TSTV-DiD_full.R

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```
#### DiD Regression ####

library(plm)
library(dplyr)
```

```
## Warning: package 'dplyr' was built under R version 3.6.2
```

```
##
## Attaching package: 'dplyr'
```

```
## The following objects are masked from 'package:plm':
##
##     between, lag, lead
```

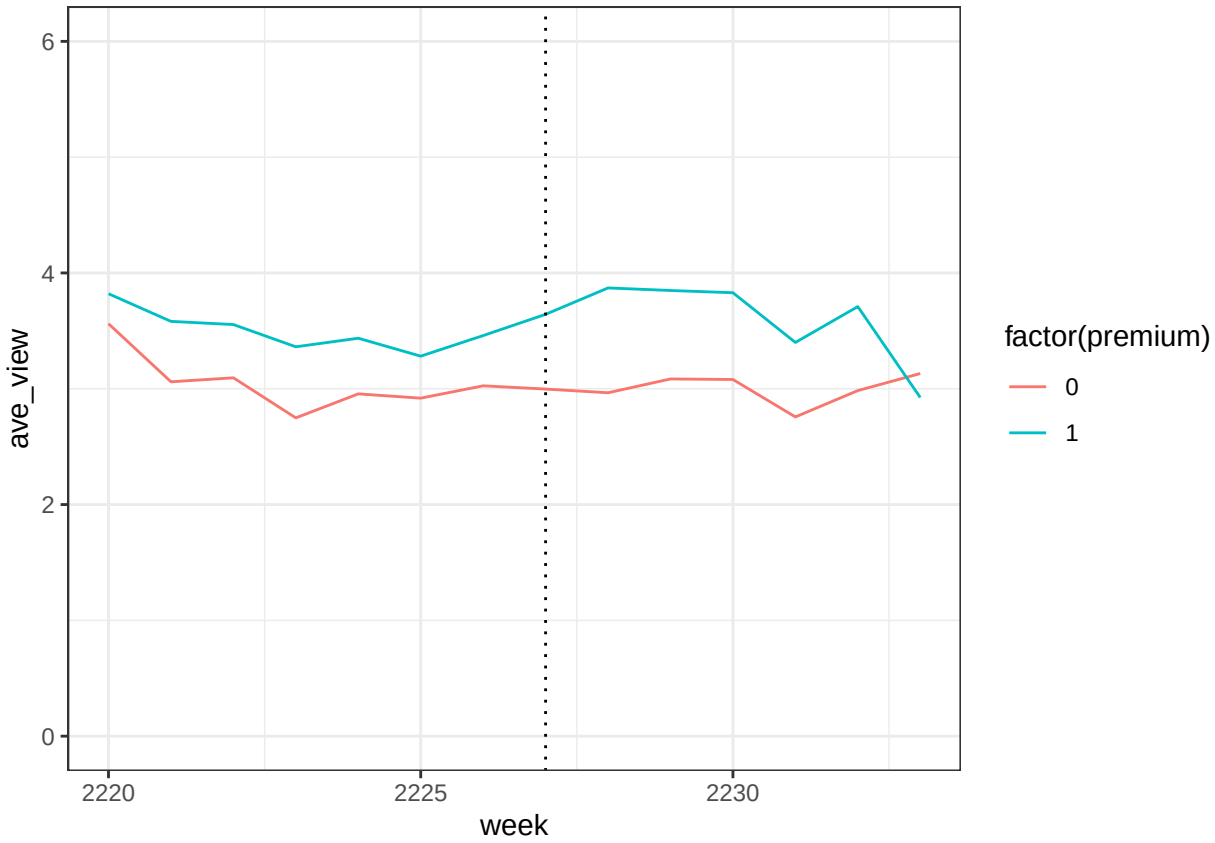
```
## The following objects are masked from 'package:stats':
##
##     filter, lag
```

```
## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union
```

```
library(ggplot2)
```

```
## Warning: package 'ggplot2' was built under R version 3.6.2
```

```
#### Load the data ####
data = read.csv("TSTV-Obs-Dataset.csv")
# As descriptive visualization, let's look at average weekly viewership for both premium and regular vi
week_ave = data %>% group_by(week, premium) %>%
  summarise(ave_view = mean(view_time_total_hr)) %>% ungroup()
ggplot(week_ave, aes(x = week, y = ave_view, color = factor(premium))) +
  geom_line() +
  geom_vline(xintercept = 2227, linetype='dotted') +
  ylim(0, 6) + xlim(2220,2233) +
  theme_bw()
```




```
#### Difference in Differences Regression ####
# Interpret the treatment effect
did_basic = lm(log(view_time_total_hr+1) ~ premium + after + premium*after, data=data)
summary(did_basic)
```

```
##
## Call:
## lm(formula = log(view_time_total_hr + 1) ~ premium + after +
##     premium * after, data = data)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -1.28421 -0.69919  0.07235  0.63026  2.05054
##
## Coefficients:
##                Estimate Std. Error t value Pr(>|t|)
## (Intercept)    1.122544   0.001491  752.67   <2e-16 ***
## premium        0.116126   0.003613   32.14   <2e-16 ***
## after         -0.029016   0.002094  -13.86   <2e-16 ***
## premium:after  0.074558   0.005042   14.79   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.7695 on 652795 degrees of freedom
## Multiple R-squared:  0.006149,   Adjusted R-squared:  0.006145
## F-statistic:  1346 on 3 and 652795 DF,  p-value: < 2.2e-16
```

```r
# Let's try replacing the treatment dummy with subject fixed effects.
# What happened to the estimate of premium?
did_fe = plm(log(view_time_total_hr+1) ~ premium + after + premium*after, data = data, index=c("id"), e
summary(did_fe)
```

```
## Oneway (individual) effect Within Model
##
## Call:
## plm(formula = log(view_time_total_hr + 1) ~ premium + after +
##     premium * after, data = data, effect = "individual", model = "within",
##     index = c("id"))
##
## Unbalanced Panel: n = 50034, T = 1-14, N = 652799
##
## Residuals:
##      Min.   1st Qu.    Median   3rd Qu.      Max.
## -2.583793 -0.252482  0.016201  0.296623  2.358606
##
## Coefficients:
##                  Estimate Std. Error t-value  Pr(>|t|)
## after         -0.0096263  0.0013662 -7.0462  1.84e-12 ***
## premium:after  0.0668180  0.0032670 20.4521 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Total Sum of Squares:    147680
## Residual Sum of Squares: 147580
## R-Squared:      0.00069803
## Adj. R-Squared: -0.082253
## F-statistic: 210.52 on 2 and 602763 DF, p-value: < 2.22e-16
```

```r
# Further add week fixed effects
did_sfe_tfe = plm(log(view_time_total_hr+1) ~ premium + after + premium*after, data = data, index=c("id
summary(did_sfe_tfe)
```

```
## Twoways effects Within Model
##
## Call:
## plm(formula = log(view_time_total_hr + 1) ~ premium + after +
##     premium * after, data = data, effect = "twoway", model = "within",
##     index = c("id", "week"))
##
## Unbalanced Panel: n = 50034, T = 1-14, N = 652799
##
## Residuals:
##      Min.   1st Qu.    Median   3rd Qu.      Max.
## -2.594527 -0.252892  0.017542  0.295771  2.273132
##
## Coefficients:
##                 Estimate Std. Error t-value  Pr(>|t|)
## premium:after 0.0682979  0.0032553   20.98 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
##
## Total Sum of Squares:    146610
## Residual Sum of Squares: 146510
## R-Squared:      0.00072974
## Adj. R-Squared: -0.082241
## F-statistic: 440.172 on 1 and 602751 DF, p-value: < 2.22e-16
```

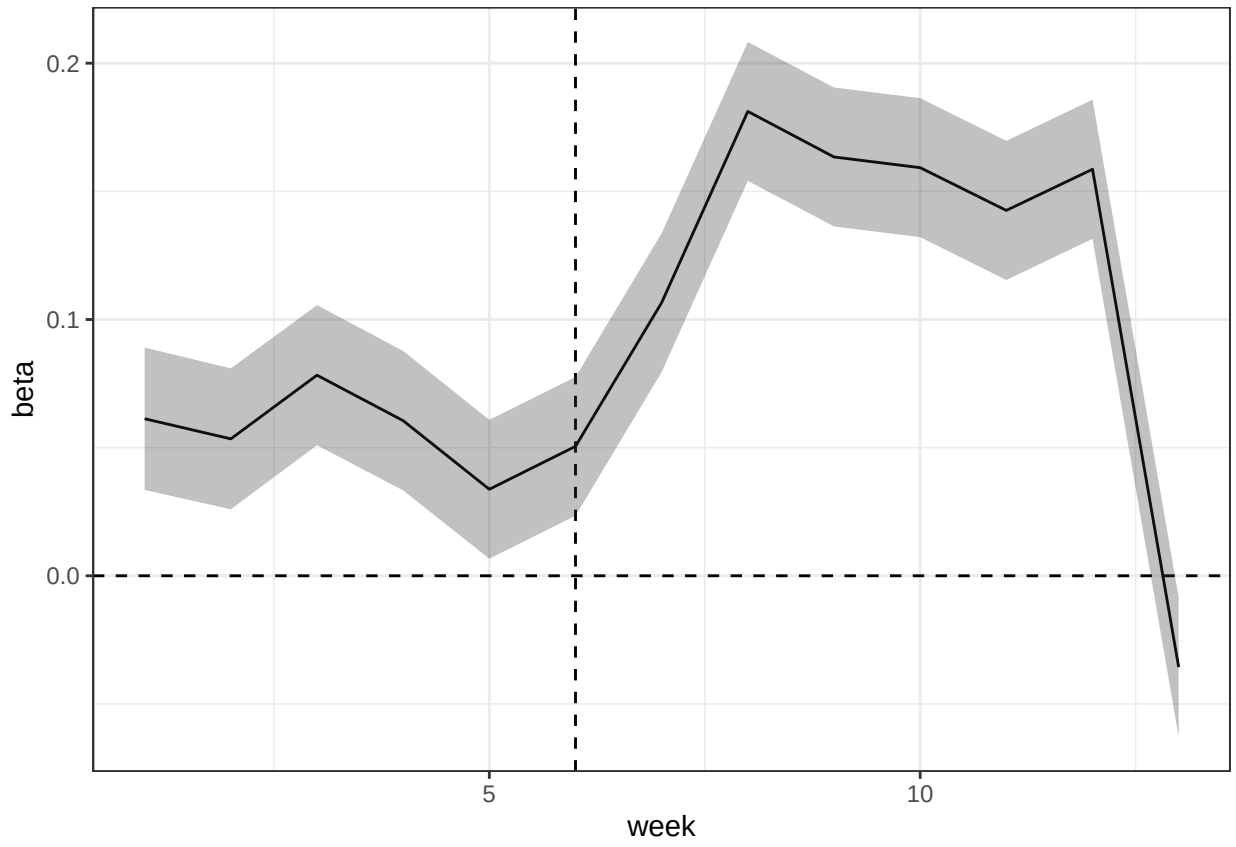
```
# Let's try dynamic DiD instead.
did_dyn_sfe_tfe <- lm(log(view_time_total_hr+1) ~ premium + factor(week) + premium*factor(week), data =
summary(did_dyn_sfe_tfe)
```

```
##
## Call:
## lm(formula = log(view_time_total_hr + 1) ~ premium + factor(week) +
##     premium * factor(week), data = data)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -1.35401 -0.70039  0.06861  0.62780  2.03182
##
## Coefficients:
##                            Estimate Std. Error t value Pr(>|t|)
## (Intercept)                1.284204   0.004361 294.479  < 2e-16 ***
## premium                    0.065613   0.010272   6.388 1.68e-10 ***
## factor(week)2221          -0.116254   0.005927 -19.614  < 2e-16 ***
## factor(week)2222          -0.131373   0.005858 -22.428  < 2e-16 ***
## factor(week)2223          -0.241444   0.005830 -41.416  < 2e-16 ***
## factor(week)2224          -0.199708   0.005810 -34.372  < 2e-16 ***
## factor(week)2225          -0.216551   0.005794 -37.375  < 2e-16 ***
## factor(week)2226          -0.185174   0.005794 -31.958  < 2e-16 ***
## factor(week)2227          -0.176850   0.005803 -30.474  < 2e-16 ***
## factor(week)2228          -0.193413   0.005814 -33.266  < 2e-16 ***
## factor(week)2229          -0.159218   0.005825 -27.336  < 2e-16 ***
## factor(week)2230          -0.162324   0.005835 -27.818  < 2e-16 ***
## factor(week)2231          -0.260881   0.005847 -44.621  < 2e-16 ***
## factor(week)2232          -0.192753   0.005860 -32.896  < 2e-16 ***
## factor(week)2233          -0.190512   0.005875 -32.426  < 2e-16 ***
## premium:factor(week)2221   0.061274   0.014178   4.322 1.55e-05 ***
## premium:factor(week)2222   0.053423   0.014022   3.810 0.000139 ***
## premium:factor(week)2223   0.078268   0.013944   5.613 1.99e-08 ***
## premium:factor(week)2224   0.060519   0.013882   4.360 1.30e-05 ***
## premium:factor(week)2225   0.033752   0.013828   2.441 0.014651 *
## premium:factor(week)2226   0.050495   0.013813   3.656 0.000257 ***
## premium:factor(week)2227   0.106577   0.013818   7.713 1.23e-14 ***
## premium:factor(week)2228   0.181185   0.013827  13.104  < 2e-16 ***
## premium:factor(week)2229   0.163413   0.013834  11.813  < 2e-16 ***
## premium:factor(week)2230   0.159237   0.013841  11.505  < 2e-16 ***
## premium:factor(week)2231   0.142558   0.013850  10.293  < 2e-16 ***
## premium:factor(week)2232   0.158616   0.013857  11.446  < 2e-16 ***
## premium:factor(week)2233  -0.035631   0.013867  -2.569 0.010186 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.7673 on 652771 degrees of freedom
```

```
## Multiple R-squared:  0.01174,    Adjusted R-squared:  0.0117
## F-statistic: 287.2 on 27 and 652771 DF,  p-value: < 2.2e-16
```

```r
# Let's retrieve the coefficients and standard errors, and create confidence intervals
model = summary(did_dyn_sfe_tfe)
coefs_ses = as.data.frame(model$coefficients[16:28,c("Estimate", "Std. Error")])
colnames(coefs_ses) = c("beta", "se")
coefs_ses = coefs_ses %>%
  mutate(ub90 = beta + 1.96*se,
         lb90 = beta - 1.96*se,
         week = 1:nrow(coefs_ses))

# Let's connect the estimates with a line and include a ribbon for the CIs.
ggplot(coefs_ses, aes(x = week, y = beta)) +
  geom_line() +
  geom_hline(yintercept=0,linetype="dashed") +
  geom_vline(xintercept=6,linetype="dashed") +
  geom_ribbon(aes(ymin = lb90, ymax = ub90), alpha = 0.3) +
  theme_bw()
```




```r
# Time for our placebo test...
# Let's shift the treatment date back in time (e.g., to week 2228), artificially, and estimate the "tre
data_placebo = data %>%
  mutate(after_placebo = ifelse(week > 2228, 1, 0))
```

```r
did_basic_placebo = lm(view_time_total_hr ~ premium + after_placebo + premium*after_placebo, data = data
summary(did_basic_placebo)
```

```
##
## Call:
## lm(formula = view_time_total_hr ~ premium + after_placebo + premium *
##     after_placebo, data = data_placebo)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -3.5521 -2.5538 -0.7587  1.7379 19.8584
##
## Coefficients:
##                         Estimate Std. Error t value Pr(>|t|)
## (Intercept)             3.022554   0.005091 593.672   <2e-16 ***
## premium                 0.529515   0.012320  42.982   <2e-16 ***
## after_placebo          -0.015221   0.008497  -1.791   0.0732 .
## premium:after_placebo   0.005916   0.020368   0.290   0.7715
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 2.996 on 652795 degrees of freedom
## Multiple R-squared:  0.004483,   Adjusted R-squared:  0.004478
## F-statistic: 979.8 on 3 and 652795 DF,  p-value: < 2.2e-16
```