Conoco Phillips 2020

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In this example we forecast Conoco Phillips stock prices in the midst of the coronavirus (COVID-19) recession. Specific interest is in predictions made after March 6th, 2020, the Friday before the stock market crash on March 9th, 2020. Conoco Phillips is chosen for this analysis because it is a large oil and gas resources company with a relatively recent initial public offering. Focus on the oil sector is because oil prices have been shown to exhibit a cointegrating behavior with economic indices (Source), and our chosen time frame represents the onset of a significant economic down turn, coupled with OPEC decreasing the global price of oil the Sunday before trading resumes on Monday, March 9th Source. Furthermore, fear of and action in response to the coronavirus pandemic began to uptick dramatically between Friday, March 6th and Monday, March 9th. Major events include the SXSW festival being cancelled as trading closed on March 6th Source, New York declared a state of emergency on March 7th Source, and by Sunday, March 8th, eight states have declared a state of emergency while Italy placed 16 million people in quarantine Source.

Economic indicators forecasted our recession before the coronavirus pandemic began. The current recession followed an inversion of the yield curve that first happend back in March 22, 2019 Source. An inversion of the yield curve is an event that signals that recessions are more likely (St. Louis Fed, San Francisco Fed, Damir Tonik).

In this analysis we investigate the performance of oil companies in previous recessions that followed an inversion of the yield curve to obtain a suitable Conoco Phillips donor pool for estimating the March 9th shock effect on Conoco Phillips oil stock. We also consider previous OPEC oil supply shocks. We will borrow from the literature on oil price forecasting to establish appropriate time horizons and forecasting models. Recessions that occured before 1973 are disregarded since oil price forecasts cannot be represented by standard time series models before 1973 (Source). We will use a simple AR(1) model to forecast Conoco Phillips stock price. This model has been shown to beat no-change forecasts when predicting oil prices over time horizons of 1 and 3 months (Source). We will consider 30 pre-shock trading days and we will forecast the immediate shock effect and the shock effect over a future five trading day window. All estimates will be adjusted for inflation using the inflation calculator at https://www.usinflationcalculator.com.

Our donor pool will consist of Conoco Phillips shock effects observed on September 11th, 2001, March 18th, 2008, many days in September and October of 2008, and November 27, 2014. The September 11th, 2001 and the 2008 shock effects were observed during recessions that were predicated by an inversion of the yield curve, and the November 27, 2014 shock was an OPEC induced supply side shock effect.

We load in the relevant R packages

```
library(data.table)
library(tidyverse)
library(tseries)
library(quantmod)
```

and load in relevant datasets with some mild preprocessing.

```
## 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/d93216330ab2c1
  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)

## inflation adjustment
getSymbols("CPIAUCSL", src='FRED')
```

```
## [1] "CPIAUCSL"
```

```
avg.cpi <- apply.yearly(CPIAUCSL, mean)
inflation_adj <- as.numeric(avg.cpi['2020'])/avg.cpi
inflation_adj <- as.data.frame(inflation_adj)
colnames(inflation_adj) <- c("dollars_2020")
inflation_adj <- inflation_adj %>% mutate(year = 1947:2020)
```

Tuesday, September 11, 2001

Here is the estimated shock effect 1 day in the future with covariates:

```
## September 11th (no trading from T-F); 1 day nowcast
COP_close <- COP %>% select(COP.Close, Date) %>%
  rename(COP_Close = COP.Close)
GSPC_close <- GSPC %>% select(GSPC.Close, Date) %>%
  rename(GSPC_Close = GSPC.Close)
COP_close <- merge(COP_close, GSPC_close)
COP_close <- merge(COP_close, WTI_Crude)
Y <- COP_close$COP_Close[-1]
COP_close <- data.frame(COP_close[-nrow(COP_close), ], Y)
start <- which(COP_close$Date == "2001-09-10")
start_day <- as.numeric(1:nrow(COP_close) == start + 1)
COP_close <- COP_close %>% mutate(start_day = start_day)
COP_close_small <- COP_close[(start-29):(start+1), ]
m_COP_9_11 <- lm(Y ~ COP_Close + start_day + GSPC_Close + WTI_Close,
                 data = COP_close_small)
alpha_9_11 <- summary(m_COP_9_11)$coef[3,1:2] *
  inflation_adj$dollars_2020[inflation_adj$year == 2001]
alpha_9_11
```

```
##   Estimate Std. Error
##  -1.828102   0.442419
```

Here is the estimated shock effect 1 day in the future without covariates:

```
m_COP_9_11_no <- lm(Y ~ COP_Close + start_day, data = COP_close_small)
alpha_9_11_no <- summary(m_COP_9_11_no)$coef[3,1:2] *
```

```
  inflation_adj$dollars_2020[inflation_adj$year == 2001]
alpha_9_11_no
```

```
##   Estimate Std. Error
##  -1.569084   0.336481
```

2008 shock effects

The first 4 major shocks of 2008 were proceeded by unprecedented failures in the financial sector that rattled markets, oil prices, and Conoco Phillips stock alike. The March 8th, September 12th, and September 26th shock effects were proceeded by the bailouts or failures of Bear Stearns, Lehman Brothers, and Washington Mutual financial institutions. The September 8th shock effect was proceeded by Fannie Mae and Freddie Mac being placed in conservatorship.

We first find the Baer Stearns shock effect. Here is the estimated shock effect 1 day in the future with covariates:

```
COP_close <- COP_close %>% select(-"start_day")
start <- which(COP_close$Date == "2008-03-18")
start_day <- as.numeric(1:nrow(COP_close) == start)
COP_close <- COP_close %>% mutate(start_day = start_day)
COP_close_small <- COP_close[(start-29):(start+1), ]
m_COP_3_18 <- lm(Y ~ COP_Close + start_day + GSPC_Close + WTI_Close,
                 data = COP_close_small)
alpha_3_18 <- summary(m_COP_3_18)$coef[3,1:2] *
  inflation_adj$dollars_2020[inflation_adj$year == 2008]
alpha_3_18
```

```
##   Estimate Std. Error
##  -4.584172   1.636725
```

Here is the estimated shock effect 1 day in the future without covariates:

```
m_COP_3_18_no <- lm(Y ~ COP_Close + start_day, data = COP_close_small)
alpha_3_18_no <- summary(m_COP_3_18_no)$coef[3,1:2] *
  inflation_adj$dollars_2020[inflation_adj$year == 2008]
alpha_3_18_no
```

```
##   Estimate Std. Error
##  -4.497804   1.409576
```

We now find the September shock effects. We estimate the financial institstution failures as if they are all the same.

```
COP_close <- COP_close %>% select(-"start_day")
COP_close[which(COP_close$COP_Close - COP_close$Y >= 3.5), ][2:4, ]
```

```
##            Date COP_Close GSPC_Close WTI_Close        Y
## 2169 2008-09-08  56.93742    1267.79    106.35 52.07384
## 2173 2008-09-12  55.97691    1251.70    101.19 52.38640
## 2183 2008-09-26  58.11901    1213.27    106.77 52.83616
```

```
start <- which(COP_close$COP_Close - COP_close$Y >= 3.5)[2:4]
start_day <- as.numeric(1:nrow(COP_close) %in% start)
COP_close <- COP_close %>% mutate(start_day = start_day)
COP_close_small <- COP_close[
  which(COP_close$Date == "2008-07-28"):which(COP_close$Date == "2008-09-26"), ]
m_COP_Sept_08 <- lm(Y ~ COP_Close + start_day + GSPC_Close + WTI_Close,
```

```
                 data = COP_close_small)
alpha_Sept_08 <- summary(m_COP_Sept_08)$coef[3,1:2] *
  inflation_adj$dollars_2020[inflation_adj$year == 2008]
alpha_Sept_08
```

```
##   Estimate Std. Error
##  -6.453668   1.137585
```

Here is the estimated shock effect 1 day in the future without covariates:

```
m_COP_Sept_08_no <- lm(Y ~ COP_Close + start_day, data = COP_close_small)
alpha_Sept_08_no <- summary(m_COP_Sept_08_no)$coef[3,1:2] *
  inflation_adj$dollars_2020[inflation_adj$year == 2008]
alpha_Sept_08_no
```

```
##   Estimate Std. Error
##  -6.436724   1.110749
```

Thursday, November 27, 2014

During the Great Recession when economic activity clearly declined, both oil and stock prices fell which points to demand factors. During the second half of 2014, oil prices plummeted but equity prices generally increased, suggesting that supply factors were the key driver Source pg 19. It is documented that oil prices fall as OPEC opts not to cut production Source on November 27th, 2014. This date will serve as our change point when we estimate a shock effect for Conoco Phillips stock.

Here is the estimated shock effect 1 day in the future with covariates:

```
COP_close <- COP_close %>% select(-"start_day")
start <- which(COP_close$Date == "2014-11-26")
start_day <- as.numeric(1:nrow(COP_close) == start)
COP_close <- COP_close %>% mutate(start_day = start_day)
COP_close_small <- COP_close[(start-30):(start), ]
m_COP_11_27_14 <- lm(Y ~ COP_Close + start_day + GSPC_Close,
                     data = COP_close_small)
alpha_11_27_14 <- summary(m_COP_11_27_14)$coef[3,1:2] *
  inflation_adj$dollars_2020[inflation_adj$year == 2014]
alpha_11_27_14
```

```
##   Estimate Std. Error
##  -5.704940   1.064489
```

Here is the estimated shock effect 1 day in the future without covariates:

```
m_COP_11_27_14 <- lm(Y ~ COP_Close + start_day, data = COP_close_small)
alpha_11_27_14_no <- summary(m_COP_11_27_14)$coef[3,1:2]  *
  inflation_adj$dollars_2020[inflation_adj$year == 2014]
alpha_11_27_14_no
```

```
##   Estimate Std. Error
## -5.3008230  0.9788334
```

The March 9th, 2020 shock effect:

```
COP_close <- COP_close %>% select(-"start_day")
start <- which(COP_close$Date == "2020-03-06")
## change to equality
start_day <- as.numeric(1:nrow(COP_close) == start)
```

```
COP_close <- COP_close %>% mutate(start_day = start_day)
COP_close_small <- COP_close[(start-30):(start), ]
```

Here is the 1 day nowcast with S&P 500:

```
m_COP_03_09_20 <- lm(Y ~ COP_Close + start_day + GSPC_Close,
                     data = COP_close_small)
alpha_03_09_20 <- summary(m_COP_03_09_20)$coef[3,1:2]
alpha_03_09_20 #-10.51414 (1.62901)
```

```
##   Estimate Std. Error
##  -10.51414    1.62901
```

Here is the 1 day nowcast without S&P 500:

```
m_COP_03_09_20 <- lm(Y ~ COP_Close + start_day, data = COP_close_small)
alpha_03_09_20_no <- summary(m_COP_03_09_20)$coef[3,1:2]
alpha_03_09_20_no #-10.533756 (1.617991)
```

```
##   Estimate Std. Error
## -10.533756   1.617991
```

Shock effect estimators

We first obtain the inflation-adjusted shock effect estimators from all of the above analyses.

```
a_estimates <- rbind( c(alpha_9_11, alpha_9_11_no),
  c(alpha_3_18, alpha_3_18_no),
  c(alpha_Sept_08, alpha_Sept_08_no),
  c(alpha_11_27_14, alpha_11_27_14_no))
colnames(a_estimates) <- c("a_1","sd_a_1","a_1_no","sd_a_1_no")
rownames(a_estimates) <- c("y2001", "my2008", "sy2008", "y2014")
```

We now compute four shock effect estimators. We compute the adjustment estimator that averages the estimated shock effects and the inverse variance weighted adjustment estimator, these two estimators are computed with and without the September 11th, 2001 shock effect. We consider analyses without the September 11th, 2001 shock effect because the stock market was closed for the week following the terrorist attack, so immediate post shock data was not actually observed.

```
a_adj <- colMeans(a_estimates[, c(1,3)])
a_adj_no911 <- colMeans(a_estimates[-1, c(1,3)])
weights <- rbind(
(1 / a_estimates[, c(2,4)])[1, ] / colSums(1 / a_estimates[, c(2,4)]),
(1 / a_estimates[, c(2,4)])[2, ] / colSums(1 / a_estimates[, c(2,4)]),
(1 / a_estimates[, c(2,4)])[3, ] / colSums(1 / a_estimates[, c(2,4)]),
(1 / a_estimates[, c(2,4)])[4, ] / colSums(1 / a_estimates[, c(2,4)])
)
a_adj_IVW <- colSums(weights * a_estimates[, c(1,3)])
weights_no911 <- rbind(
(1 / a_estimates[-1, c(2,4)])[1, ] / colSums(1 / a_estimates[-1, c(2,4)]),
(1 / a_estimates[-1, c(2,4)])[2, ] / colSums(1 / a_estimates[-1, c(2,4)]),
(1 / a_estimates[-1, c(2,4)])[3, ] / colSums(1 / a_estimates[-1, c(2,4)])
)
a_adj_IVW_no911 <- colSums(weights_no911 * a_estimates[-1, c(1,3)])
```

Here are the estimators:

```
shock_effects <- rbind(a_adj, a_adj_no911,
                       a_adj_IVW, a_adj_IVW_no911)
shock_effects
```

```
##                       a_1    a_1_no
## a_adj           -4.642720 -4.451109
## a_adj_no911     -5.580926 -5.411784
## a_adj_IVW       -3.830765 -3.402378
## a_adj_IVW_no911 -5.693995 -5.472961
```

Interesting to note that the March 9th, 2020 shock effect is closely approximated by the additive effect of the average of the 2008 recession diven shocks and the OPEC supply driven shock on November 27, 2014.

```
additive <- colMeans(a_estimates[c(2,3), c(1,3)]) + a_estimates[4, c(1,3)]
additive
```

```
##       a_1    a_1_no
## -11.22386 -10.76809
```

Post-shock forecasts

```
COP_close <- COP_close %>% select(-"start_day")
start <- which(COP_close$Date == "2020-03-06")
#start_day <- as.numeric(1:nrow(COP_close) >= start)
#COP_close <- COP_close %>% mutate(start_day = start_day)
COP_close_small <- COP_close[(start-30):(start), ]
```

Here is the 1 day nowcast with S&P 500:

```
m_COP_03_06_20 <- lm(Y ~ COP_Close + GSPC_Close + WTI_Close,
                     data = COP_close_small[-nrow(COP_close_small), ])
preds <- predict(m_COP_03_06_20)
summary(m_COP_03_06_20)
```

```
##
## Call:
## lm(formula = Y ~ COP_Close + GSPC_Close + WTI_Close, data = COP_close_small[-nrow(COP_close_small),
##     ])
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -3.2156 -0.8340  0.0827  1.0014  2.5115
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) -2.430990  10.447490  -0.233    0.818
## COP_Close    1.045492   0.176103   5.937  2.9e-06 ***
## GSPC_Close   0.003063   0.004151   0.738    0.467
## WTI_Close   -0.210924   0.253788  -0.831    0.413
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.481 on 26 degrees of freedom
## Multiple R-squared:  0.9238, Adjusted R-squared:  0.915
## F-statistic:   105 on 3 and 26 DF,  p-value: 1.183e-14
```

```r
Yhat_nothing <- -2.430990 + 1.045492 * 47.01888 +
  0.003063 * 3023.94 + -0.210924 * 45.90
Yhat_adj <- Yhat_nothing + shock_effects[, 1]
Yhat_adj_additive <- Yhat_nothing + additive[1]

## doing nothing completely misses the mark
Yhat_nothing - COP_close_small$Y[nrow(COP_close_small)]
```

```
## [1] 12.23779
```

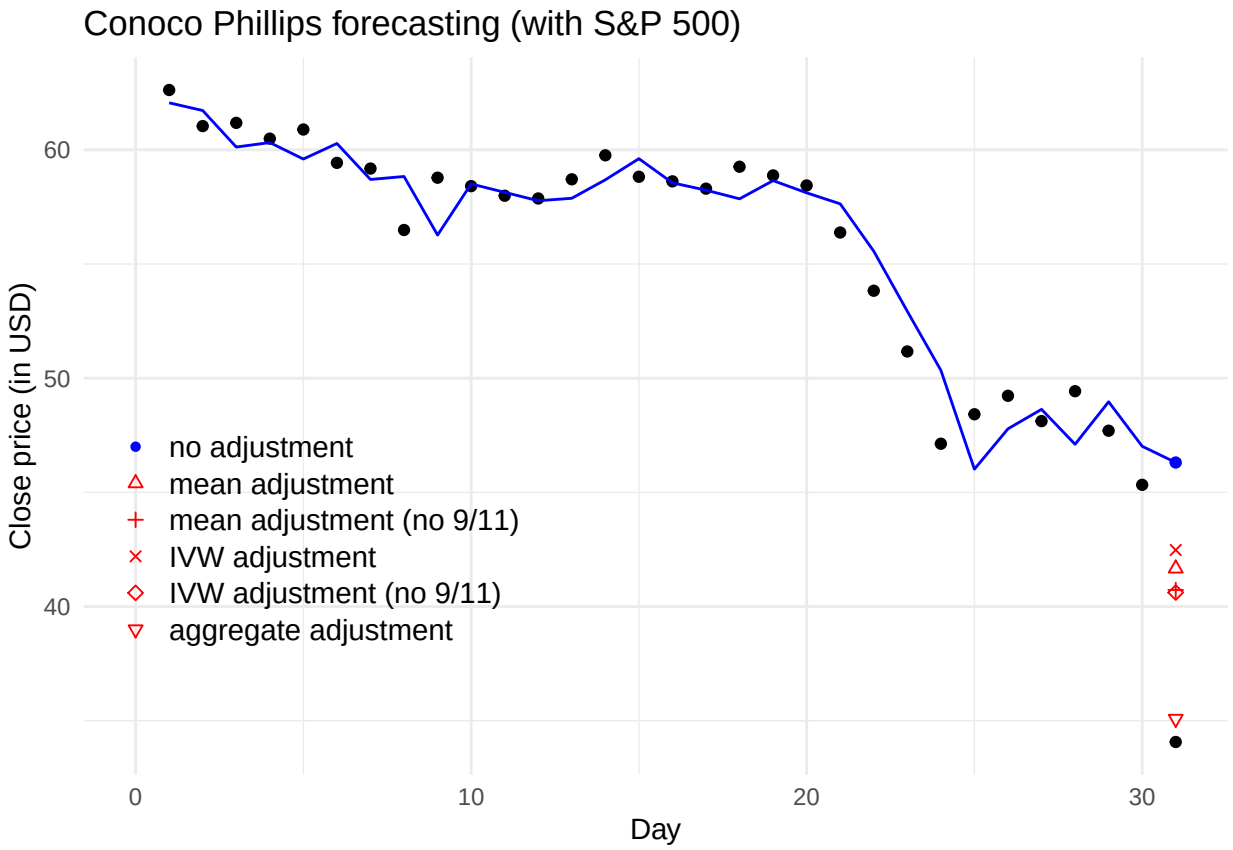
```r
## adjustment gets closer
Yhat_adj - COP_close_small$Y[nrow(COP_close_small)]
```

```
##           a_adj     a_adj_no911       a_adj_IVW a_adj_IVW_no911
##        7.595069        6.656863        8.407024        6.543794
```

```r
## additive effect does well
Yhat_adj_additive - COP_close_small$Y[nrow(COP_close_small)]
```

```
##     a_1
## 1.01393
```

```r
COP_close_small$id <- 1:nrow(COP_close_small)
mat <- cbind(COP_close_small$id[nrow(COP_close_small)],
             c(Yhat_adj, Yhat_adj_additive))
colnames(mat) <- c("id", "Yhat_adj")
dat <- as.data.frame(mat)
ggplot(COP_close_small, mapping = aes(x = id, y = Y)) +
  labs(title = "Conoco Phillips forecasting (with S&P 500)",
       x = "Day", y = "Close price (in USD)") +
  geom_point() +
  geom_point(data = dat, aes(x = id, y = Yhat_adj), col = 2, pch = 2:6) +
  geom_point(data = data.frame(x = unique(dat$id), y =Yhat_nothing),
             aes(x = x, y = y), col = "blue", cex = 1.5) +
  geom_line(aes(x = id, y = c(m_COP_03_06_20$fitted.values, Yhat_nothing)),
            col = "blue") +
    annotate("text", x=1, y=seq(from = 47, to = 39,length.out=6),
             label=c("no adjustment","mean adjustment",
                     "mean adjustment (no 9/11)","IVW adjustment",
                     "IVW adjustment (no 9/11)", "aggregate adjustment"),
             hjust=0) +
    annotate("point", x = 0, y=seq(from = 47, to = 39,length.out=6),
             pch = c(16,2:6),
             color = c("blue","red","red","red","red","red")) +
  theme_minimal()
```



Here is the 1 day nowcast without covariates:

```
m_COP_03_06_20 <- lm(Y ~ COP_Close,
                     data = COP_close_small[-nrow(COP_close_small), ])
summary(m_COP_03_06_20)
```

```
##
## Call:
## lm(formula = Y ~ COP_Close, data = COP_close_small[-nrow(COP_close_small),
##     ])
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -3.3821 -1.0178  0.1682  0.8822  2.8856
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept) -1.25682    3.20708  -0.392    0.698
## COP_Close    1.01170    0.05641  17.935   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.462 on 28 degrees of freedom
## Multiple R-squared:  0.9199, Adjusted R-squared:  0.9171
## F-statistic: 321.7 on 1 and 28 DF,  p-value: < 2.2e-16
```

```
preds <- predict(m_COP_03_06_20)
Yhat_nothing_no <- -1.25682 + 1.01170 * 47.00149
```

```
Yhat_adj_no <- Yhat_nothing_no + shock_effects[, 2]
Yhat_adj_additive_no <- Yhat_nothing_no + additive[2]

## doing nothing misses the mark
Yhat_nothing_no - COP_close_small$Y[nrow(COP_close_small)]
```

```
## [1] 12.22459
```

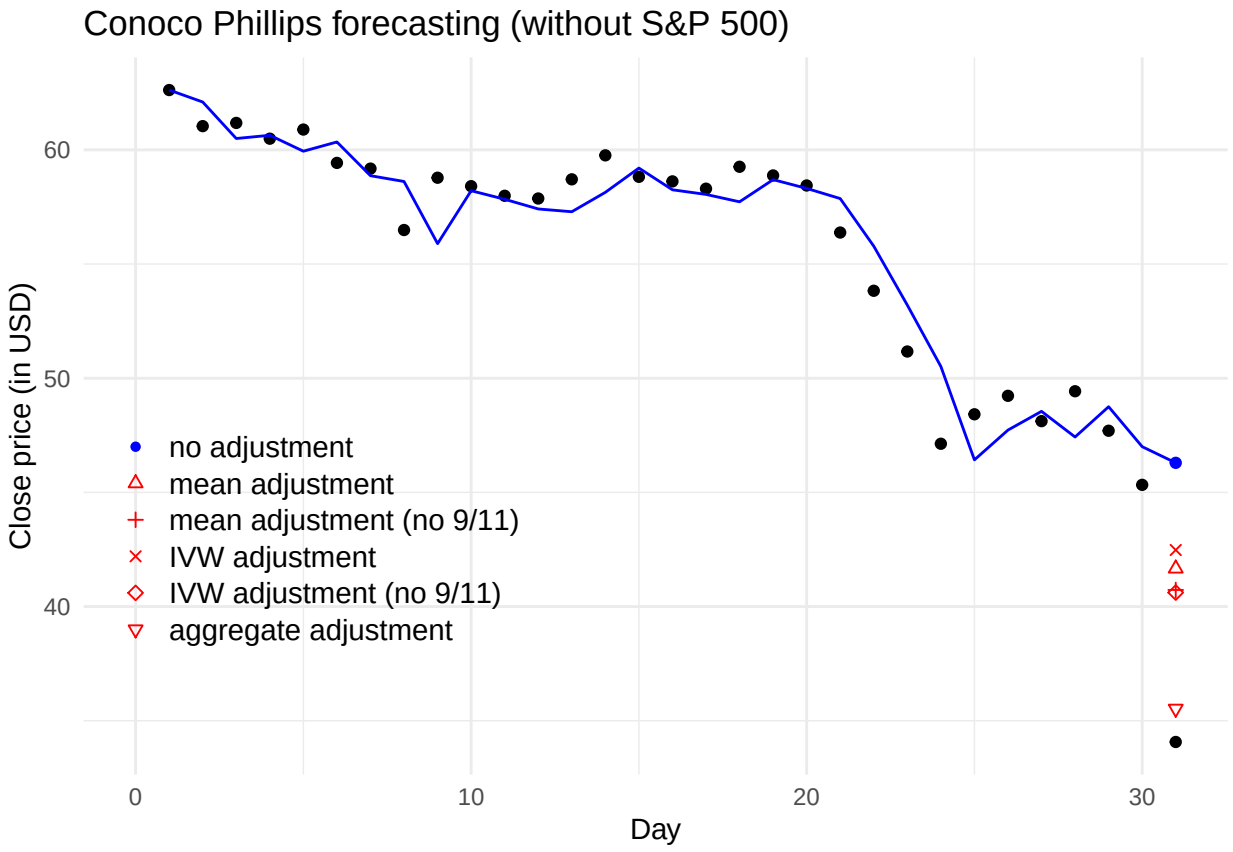
```
## adjustment gets closer
Yhat_adj_no - COP_close_small$Y[nrow(COP_close_small)]
```

```
##           a_adj     a_adj_no911       a_adj_IVW a_adj_IVW_no911
##        7.773479        6.812804        8.822210        6.751627
```

```
## additive effect does well
Yhat_adj_additive_no - COP_close_small$Y[nrow(COP_close_small)]
```

```
##   a_1_no
## 1.456501
```

```
COP_close_small$id <- 1:nrow(COP_close_small)
mat <- cbind(COP_close_small$id[nrow(COP_close_small)],
             c(Yhat_adj,  Yhat_adj_additive_no))
colnames(mat) <- c("id", "Yhat_adj")
dat <- as.data.frame(mat)
ggplot(COP_close_small, mapping = aes(x = id, y = Y)) +
  labs(title = "Conoco Phillips forecasting (without S&P 500)",
       x = "Day", y = "Close price (in USD)") +
  geom_point() +
  geom_point(data = dat, aes(x = id, y = Yhat_adj),
                              col = 2, pch = 2:6) +
  geom_point(data = data.frame(x = unique(dat$id), y =Yhat_nothing_no),
             aes(x = x, y = y), col = "blue", cex = 1.5) +
  geom_line(aes(x = id, y = c(m_COP_03_06_20$fitted.values,
                              Yhat_nothing_no)),
            col = "blue") +
      annotate("text", x=1, y=seq(from = 47, to = 39,length.out=6),
             label=c("no adjustment","mean adjustment",
                     "mean adjustment (no 9/11)","IVW adjustment",
                     "IVW adjustment (no 9/11)", "aggregate adjustment"),
             hjust=0) +
    annotate("point", x = 0, y=seq(from = 47, to = 39,length.out=6),
             pch = c(16,2:6),
             color = c("blue","red","red","red","red","red")) +
  theme_minimal()
```


Conoco Phillips forecasting (without S&P 500)
Close price (in USD)
60
50
40
0
10
20
30
Day
no adjustment
mean adjustment
mean adjustment (no 9/11)
IVW adjustment
IVW adjustment (no 9/11)
aggregate adjustment