
## 3765 63.07                 0                 0                 0
## 3766 62.44                 0                 0                 0
##      start_day_09_26_08 start_day_20141127 start_day_20200309
## 3707                  0                 0                 0
## 3708                  0                 0                 0
## 3709                  0                 0                 0
## 3710                  0                 0                 0
## 3711                  0                 0                 0
## 3712                  0                 0                 0
## 3713                  0                 0                 0
## 3714                  0                 0                 0
## 3715                  0                 0                 0
## 3716                  0                 0                 0
## 3717                  0                 0                 0
```

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## 3718                 0                 0                 0
## 3719                 0                 0                 0
## 3720                 0                 0                 0
## 3721                 0                 0                 0
## 3722                 0                 0                 0
## 3723                 0                 0                 0
## 3724                 0                 0                 0
## 3725                 0                 0                 0
## 3726                 0                 0                 0
## 3727                 0                 0                 0
## 3728                 0                 0                 0
## 3729                 0                 0                 0
## 3730                 0                 0                 0
## 3731                 0                 0                 0
## 3732                 0                 0                 0
## 3733                 0                 0                 0
## 3734                 0                 0                 0
## 3735                 0                 0                 0
## 3736                 0                 1                 0
## 3737                 0                 0                 0
## 3738                 0                 0                 0
## 3739                 0                 0                 0
## 3740                 0                 0                 0
## 3741                 0                 0                 0
## 3742                 0                 0                 0
## 3743                 0                 0                 0
## 3744                 0                 0                 0
## 3745                 0                 0                 0
## 3746                 0                 0                 0
## 3747                 0                 0                 0
## 3748                 0                 0                 0
## 3749                 0                 0                 0
## 3750                 0                 0                 0
## 3751                 0                 0                 0
## 3752                 0                 0                 0
## 3753                 0                 0                 0
## 3754                 0                 0                 0
## 3755                 0                 0                 0
## 3756                 0                 0                 0
## 3757                 0                 0                 0
## 3758                 0                 0                 0
## 3759                 0                 0                 0
## 3760                 0                 0                 0
## 3761                 0                 0                 0
## 3762                 0                 0                 0
## 3763                 0                 0                 0
## 3764                 0                 0                 0
## 3765                 0                 0                 0
## 3766                 0                 0                 0
```

```
print(TS_2008_09_09)   # donor 3
```

```
##            Date COP_Close GSPC_Close WTI_Close USD_Close   TB_Close VIX_Close
## 2140 2008-07-28  75.40104   1484.402 149.98305  87.36585 2.00225925  29.13798
```

```
## 2141 2008-07-29  73.58592   1519.071 146.96463  88.15953 2.02029761  26.49236
## 2142 2008-07-30  77.62869   1544.397 152.41222  88.17156 2.00827204  25.50626
## 2143 2008-07-31  74.82350   1524.098 149.32164  88.06334 1.96618254  27.58668
## 2144 2008-08-01  74.39264   1515.596 150.35584  88.29182 1.96016976  27.14174
## 2145 2008-08-04  72.83420   1502.007 146.05069  88.33992 1.99624647  28.24809
## 2146 2008-08-05  73.19172   1545.143 142.75568  88.84499 2.05637446  25.42208
## 2147 2008-08-06  74.61265   1550.326 142.58732  89.27791 1.92409305  24.32775
## 2148 2008-08-07  74.05345   1522.523 144.11457  89.65071 1.96016976  25.43410
## 2149 2008-08-08  74.17262   1558.900 138.79926  91.21403 2.00225925  24.84485
## 2150 2008-08-11  73.54924   1569.723 137.62075  91.55075 2.12852788  24.19547
## 2151 2008-08-12  73.29256   1550.807 136.00933  91.57480 2.19466866  25.45816
## 2152 2008-08-13  75.51105   1546.285 139.44864  91.64695 2.18264309  25.91513
## 2153 2008-08-14  72.76086   1554.824 138.35431  92.20013 2.20068144  24.46003
## 2154 2008-08-15  71.19325   1561.161 136.44225  92.81344 2.16460459  23.54609
## 2155 2008-08-18  70.58821   1537.591 135.79286  92.74129 2.09245117  25.22967
## 2156 2008-08-19  72.65085   1523.268 137.56063  92.40456 2.12251510  25.59044
## 2157 2008-08-20  74.11762   1532.708 138.87141  92.54887 2.00827204  24.55624
## 2158 2008-08-21  77.96788   1536.533 145.78612  91.63493 2.02631039  23.83470
## 2159 2008-08-22  76.25360   1553.946 137.66886  92.36849 2.00225925  22.62012
## 2160 2008-08-25  75.00685   1523.449 138.11380  92.34444 1.97820811  25.21764
## 2161 2008-08-26  75.52021   1529.065 139.86954  92.89762 2.01428482  24.64042
## 2162 2008-08-27  76.51945   1541.271 142.10630  92.65711 1.97219533  23.76255
## 2163 2008-08-28  76.37277   1564.143 138.99167  92.77736 2.04434889  23.36570
## 2164 2008-08-29  75.63939   1542.678 138.95559  93.05395 2.03232332  24.83283
## 2165 2008-09-02  72.42167   1536.364 131.83645  93.87169 1.98422090  26.44425
## 2166 2008-09-03  72.50418   1533.238 131.53581  93.90776 2.00225925  25.77082
## 2167 2008-09-04  70.11151   1487.360 129.86425  94.53310 1.98422090  28.89747
## 2168 2008-09-05  69.14894   1493.950 128.03636  94.91791 1.97219533  27.73099
## 2169 2008-09-08  68.47056   1524.591 127.89206  95.71160 2.00827204  27.22592
## 2170 2008-09-09  62.62183   1472.544 124.14008  95.30273 1.97219533  30.62915
## 2171 2008-09-10  65.88538   1481.600 123.45462  96.02427 1.94814419  29.48673
## 2172 2008-09-11  66.44459   1502.055 121.39824  96.38504 1.90004191  29.33039
## 2173 2008-09-12  67.31548   1505.242 121.68686  94.96602 1.75573493  30.85764
## 2174 2008-09-15  62.99769   1434.291 114.86835  94.89387 0.97407209  38.12109
## 2175 2008-09-16  66.26125   1459.425 110.02204  95.08627 1.03420002  36.43751
## 2176 2008-09-17  63.54772   1390.626 117.11714  93.91979 0.02405116  43.55666
## 2177 2008-09-18  66.24291   1450.898 117.24942  93.82358 0.08417907  39.80467
## 2178 2008-09-19  71.78913   1509.307 125.12617  93.41472 1.10635351  38.56604
## 2179 2008-09-22  71.24825   1451.596 147.44565  91.57480 1.05223837  40.70659
## 2180 2008-09-23  68.36972   1428.904 129.69590  91.95962 0.96204652  42.95538
## 2181 2008-09-24  68.61724   1426.078 128.48131  92.34444 0.52912558  42.31802
## 2182 2008-09-25  70.45070   1454.109 134.13333  92.58495 0.85381625  39.46796
## 2183 2008-09-26  69.89149   1459.028 128.39713  92.53685 0.99812323  41.77687
## 2184 2008-09-29  63.53856   1330.534 115.79432  93.16218 0.54115115  56.18352
## 2185 2008-09-30  67.15047   1402.616 121.09760  95.54324 1.08230230  47.36876
## 2186 2008-10-01  64.81281   1396.242 118.12729  95.55527 0.96204652  47.87384
## 2187 2008-10-02  62.08095   1339.987 112.84806  96.73378 0.70950927  54.42778
## 2188 2008-10-03  60.63252   1321.888 112.93223  96.57744 0.56520232  54.28347
## 2189 2008-10-06  59.34910   1270.972 106.00550  98.22495 0.49304883  62.59315
## 2190 2008-10-07  56.06720   1198.024 108.44669  97.37113 0.94400817  64.55332
## 2191 2008-10-08  56.86476   1184.448 106.95552  97.29898 0.76963719  69.18317
## 2192 2008-10-09  49.34757   1094.232 104.02128  97.59962 0.69748370  76.86751
## 2193 2008-10-10  44.21389   1081.364  93.12610  99.81233 0.25253720  84.11894
## 2194 2008-10-13  51.55690   1206.587  97.61164  98.46546 0.25253720  66.12867
```

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## 2195 2008-10-14  52.21694   1200.165  94.62930  97.84013 0.28260116  66.29703
## 2196 2008-10-15  45.00227   1091.730  89.44627  98.66990 0.24051163  83.27715
## 2197 2008-10-16  47.61496   1138.137  83.95058  99.16294 0.52311279  81.30496
## 2198 2008-10-17  48.13749   1131.066  86.46393  99.10282 0.93799531  84.57592
## 2199 2008-10-20  52.92282   1185.001  89.08551  99.93258 1.22660928  63.69951
##             Y start_day_20080317 start_day_09_08_08 start_day_09_12_08
## 2140 61.19115                  0                  0                  0
## 2141 64.55296                  0                  0                  0
## 2142 62.22028                  0                  0                  0
## 2143 61.86199                  0                  0                  0
## 2144 60.56605                  0                  0                  0
## 2145 60.86335                  0                  0                  0
## 2146 62.04494                  0                  0                  0
## 2147 61.57993                  0                  0                  0
## 2148 61.67903                  0                  0                  0
## 2149 61.16066                  0                  0                  0
## 2150 60.94721                  0                  0                  0
## 2151 62.79202                  0                  0                  0
## 2152 60.50507                  0                  0                  0
## 2153 59.20150                  0                  0                  0
## 2154 58.69838                  0                  0                  0
## 2155 60.41359                  0                  0                  0
## 2156 61.63329                  0                  0                  0
## 2157 64.83502                  0                  0                  0
## 2158 63.40949                  0                  0                  0
## 2159 62.37274                  0                  0                  0
## 2160 62.79964                  0                  0                  0
## 2161 63.63056                  0                  0                  0
## 2162 63.50859                  0                  0                  0
## 2163 62.89874                  0                  0                  0
## 2164 60.22301                  0                  0                  0
## 2165 60.29162                  0                  0                  0
## 2166 58.30197                  0                  0                  0
## 2167 57.50154                  0                  0                  0
## 2168 56.93742                  0                  0                  0
## 2169 52.07384                  0                  1                  0
## 2170 54.78769                  0                  0                  0
## 2171 55.25270                  0                  0                  0
## 2172 55.97691                  0                  0                  0
## 2173 52.38639                  0                  0                  1
## 2174 55.10024                  0                  0                  0
## 2175 52.84378                  0                  0                  0
## 2176 55.08500                  0                  0                  0
## 2177 59.69701                  0                  0                  0
## 2178 59.24724                  0                  0                  0
## 2179 56.85357                  0                  0                  0
## 2180 57.05939                  0                  0                  0
## 2181 58.58403                  0                  0                  0
## 2182 58.11901                  0                  0                  0
## 2183 52.83616                  0                  0                  0
## 2184 55.83969                  0                  0                  0
## 2185 53.89578                  0                  0                  0
## 2186 51.62408                  0                  0                  0
## 2187 50.41962                  0                  0                  0
```

```
## 2188 49.35238                0                0                0
## 2189 46.62328                0                0                0
## 2190 47.28650                0                0                0
## 2191 41.03550                0                0                0
## 2192 36.76653                0                0                0
## 2193 42.87268                0                0                0
## 2194 43.42155                0                0                0
## 2195 37.42212                0                0                0
## 2196 39.59472                0                0                0
## 2197 40.02924                0                0                0
## 2198 44.00853                0                0                0
## 2199 41.13460                0                0                0
##      start_day_09_26_08 start_day_20141127 start_day_20200309
## 2140                  0                  0                  0
## 2141                  0                  0                  0
## 2142                  0                  0                  0
## 2143                  0                  0                  0
## 2144                  0                  0                  0
## 2145                  0                  0                  0
## 2146                  0                  0                  0
## 2147                  0                  0                  0
## 2148                  0                  0                  0
## 2149                  0                  0                  0
## 2150                  0                  0                  0
## 2151                  0                  0                  0
## 2152                  0                  0                  0
## 2153                  0                  0                  0
## 2154                  0                  0                  0
## 2155                  0                  0                  0
## 2156                  0                  0                  0
## 2157                  0                  0                  0
## 2158                  0                  0                  0
## 2159                  0                  0                  0
## 2160                  0                  0                  0
## 2161                  0                  0                  0
## 2162                  0                  0                  0
## 2163                  0                  0                  0
## 2164                  0                  0                  0
## 2165                  0                  0                  0
## 2166                  0                  0                  0
## 2167                  0                  0                  0
## 2168                  0                  0                  0
## 2169                  0                  0                  0
## 2170                  0                  0                  0
## 2171                  0                  0                  0
## 2172                  0                  0                  0
## 2173                  0                  0                  0
## 2174                  0                  0                  0
## 2175                  0                  0                  0
## 2176                  0                  0                  0
## 2177                  0                  0                  0
## 2178                  0                  0                  0
## 2179                  0                  0                  0
## 2180                  0                  0                  0
```

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## 2181                 0                 0                 0
## 2182                 0                 0                 0
## 2183                 1                 0                 0
## 2184                 0                 0                 0
## 2185                 0                 0                 0
## 2186                 0                 0                 0
## 2187                 0                 0                 0
## 2188                 0                 0                 0
## 2189                 0                 0                 0
## 2190                 0                 0                 0
## 2191                 0                 0                 0
## 2192                 0                 0                 0
## 2193                 0                 0                 0
## 2194                 0                 0                 0
## 2195                 0                 0                 0
## 2196                 0                 0                 0
## 2197                 0                 0                 0
## 2198                 0                 0                 0
## 2199                 0                 0                 0
```

```
print(TS_2008_09_15)   # donor 4
```

```
##            Date COP_Close GSPC_Close WTI_Close USD_Close   TB_Close VIX_Close
## 2144 2008-08-01  74.39264   1515.596 150.35584  88.29182 1.96016976  27.14174
## 2145 2008-08-04  72.83420   1502.007 146.05069  88.33992 1.99624647  28.24809
## 2146 2008-08-05  73.19172   1545.143 142.75568  88.84499 2.05637446  25.42208
## 2147 2008-08-06  74.61265   1550.326 142.58732  89.27791 1.92409305  24.32775
## 2148 2008-08-07  74.05345   1522.523 144.11457  89.65071 1.96016976  25.43410
## 2149 2008-08-08  74.17262   1558.900 138.79926  91.21403 2.00225925  24.84485
## 2150 2008-08-11  73.54924   1569.723 137.62075  91.55075 2.12852788  24.19547
## 2151 2008-08-12  73.29256   1550.807 136.00933  91.57480 2.19466866  25.45816
## 2152 2008-08-13  75.51105   1546.285 139.44864  91.64695 2.18264309  25.91513
## 2153 2008-08-14  72.76086   1554.824 138.35431  92.20013 2.20068144  24.46003
## 2154 2008-08-15  71.19325   1561.161 136.44225  92.81344 2.16460459  23.54609
## 2155 2008-08-18  70.58821   1537.591 135.79286  92.74129 2.09245117  25.22967
## 2156 2008-08-19  72.65085   1523.268 137.56063  92.40456 2.12251510  25.59044
## 2157 2008-08-20  74.11762   1532.708 138.87141  92.54887 2.00827204  24.55624
## 2158 2008-08-21  77.96788   1536.533 145.78612  91.63493 2.02631039  23.83470
## 2159 2008-08-22  76.25360   1553.946 137.66886  92.36849 2.00225925  22.62012
## 2160 2008-08-25  75.00685   1523.449 138.11380  92.34444 1.97820811  25.21764
## 2161 2008-08-26  75.52021   1529.065 139.86954  92.89762 2.01428482  24.64042
## 2162 2008-08-27  76.51945   1541.271 142.10630  92.65711 1.97219533  23.76255
## 2163 2008-08-28  76.37277   1564.143 138.99167  92.77736 2.04434889  23.36570
## 2164 2008-08-29  75.63939   1542.678 138.95559  93.05395 2.03232332  24.83283
## 2165 2008-09-02  72.42167   1536.364 131.83645  93.87169 1.98422090  26.44425
## 2166 2008-09-03  72.50418   1533.238 131.53581  93.90776 2.00225925  25.77082
## 2167 2008-09-04  70.11151   1487.360 129.86425  94.53310 1.98422090  28.89747
## 2168 2008-09-05  69.14894   1493.950 128.03636  94.91791 1.97219533  27.73099
## 2169 2008-09-08  68.47056   1524.591 127.89206  95.71160 2.00827204  27.22592
## 2170 2008-09-09  62.62183   1472.544 124.14008  95.30273 1.97219533  30.62915
## 2171 2008-09-10  65.88538   1481.600 123.45462  96.02427 1.94814419  29.48673
## 2172 2008-09-11  66.44459   1502.055 121.39824  96.38504 1.90004191  29.33039
## 2173 2008-09-12  67.31548   1505.242 121.68686  94.96602 1.75573493  30.85764
## 2174 2008-09-15  62.99769   1434.291 114.86835  94.89387 0.97407209  38.12109
```

```
## 2175 2008-09-16  66.26125   1459.425 110.02204  95.08627 1.03420002  36.43751
## 2176 2008-09-17  63.54772   1390.626 117.11714  93.91979 0.02405116  43.55666
## 2177 2008-09-18  66.24291   1450.898 117.24942  93.82358 0.08417907  39.80467
## 2178 2008-09-19  71.78913   1509.307 125.12617  93.41472 1.10635351  38.56604
## 2179 2008-09-22  71.24825   1451.596 147.44565  91.57480 1.05223837  40.70659
## 2180 2008-09-23  68.36972   1428.904 129.69590  91.95962 0.96204652  42.95538
## 2181 2008-09-24  68.61724   1426.078 128.48131  92.34444 0.52912558  42.31802
## 2182 2008-09-25  70.45070   1454.109 134.13333  92.58495 0.85381625  39.46796
## 2183 2008-09-26  69.89149   1459.028 128.39713  92.53685 0.99812323  41.77687
## 2184 2008-09-29  63.53856   1330.534 115.79432  93.16218 0.54115115  56.18352
## 2185 2008-09-30  67.15047   1402.616 121.09760  95.54324 1.08230230  47.36876
## 2186 2008-10-01  64.81281   1396.242 118.12729  95.55527 0.96204652  47.87384
## 2187 2008-10-02  62.08095   1339.987 112.84806  96.73378 0.70950927  54.42778
## 2188 2008-10-03  60.63252   1321.888 112.93223  96.57744 0.56520232  54.28347
## 2189 2008-10-06  59.34910   1270.972 106.00550  98.22495 0.49304883  62.59315
## 2190 2008-10-07  56.06720   1198.024 108.44669  97.37113 0.94400817  64.55332
## 2191 2008-10-08  56.86476   1184.448 106.95552  97.29898 0.76963719  69.18317
## 2192 2008-10-09  49.34757   1094.232 104.02128  97.59962 0.69748370  76.86751
## 2193 2008-10-10  44.21389   1081.364  93.12610  99.81233 0.25253720  84.11894
## 2194 2008-10-13  51.55690   1206.587  97.61164  98.46546 0.25253720  66.12867
## 2195 2008-10-14  52.21694   1200.165  94.62930  97.84013 0.28260116  66.29703
## 2196 2008-10-15  45.00227   1091.730  89.44627  98.66990 0.24051163  83.27715
## 2197 2008-10-16  47.61496   1138.137  83.95058  99.16294 0.52311279  81.30496
## 2198 2008-10-17  48.13749   1131.066  86.46393  99.10282 0.93799531  84.57592
## 2199 2008-10-20  52.92282   1185.001  89.08551  99.93258 1.22660928  63.69951
## 2200 2008-10-21  49.46675   1148.503  85.73037 101.00286 1.31680120  63.86786
## 2201 2008-10-22  44.97477   1078.430  80.47519 102.66239 1.21458371  83.75818
## 2202 2008-10-23  47.20243   1092.055  80.77583 102.65036 1.09432794  81.53345
## 2203 2008-10-24  44.41557   1054.367  76.17003 103.94913 0.98609766  95.15842
##             Y start_day_20080317 start_day_09_08_08 start_day_09_12_08
## 2144 60.56605                  0                   0                   0
## 2145 60.86335                  0                   0                   0
## 2146 62.04494                  0                   0                   0
## 2147 61.57993                  0                   0                   0
## 2148 61.67903                  0                   0                   0
## 2149 61.16066                  0                   0                   0
## 2150 60.94721                  0                   0                   0
## 2151 62.79202                  0                   0                   0
## 2152 60.50507                  0                   0                   0
## 2153 59.20150                  0                   0                   0
## 2154 58.69838                  0                   0                   0
## 2155 60.41359                  0                   0                   0
## 2156 61.63329                  0                   0                   0
## 2157 64.83502                  0                   0                   0
## 2158 63.40949                  0                   0                   0
## 2159 62.37274                  0                   0                   0
## 2160 62.79964                  0                   0                   0
## 2161 63.63056                  0                   0                   0
## 2162 63.50859                  0                   0                   0
## 2163 62.89874                  0                   0                   0
## 2164 60.22301                  0                   0                   0
## 2165 60.29162                  0                   0                   0
## 2166 58.30197                  0                   0                   0
## 2167 57.50154                  0                   0                   0
```

```
## 2168 56.93742                0                0                0
## 2169 52.07384                0                1                0
## 2170 54.78769                0                0                0
## 2171 55.25270                0                0                0
## 2172 55.97691                0                0                0
## 2173 52.38639                0                0                1
## 2174 55.10024                0                0                0
## 2175 52.84378                0                0                0
## 2176 55.08500                0                0                0
## 2177 59.69701                0                0                0
## 2178 59.24724                0                0                0
## 2179 56.85357                0                0                0
## 2180 57.05939                0                0                0
## 2181 58.58403                0                0                0
## 2182 58.11901                0                0                0
## 2183 52.83616                0                0                0
## 2184 55.83969                0                0                0
## 2185 53.89578                0                0                0
## 2186 51.62408                0                0                0
## 2187 50.41962                0                0                0
## 2188 49.35238                0                0                0
## 2189 46.62328                0                0                0
## 2190 47.28650                0                0                0
## 2191 41.03550                0                0                0
## 2192 36.76653                0                0                0
## 2193 42.87268                0                0                0
## 2194 43.42155                0                0                0
## 2195 37.42212                0                0                0
## 2196 39.59472                0                0                0
## 2197 40.02924                0                0                0
## 2198 44.00853                0                0                0
## 2199 41.13460                0                0                0
## 2200 37.39925                0                0                0
## 2201 39.25168                0                0                0
## 2202 36.93424                0                0                0
## 2203 34.77688                0                0                0
##      start_day_09_26_08 start_day_20141127 start_day_20200309
## 2144                  0                  0                  0
## 2145                  0                  0                  0
## 2146                  0                  0                  0
## 2147                  0                  0                  0
## 2148                  0                  0                  0
## 2149                  0                  0                  0
## 2150                  0                  0                  0
## 2151                  0                  0                  0
## 2152                  0                  0                  0
## 2153                  0                  0                  0
## 2154                  0                  0                  0
## 2155                  0                  0                  0
## 2156                  0                  0                  0
## 2157                  0                  0                  0
## 2158                  0                  0                  0
## 2159                  0                  0                  0
## 2160                  0                  0                  0
```

```
## 2161                 0                 0                 0
## 2162                 0                 0                 0
## 2163                 0                 0                 0
## 2164                 0                 0                 0
## 2165                 0                 0                 0
## 2166                 0                 0                 0
## 2167                 0                 0                 0
## 2168                 0                 0                 0
## 2169                 0                 0                 0
## 2170                 0                 0                 0
## 2171                 0                 0                 0
## 2172                 0                 0                 0
## 2173                 0                 0                 0
## 2174                 0                 0                 0
## 2175                 0                 0                 0
## 2176                 0                 0                 0
## 2177                 0                 0                 0
## 2178                 0                 0                 0
## 2179                 0                 0                 0
## 2180                 0                 0                 0
## 2181                 0                 0                 0
## 2182                 0                 0                 0
## 2183                 1                 0                 0
## 2184                 0                 0                 0
## 2185                 0                 0                 0
## 2186                 0                 0                 0
## 2187                 0                 0                 0
## 2188                 0                 0                 0
## 2189                 0                 0                 0
## 2190                 0                 0                 0
## 2191                 0                 0                 0
## 2192                 0                 0                 0
## 2193                 0                 0                 0
## 2194                 0                 0                 0
## 2195                 0                 0                 0
## 2196                 0                 0                 0
## 2197                 0                 0                 0
## 2198                 0                 0                 0
## 2199                 0                 0                 0
## 2200                 0                 0                 0
## 2201                 0                 0                 0
## 2202                 0                 0                 0
## 2203                 0                 0                 0
```

```
print(TS_2008_09_29)   # donor 5
```

```
##            Date COP_Close GSPC_Close WTI_Close USD_Close   TB_Close VIX_Close
## 2154 2008-08-15  71.19325   1561.161 136.44225  92.81344 2.16460459  23.54609
## 2155 2008-08-18  70.58821   1537.591 135.79286  92.74129 2.09245117  25.22967
## 2156 2008-08-19  72.65085   1523.268 137.56063  92.40456 2.12251510  25.59044
## 2157 2008-08-20  74.11762   1532.708 138.87141  92.54887 2.00827204  24.55624
## 2158 2008-08-21  77.96788   1536.533 145.78612  91.63493 2.02631039  23.83470
## 2159 2008-08-22  76.25360   1553.946 137.66886  92.36849 2.00225925  22.62012
## 2160 2008-08-25  75.00685   1523.449 138.11380  92.34444 1.97820811  25.21764
```

```
## 2161 2008-08-26  75.52021   1529.065 139.86954  92.89762 2.01428482  24.64042
## 2162 2008-08-27  76.51945   1541.271 142.10630  92.65711 1.97219533  23.76255
## 2163 2008-08-28  76.37277   1564.143 138.99167  92.77736 2.04434889  23.36570
## 2164 2008-08-29  75.63939   1542.678 138.95559  93.05395 2.03232332  24.83283
## 2165 2008-09-02  72.42167   1536.364 131.83645  93.87169 1.98422090  26.44425
## 2166 2008-09-03  72.50418   1533.238 131.53581  93.90776 2.00225925  25.77082
## 2167 2008-09-04  70.11151   1487.360 129.86425  94.53310 1.98422090  28.89747
## 2168 2008-09-05  69.14894   1493.950 128.03636  94.91791 1.97219533  27.73099
## 2169 2008-09-08  68.47056   1524.591 127.89206  95.71160 2.00827204  27.22592
## 2170 2008-09-09  62.62183   1472.544 124.14008  95.30273 1.97219533  30.62915
## 2171 2008-09-10  65.88538   1481.600 123.45462  96.02427 1.94814419  29.48673
## 2172 2008-09-11  66.44459   1502.055 121.39824  96.38504 1.90004191  29.33039
## 2173 2008-09-12  67.31548   1505.242 121.68686  94.96602 1.75573493  30.85764
## 2174 2008-09-15  62.99769   1434.291 114.86835  94.89387 0.97407209  38.12109
## 2175 2008-09-16  66.26125   1459.425 110.02204  95.08627 1.03420002  36.43751
## 2176 2008-09-17  63.54772   1390.626 117.11714  93.91979 0.02405116  43.55666
## 2177 2008-09-18  66.24291   1450.898 117.24942  93.82358 0.08417907  39.80467
## 2178 2008-09-19  71.78913   1509.307 125.12617  93.41472 1.10635351  38.56604
## 2179 2008-09-22  71.24825   1451.596 147.44565  91.57480 1.05223837  40.70659
## 2180 2008-09-23  68.36972   1428.904 129.69590  91.95962 0.96204652  42.95538
## 2181 2008-09-24  68.61724   1426.078 128.48131  92.34444 0.52912558  42.31802
## 2182 2008-09-25  70.45070   1454.109 134.13333  92.58495 0.85381625  39.46796
## 2183 2008-09-26  69.89149   1459.028 128.39713  92.53685 0.99812323  41.77687
## 2184 2008-09-29  63.53856   1330.534 115.79432  93.16218 0.54115115  56.18352
## 2185 2008-09-30  67.15047   1402.616 121.09760  95.54324 1.08230230  47.36876
## 2186 2008-10-01  64.81281   1396.242 118.12729  95.55527 0.96204652  47.87384
## 2187 2008-10-02  62.08095   1339.987 112.84806  96.73378 0.70950927  54.42778
## 2188 2008-10-03  60.63252   1321.888 112.93223  96.57744 0.56520232  54.28347
## 2189 2008-10-06  59.34910   1270.972 106.00550  98.22495 0.49304883  62.59315
## 2190 2008-10-07  56.06720   1198.024 108.44669  97.37113 0.94400817  64.55332
## 2191 2008-10-08  56.86476   1184.448 106.95552  97.29898 0.76963719  69.18317
## 2192 2008-10-09  49.34757   1094.232 104.02128  97.59962 0.69748370  76.86751
## 2193 2008-10-10  44.21389   1081.364  93.12610  99.81233 0.25253720  84.11894
## 2194 2008-10-13  51.55690   1206.587  97.61164  98.46546 0.25253720  66.12867
## 2195 2008-10-14  52.21694   1200.165  94.62930  97.84013 0.28260116  66.29703
## 2196 2008-10-15  45.00227   1091.730  89.44627  98.66990 0.24051163  83.27715
## 2197 2008-10-16  47.61496   1138.137  83.95058  99.16294 0.52311279  81.30496
## 2198 2008-10-17  48.13749   1131.066  86.46393  99.10282 0.93799531  84.57592
## 2199 2008-10-20  52.92282   1185.001  89.08551  99.93258 1.22660928  63.69951
## 2200 2008-10-21  49.46675   1148.503  85.73037 101.00286 1.31680120  63.86786
## 2201 2008-10-22  44.97477   1078.430  80.47519 102.66239 1.21458371  83.75818
## 2202 2008-10-23  47.20243   1092.055  80.77583 102.65036 1.09432794  81.53345
## 2203 2008-10-24  44.41557   1054.367  76.17003 103.94913 0.98609766  95.15842
## 2204 2008-10-27  41.82122   1020.876  74.46240 104.53838 0.87786746  96.27680
## 2205 2008-10-28  45.98318   1131.018  75.52065 104.65863 0.90191860  80.52329
## 2206 2008-10-29  45.97401   1118.487  81.11255 102.30162 0.67944534  84.13097
## 2207 2008-10-30  47.52328   1147.349  79.11630 101.68831 0.45095930  75.64091
## 2208 2008-10-31  47.67912   1164.978  81.89421 102.97505 0.52311279  72.02121
## 2209 2008-11-03  47.26660   1162.032  76.87954 103.84089 0.50507440  64.55332
## 2210 2008-11-04  51.12603   1209.473  84.67212 101.95288 0.55918954  57.39810
## 2211 2008-11-05  49.00839   1145.761  78.65933 101.74844 0.45697209  65.61157
## 2212 2008-11-06  45.02061   1088.171  73.01933 103.28772 0.37880581  76.57890
## 2213 2008-11-07  47.28493   1119.570  73.42820 103.31177 0.34874185  67.46351
##             Y start_day_20080317 start_day_09_08_08 start_day_09_12_08
```

```
## 2154 58.69838                0                0                0
## 2155 60.41359                0                0                0
## 2156 61.63329                0                0                0
## 2157 64.83502                0                0                0
## 2158 63.40949                0                0                0
## 2159 62.37274                0                0                0
## 2160 62.79964                0                0                0
## 2161 63.63056                0                0                0
## 2162 63.50859                0                0                0
## 2163 62.89874                0                0                0
## 2164 60.22301                0                0                0
## 2165 60.29162                0                0                0
## 2166 58.30197                0                0                0
## 2167 57.50154                0                0                0
## 2168 56.93742                0                0                0
## 2169 52.07384                0                1                0
## 2170 54.78769                0                0                0
## 2171 55.25270                0                0                0
## 2172 55.97691                0                0                0
## 2173 52.38639                0                0                1
## 2174 55.10024                0                0                0
## 2175 52.84378                0                0                0
## 2176 55.08500                0                0                0
## 2177 59.69701                0                0                0
## 2178 59.24724                0                0                0
## 2179 56.85357                0                0                0
## 2180 57.05939                0                0                0
## 2181 58.58403                0                0                0
## 2182 58.11901                0                0                0
## 2183 52.83616                0                0                0
## 2184 55.83969                0                0                0
## 2185 53.89578                0                0                0
## 2186 51.62408                0                0                0
## 2187 50.41962                0                0                0
## 2188 49.35238                0                0                0
## 2189 46.62328                0                0                0
## 2190 47.28650                0                0                0
## 2191 41.03550                0                0                0
## 2192 36.76653                0                0                0
## 2193 42.87268                0                0                0
## 2194 43.42155                0                0                0
## 2195 37.42212                0                0                0
## 2196 39.59472                0                0                0
## 2197 40.02924                0                0                0
## 2198 44.00853                0                0                0
## 2199 41.13460                0                0                0
## 2200 37.39925                0                0                0
## 2201 39.25168                0                0                0
## 2202 36.93424                0                0                0
## 2203 34.77688                0                0                0
## 2204 38.23780                0                0                0
## 2205 38.23018                0                0                0
## 2206 39.51849                0                0                0
## 2207 39.64808                0                0                0
```

```
## 2208 39.30504                0                0                0
## 2209 42.51439                0                0                0
## 2210 40.75344                0                0                0
## 2211 37.43737                0                0                0
## 2212 39.32029                0                0                0
## 2213 38.82478                0                0                0
##      start_day_09_26_08 start_day_20141127 start_day_20200309
## 2154                  0                  0                  0
## 2155                  0                  0                  0
## 2156                  0                  0                  0
## 2157                  0                  0                  0
## 2158                  0                  0                  0
## 2159                  0                  0                  0
## 2160                  0                  0                  0
## 2161                  0                  0                  0
## 2162                  0                  0                  0
## 2163                  0                  0                  0
## 2164                  0                  0                  0
## 2165                  0                  0                  0
## 2166                  0                  0                  0
## 2167                  0                  0                  0
## 2168                  0                  0                  0
## 2169                  0                  0                  0
## 2170                  0                  0                  0
## 2171                  0                  0                  0
## 2172                  0                  0                  0
## 2173                  0                  0                  0
## 2174                  0                  0                  0
## 2175                  0                  0                  0
## 2176                  0                  0                  0
## 2177                  0                  0                  0
## 2178                  0                  0                  0
## 2179                  0                  0                  0
## 2180                  0                  0                  0
## 2181                  0                  0                  0
## 2182                  0                  0                  0
## 2183                  1                  0                  0
## 2184                  0                  0                  0
## 2185                  0                  0                  0
## 2186                  0                  0                  0
## 2187                  0                  0                  0
## 2188                  0                  0                  0
## 2189                  0                  0                  0
## 2190                  0                  0                  0
## 2191                  0                  0                  0
## 2192                  0                  0                  0
## 2193                  0                  0                  0
## 2194                  0                  0                  0
## 2195                  0                  0                  0
## 2196                  0                  0                  0
## 2197                  0                  0                  0
## 2198                  0                  0                  0
## 2199                  0                  0                  0
## 2200                  0                  0                  0
```

```
## 2201                 0                 0                 0
## 2202                 0                 0                 0
## 2203                 0                 0                 0
## 2204                 0                 0                 0
## 2205                 0                 0                 0
## 2206                 0                 0                 0
## 2207                 0                 0                 0
## 2208                 0                 0                 0
## 2209                 0                 0                 0
## 2210                 0                 0                 0
## 2211                 0                 0                 0
## 2212                 0                 0                 0
## 2213                 0                 0                 0
```

```
lapply(
  list(TS_target, TS_2008_03_17, TS_2014_11_28, TS_2008_09_09, TS_2008_09_15, TS_2008_09_29),
  function(ts) ts[c(30, 31), c("Date", "COP_Close")]
)
```

```
## [[1]]
##            Date COP_Close
## 5054 2020-03-06     45.33
## 5055 2020-03-09     34.07
##
## [[2]]
##            Date COP_Close
## 2047 2008-03-14  71.03741
## 2048 2008-03-17  69.56147
##
## [[3]]
##            Date COP_Close
## 3736 2014-11-26  77.45497
## 3737 2014-11-28  72.24975
##
## [[4]]
##            Date COP_Close
## 2169 2008-09-08  68.47056
## 2170 2008-09-09  62.62183
##
## [[5]]
##            Date COP_Close
## 2173 2008-09-12  67.31548
## 2174 2008-09-15  62.99769
##
## [[6]]
##            Date COP_Close
## 2183 2008-09-26  69.89149
## 2184 2008-09-29  63.53856
```

```
## ========== 1) Choose the 5 covariates to use ==========
covar_names <- c("GSPC_Close", "WTI_Close", "USD_Close", "TB_Close", "VIX_Close")

## ========== 2) Build Y_series_list (target + 5 donors) ==========
```

```r
# Each element is a univariate time series of COP closing prices
Y_series_list <- list(
  Y_target      = TS_target$COP_Close,      # target series: 2020-03-09 window
  Y_2008_03_17  = TS_2008_03_17$COP_Close,  # donor: 2008-03-17 shock
  Y_2014_11_28  = TS_2014_11_28$COP_Close,  # donor: 2014-11-28 shock
  Y_2008_09_09  = TS_2008_09_09$COP_Close,  # donor: 2008-09-09 shock
  Y_2008_09_15  = TS_2008_09_15$COP_Close,  # donor: 2008-09-15 shock
  Y_2008_09_29  = TS_2008_09_29$COP_Close   # donor: 2008-09-29 shock
)

## ========== 3) Build covariates_series_list (X for dbw and ARIMA xreg) ==========
# Each element is a matrix of covariates aligned with the corresponding Y series
covariates_series_list <- list(
  X_target      = as.matrix(TS_target[,      covar_names]),
  X_2008_03_17  = as.matrix(TS_2008_03_17[,  covar_names]),
  X_2014_11_28  = as.matrix(TS_2014_11_28[,  covar_names]),
  X_2008_09_09  = as.matrix(TS_2008_09_09[,  covar_names]),
  X_2008_09_15  = as.matrix(TS_2008_09_15[,  covar_names]),
  X_2008_09_29  = as.matrix(TS_2008_09_29[,  covar_names])
)

## ========== 4) Specify pre- and post-shock lengths ==========
# Each window has 30 pre-shock days and 1 post-shock day (shock occurs at T_pre + 1)
pre_len  <- 30L
post_len <- 1L

# shock_time_vec: index of the last pre-shock observation in each series
shock_time_vec   <- rep(pre_len,  length(Y_series_list))   # all 30

# shock_length_vec: number of post-shock points used to estimate the shock effect
shock_length_vec <- rep(post_len, length(Y_series_list))   # all 1

## ========== 5) Quick sanity checks ==========
sapply(Y_series_list, length)  # should all be 60 (30 pre + 30 post)
```

```
##     Y_target Y_2008_03_17 Y_2014_11_28 Y_2008_09_09 Y_2008_09_15 Y_2008_09_29
##           60           60           60           60           60           60
```

```r
shock_time_vec                 # all equal to 30
```

```
## [1] 30 30 30 30 30 30
```

```r
shock_length_vec               # all equal to 1
```

```
## [1] 1 1 1 1 1 1
```

```r
library(postshock)

set.seed(2025)

out <- SynthPrediction(
```

```
  Y_series_list          = Y_series_list,
  covariates_series_list = covariates_series_list,
  shock_time_vec         = shock_time_vec,
  shock_length_vec       = shock_length_vec,
  k                      = 1,      # forecast only the first post-shock day
  covariate_indices      = 1:5,    # use the 5 covariates as xreg
  use_dbw                = TRUE,   # use dbw donor-balancing weights
  dbw_scale              = TRUE,   # scale covariates inside dbw
  dbw_center             = TRUE,   # center covariates inside dbw
  seasonal               = FALSE,  # turn OFF seasonality for these short windows
  plots                  = FALSE   # do not produce plots inside the function
)
```

```
## Warning in dbw(X = X_for_dbw, dbw_indices = dbw_indices, shock_time_vec =
## as.integer(integer_shock_time_vec), : Design matrix is rank-deficient
## (collinearity). Consider PCA.
```

```
##
## Iter: 1 fn: 6.3015    Pars:  0.000000009242 0.636603889381 0.000000001636 0.000000013083 0.363396086
## Iter: 2 fn: 6.3015    Pars:  0.0000000082101 0.6366038896691 0.0000000009315 0.0000000118876 0.36339
## solnp--> Completed in 2 iterations
```

```
# Donor weights
out$linear_combinations
```

```
## [1] 8.210053e-09 6.366039e-01 9.314648e-10 1.188764e-08 3.633961e-01
```

```
# Shock-effect estimates (one omega for each donor)
out$meta$omega_vec
```

```
## [1]  0.2685332 -3.0347348 -2.8720615 -0.6434998  3.5023547
```

```
# Forecasts: unadjusted / adjusted / arithmetic mean
out$predictions
```

```
## $unadjusted
## [1] 42.80116
##
## $adjusted
## [1] 42.14198
##
## $arithmetic_mean
## [1] 42.24528
```

```
# Full meta information (weights, omega_vec, combined_omega, ARIMA orders, etc.)
out$meta
```

```
## $n_donors
## [1] 5
##
```

```
## $shock_time
## [1] 30 30 30 30 30 30
##
## $shock_length
## [1] 1 1 1 1 1 1
##
## $dbw_status
## [1] "convergence"
##
## $weights
## [1] 8.210053e-09 6.366039e-01 9.314648e-10 1.188764e-08 3.633961e-01
##
## $omega_vec
## [1]  0.2685332 -3.0347348 -2.8720615 -0.6434998  3.5023547
##
## $combined_omega
## [1] -0.659182
##
## $arima_order
## $arima_order[[1]]
## NULL
##
## $arima_order[[2]]
## [1] 3 0 0 0 1 0 0
##
## $arima_order[[3]]
## [1] 2 0 0 0 1 0 0
##
## $arima_order[[4]]
## [1] 1 0 0 0 1 0 0
##
## $arima_order[[5]]
## [1] 2 0 0 0 1 0 0
##
## $arima_order[[6]]
## [1] 3 0 0 0 1 0 0
##
##
## $ic_used
## [1] "aicc"
```

```r
## Extract the donor's closing price series (COP as donor)
y_donor <- TS_2008_09_29$COP_Close

Tpre <- 30L          # number of pre-shock observations
Ls   <- 1L           # length of the shock window (1 day)
last <- Tpre + Ls    # total number of points used (30 pre + 1 post = 31)

## Use only the first 31 points: 30 pre-shock + 1 post-shock
y_fit <- y_donor[1:last]

## Post-shock dummy: 0 for the first 30 days, 1 for the 31st day (2008-09-29)
D <- c(rep(0, Tpre), rep(1, Ls))
```

```r
## Check the last few observations of y and the dummy
tail(cbind(y_fit, D), 5)
```

```
##          y_fit D
## [27,] 68.36972 0
## [28,] 68.61724 0
## [29,] 70.45070 0
## [30,] 69.89149 0
## [31,] 63.53856 1
```

```r
## Simple OLS regression of y on the post-shock dummy
m_ols <- lm(y_fit ~ D)
summary(m_ols)$coef
```

```
##              Estimate Std. Error   t value     Pr(>|t|)
## (Intercept) 70.539011  0.7766849 90.820624 3.656204e-37
## D           -7.000453  4.3243987 -1.618827 1.163106e-01
```

```r
library(forecast)
```

```
##
## Attaching package: 'forecast'

## The following object is masked _by_ '.GlobalEnv':
##
##     gold
```

```r
library(lmtest)

## AR(1) model with the post-shock dummy as an exogenous regressor
m_ar1 <- Arima(y_fit, order = c(1, 0, 0), xreg = D)
coeftest(m_ar1)
```

```
##
## z test of coefficients:
##
##            Estimate Std. Error z value  Pr(>|z|)
## ar1         0.807311   0.094172  8.5727 < 2.2e-16 ***
## intercept 70.539821   1.924254 36.6583 < 2.2e-16 ***
## xreg      -6.477895   2.327589 -2.7831  0.005384 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
## Use the covariate names defined earlier
# covar_names <- c("GSPC_Close", "WTI_Close", "USD_Close", "TB_Close", "VIX_Close")

## Build the covariate matrix for the same 31-day window
X_cov <- as.matrix(TS_2008_09_29[1:last, covar_names])

## As in SynthPrediction: covariates + post-shock dummy as xreg
```

```r
X_for_arima <- cbind(X_cov, D)

## Automatic ARIMA selection with exogenous regressors (covariates + dummy)
## - AICc as the information criterion
## - Seasonal component allowed (following your package default)
## - Stepwise + approximation to speed up the search
m_auto <- auto.arima(
  y_fit,
  xreg          = X_for_arima,
  ic            = "aicc",
  seasonal      = TRUE,   # same as the default in your package
  stepwise      = TRUE,
  approximation = TRUE
)

## Robust coefficient tests for the selected ARIMA model
coeftest(m_auto)
```

```
##
## z test of coefficients:
##
##              Estimate Std. Error z value Pr(>|z|)
## ar1          0.703285   0.236973  2.9678 0.002999 **
## ar2         -0.208587   0.308199 -0.6768 0.498536
## ar3          0.029799   0.235381  0.1266 0.899257
## intercept   26.002845  69.042449  0.3766 0.706455
## GSPC_Close   0.069719   0.017796  3.9177 8.94e-05 ***
## WTI_Close    0.129840   0.062369  2.0818 0.037358 *
## USD_Close   -0.847778   0.543917 -1.5587 0.119078
## TB_Close    -0.377206   1.299827 -0.2902 0.771666
## VIX_Close    0.093641   0.165618  0.5654 0.571799
## D            3.502355   1.939990  1.8053 0.071020 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
# GSPC_Close is the 1st column in covar_names, WTI_Close is the 2nd
covariate_indices <- c(1, 2)

out <- SynthPrediction(
  Y_series_list          = Y_series_list,          # list of outcome series (target + donors)
  covariates_series_list = covariates_series_list, # list of corresponding covariate series
  shock_time_vec         = shock_time_vec,         # vector of shock dates (per series)
  shock_length_vec       = shock_length_vec,       # vector of shock window lengths
  k                      = 1,                      # forecast horizon: predict 1 day after the shock
  covariate_indices      = NULL,                   # use all available covariates (no sub-selection)
  use_dbw                = TRUE,                   # use donor balancing weights (DBW)
  seasonal               = TRUE,                   # allow seasonal ARIMA structure (as in package defa
  plots                  = FALSE                   # do not produce plots in this call
)
```

```
## Warning in dbw(X = X_for_dbw, dbw_indices = dbw_indices, shock_time_vec =
## as.integer(integer_shock_time_vec), : Design matrix is rank-deficient
## (collinearity). Consider PCA.
```

```
##
## Iter: 1 fn: 6.3015    Pars:  0.000000009242 0.636603889381 0.000000001636 0.000000013083 0.363396086
## Iter: 2 fn: 6.3015    Pars:  0.0000000082101 0.6366038896691 0.0000000009315 0.0000000118876 0.36339
## solnp--> Completed in 2 iterations

## Warning in value[[3L]](cond): Target predict() failed: 'data' must be of a
## vector type, was 'NULL'
```

```
out$linear_combinations    # synthetic control donor weights (for the target series)
```

```
## [1] 8.210053e-09 6.366039e-01 9.314648e-10 1.188764e-08 3.633961e-01
```

```
out$meta$omega_vec         # estimated shock effects for each donor
```

```
## [1] -1.771793 -5.205221 -7.269179 -4.317799 -6.352937
```

```
out$predictions            # list of unadjusted / adjusted / arithmetic_mean forecasts
```

```
## $unadjusted
## [1] 44.7338
##
## $adjusted
## [1] 39.1115
##
## $arithmetic_mean
## [1] 39.75041
```

```
## ================== 1) Choose covariates (same as prof's alpha setup, exclude VIX) ==================
covar_names <- c("GSPC_Close", "WTI_Close", "USD_Close", "TB_Close")

## ================== 2) Build Y_series_list: 1 target + 5 donors ==================
## Here we assume that, as in the professor's code, each TS_xxxx window
## has already been cropped to "30 pre + 1 shock" and converted to 2020 dollars
## (i.e., multiplied by dollars_2020).

Y_series_list <- list(
  Y_target      = TS_target$COP_Close,      # target series: 2020-03-09 window
  Y_2008_03_17  = TS_2008_03_17$COP_Close,  # donor: 2008-03-17 shock
  Y_2014_11_28  = TS_2014_11_28$COP_Close,  # donor: 2014-11-28 shock
  Y_2008_09_09  = TS_2008_09_09$COP_Close,  # donor: 2008-09-09 shock
  Y_2008_09_15  = TS_2008_09_15$COP_Close,  # donor: 2008-09-15 shock
  Y_2008_09_29  = TS_2008_09_29$COP_Close   # donor: 2008-09-29 shock
)

## ========== 3) Build covariates_series_list (X for dbw and ARIMA xreg) ==========
# Each element is a matrix of covariates aligned with the corresponding Y series
covariates_series_list <- list(
  X_target      = as.matrix(TS_target[,      covar_names]),
  X_2008_03_17  = as.matrix(TS_2008_03_17[,  covar_names]),
  X_2014_11_28  = as.matrix(TS_2014_11_28[,  covar_names]),
  X_2008_09_09  = as.matrix(TS_2008_09_09[,  covar_names]),
```

```
  X_2008_09_15  = as.matrix(TS_2008_09_15[,  covar_names]),
  X_2008_09_29  = as.matrix(TS_2008_09_29[,  covar_names])
)

## Each window: 30 pre + 1 post (shock only occurs at time T_pre + 1)
pre_len  <- 30L
post_len <- 1L

shock_time_vec   <- rep(pre_len,  length(Y_series_list))   # T_pre = 30 for all series
shock_length_vec <- rep(post_len, length(Y_series_list))   # L_s  = 1 for all series

## ====================================================================
## 4) Version A: exact analogue of the paper's "adjustment estimator" ^_adj
##    -- donors are equally weighted; ARIMA(1,0,0)+X, i.e., AR(1)+X
## ====================================================================

out_adj <- SynthPrediction(
  Y_series_list          = Y_series_list,           # target + donors' outcome series
  covariates_series_list = covariates_series_list,  # corresponding covariate series
  shock_time_vec         = shock_time_vec,          # shock time (T_pre) for each series
  shock_length_vec       = shock_length_vec,        # shock length (L_s) for each series
  k                      = 1,                       # predict only the first point after the shock
  dbw_scale              = TRUE,                    # scaling option for DBW (irrelevant when use_dbw =
  dbw_center             = TRUE,                    # centering option for DBW (irrelevant when use_dbw
  dbw_indices            = NULL,                    # indices for DBW (not used here)
  use_dbw                = FALSE,                   # **key**: equal donor weights -> matches paper's ^_
  covariate_indices      = 1:4,                     # use all 4 covariates in X
  arima_order            = c(1, 0, 0),              # fix ARIMA to AR(1) with no differencing/MA
  seasonal               = FALSE,                   # no seasonal component (as in the paper)
  plots                  = FALSE                    # no plots in this run
)

## Extract quantities corresponding to the paper's notation
alpha_hat_i   <- out_adj$meta$omega_vec        # ^_i: estimated shock effect for each donor i
alpha_adj_hat <- out_adj$meta$combined_omega   # ^_adj: average of ^_i (equal-weight adjustment)
weights_equal <- out_adj$linear_combinations   # donor weights W: should be (1/5, ..., 1/5)

alpha_hat_i
```

```
## [1]  0.4047153 -2.2785037 -2.7644913 -1.0816560  3.4980315
```

```
alpha_adj_hat
```

```
## [1] -0.4443808
```

```
## ====================================================================
## 6) Version B: DBW-based "weighted adjustment", analogous to ^_wadj
##    (the weighting rule is different from the paper, but plays the same role)
## ====================================================================

out_dbw <- SynthPrediction(
  Y_series_list          = Y_series_list,
```

```
  covariates_series_list = covariates_series_list,
  shock_time_vec         = shock_time_vec,
  shock_length_vec       = shock_length_vec,
  k                      = 1,                        # same 1-step-ahead prediction
  dbw_scale              = TRUE,                     # standardize covariates before DBW
  dbw_center             = TRUE,                     # center covariates before DBW
  dbw_indices            = NULL,                     # let DBW automatically choose columns based on pre
  use_dbw                = TRUE,                     # **key**: turn DBW on to get data-driven donor wei
  covariate_indices      = 1:4,                      # still use all 4 covariates in X
  arima_order            = c(1, 0, 0),               # still AR(1) + X for each series
  seasonal               = FALSE,                    # no seasonal component
  plots                  = FALSE
)
```

```
## Warning in dbw(X = X_for_dbw, dbw_indices = dbw_indices, shock_time_vec =
## as.integer(integer_shock_time_vec), : Design matrix is rank-deficient
## (collinearity). Consider PCA.
```

```
##
## Iter: 1 fn: 3.3094    Pars:  0.00000001875 0.99999988807 0.00000004035 0.00000003825 0.00000001458
## Iter: 2 fn: 3.3094    Pars:  0.000000006235 0.999999950074 0.000000020766 0.000000019402 0.0000000035
## Iter: 3 fn: 3.3094    Pars:  0.000000003536 0.999999963218 0.000000016678 0.000000015441 0.0000000011
## solnp--> Completed in 3 iterations
```

```
alpha_hat_i_dbw <- out_dbw$meta$omega_vec         # same ^_i for each donor as above
alpha_wadj_dbw  <- out_dbw$meta$combined_omega    # DBW-weighted aggregate shock effect (^_wadj analogue)
weights_dbw     <- out_dbw$linear_combinations    # Ŵ from DBW: data-driven donor weights

alpha_hat_i_dbw
```

```
## [1]  0.4047153 -2.2785037 -2.7644913 -1.0816560  3.4980315
```

```
weights_dbw
```

```
## [1] 3.536474e-09 1.000000e+00 1.667804e-08 1.544134e-08 1.126556e-09
```

```
alpha_wadj_dbw
```

```
## [1] -2.278504
```

```
## Predicted outcomes: with and without shock adjustment
adjusted_preds   <- out_dbw$predictions$adjusted      # forecasts after applying the DBW-based shock ad
unadjusted_preds <- out_dbw$predictions$unadjusted    # raw AR(1)+X forecasts without shock adjustment

adjusted_preds
```

```
## [1] 40.68229
```

```
unadjusted_preds
```

```
## [1] 42.96079
```