Day 11 - TSCS

David Carlson

May 9, 2022

TSCS and Panel Data Analyses

- There are no agreed upon defining characteristics between TSCS and panel data, but for our purposes we will refer to large N, mostly balanced data as panel
- It is very important to note which of the modeling strategies (most of them) assume balance; this is often overlooked
- We will first deal with protest data, and the relationship between violent protest and polity change

One- and Two-Way Fixed Effects Models

- A 'fixed effect' is colloquially simply an indicator, a dummy variable - but really they are all effects that are not assumed randomly distributed
- In panel data, we can include a 'wave' (temporal) effect and/or a unit effect
- Most common to use two-way (both temporal and unit) for panel data
- For TSCS, two-way is also common, but the interpretability and framework are hurt by multiple observations for a unit-time
- Fixed effects control for heterogeneity in the data
- The inclusion of unit and time fixed effects accounts for both unit-specific (but time-invariant) and time-specific (but unit-invariant) unobserved confounders in a flexible manner
- Additivity and separability of the two types of unobserved confounders
- However, their statistical power can be very low with small N, because of the loss in degrees of freedom
- Unlike random/mixed effects, they do not have distributional assumptions
- These two points mean that there is no information 'borrowed' from other unit-times, and the variation that would be explained by your independent variable is largely absorbed
- These have great asymptotic properties, but a lot of research on the actual practice show they perform rather poorly, even when assumptions are met
  - Linearity (although one could nonparametrically adjust for unit-specific (time-specific) unobserved confounders by matching a treated observation with control observations of the same unit (time period), no other observation shares the same unit and time indices. Thus, the 2FE estimator critically relies upon the linearity assumption for its simultaneous adjustment for the two types of unobserved confounders)
  - Separability (precisely when their respective convex hulls are disjoint (colloquially, do not overlap); means that the marginal rate of substitution between any pair of primary inputs is independent of the amount of intermediate inputs used)
  - Additivity (means that the effect of one independent variable(s) on the dependent variable does NOT depend on the value of another independent variable(s))
  - Functional form assumption (are we modeling the DGP?)
  - Adjustment for the two types of unobserved confounders cannot be done nonparametrically under the 2FE framework
- Very simple to run; just a linear model with factors
- Let us explore the models from last week, but take into account that this is actually (highly unbalanced) TSCS data

```r
simpleMod = lm(politychanget1 ~ nonviol, data = data)
summary(simpleMod)
```

```
##
## Call:
## lm(formula = politychanget1 ~ nonviol, data = data)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -17.8295  -2.8295   0.0643   1.0643  12.1705
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept) -0.06433    0.32629  -0.197    0.844
## nonviol      3.89387    0.55977   6.956 2.89e-11 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 4.267 on 257 degrees of freedom
##   (64 observations deleted due to missingness)
## Multiple R-squared:  0.1585, Adjusted R-squared:  0.1552
## F-statistic: 48.39 on 1 and 257 DF,  p-value: 2.89e-11
```

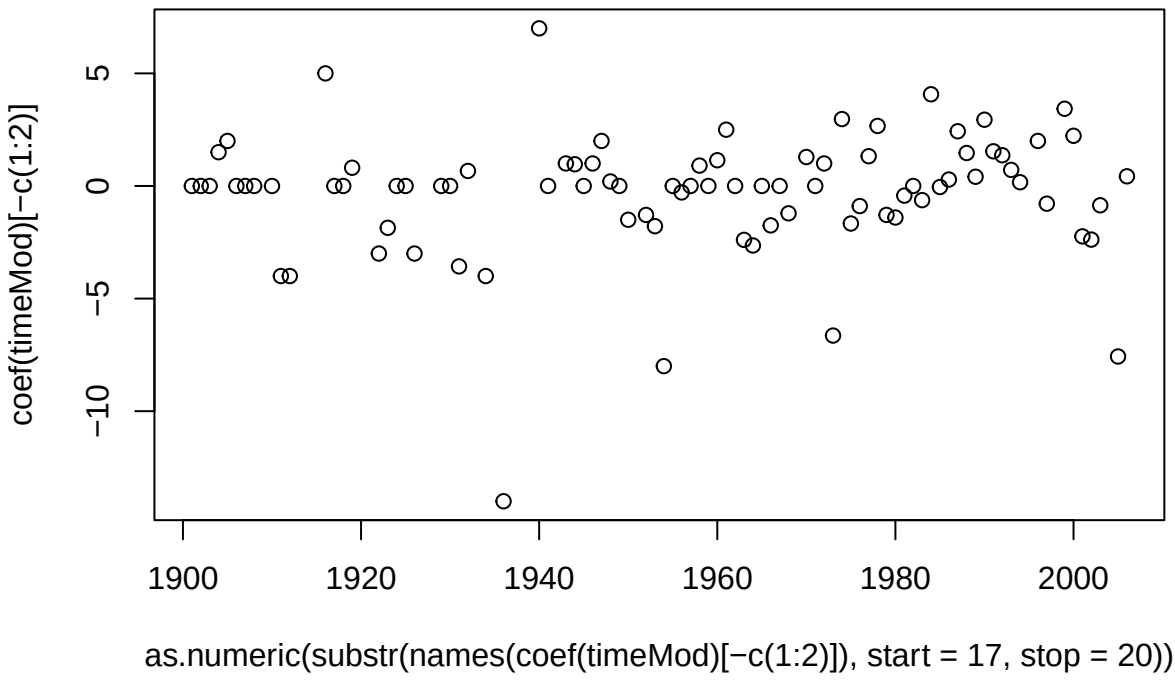
```r
#lets add a temporal effect - the beginning year seems most appropriate
timeMod = lm(politychanget1 ~ nonviol + as.factor(byear), #notice the as.factor wrapper - always use th
             data = data)
summary(timeMod) #holds up
```

```
##
## Call:
## lm(formula = politychanget1 ~ nonviol + as.factor(byear), data = data)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -12.600  -2.000   0.000   1.479  10.107
##
## Coefficients:
##                          Estimate Std. Error t value Pr(>|t|)
## (Intercept)          -2.545e-13  4.482e+00   0.000   1.0000
## nonviol               3.571e+00  8.318e-01   4.293 2.95e-05 ***
## as.factor(byear)1901  2.163e-13  6.339e+00   0.000   1.0000
## as.factor(byear)1902  2.554e-13  6.339e+00   0.000   1.0000
## as.factor(byear)1903  2.560e-13  6.339e+00   0.000   1.0000
## as.factor(byear)1904  1.500e+00  5.490e+00   0.273   0.7850
## as.factor(byear)1905  2.000e+00  6.339e+00   0.316   0.7528
## as.factor(byear)1906  2.540e-13  6.339e+00   0.000   1.0000
## as.factor(byear)1907  2.575e-13  5.490e+00   0.000   1.0000
## as.factor(byear)1908  2.909e-13  6.339e+00   0.000   1.0000
## as.factor(byear)1910  2.342e-13  6.339e+00   0.000   1.0000
## as.factor(byear)1911 -4.000e+00  6.339e+00  -0.631   0.5289
## as.factor(byear)1912 -4.000e+00  6.339e+00  -0.631   0.5289
## as.factor(byear)1916  5.000e+00  6.339e+00   0.789   0.4313
## as.factor(byear)1917  2.511e-13  5.490e+00   0.000   1.0000
## as.factor(byear)1918  2.425e-13  5.490e+00   0.000   1.0000
```

```
## as.factor(byear)1919  8.096e-01  5.183e+00   0.156   0.8761
## as.factor(byear)1922 -3.000e+00  6.339e+00  -0.473   0.6366
## as.factor(byear)1923 -1.857e+00  5.183e+00  -0.358   0.7206
## as.factor(byear)1924  2.344e-13  5.490e+00   0.000   1.0000
## as.factor(byear)1925  2.389e-13  6.339e+00   0.000   1.0000
## as.factor(byear)1926 -3.000e+00  6.339e+00  -0.473   0.6366
## as.factor(byear)1929  2.461e-13  5.490e+00   0.000   1.0000
## as.factor(byear)1930  2.532e-13  6.339e+00   0.000   1.0000
## as.factor(byear)1931 -3.571e+00  6.393e+00  -0.559   0.5772
## as.factor(byear)1932  6.667e-01  5.176e+00   0.129   0.8977
## as.factor(byear)1934 -4.000e+00  5.490e+00  -0.729   0.4672
## as.factor(byear)1936 -1.400e+01  6.339e+00  -2.209   0.0285 *
## as.factor(byear)1940  7.000e+00  6.339e+00   1.104   0.2710
## as.factor(byear)1941  2.534e-13  5.490e+00   0.000   1.0000
## as.factor(byear)1943  1.000e+00  5.490e+00   0.182   0.8557
## as.factor(byear)1944  9.645e-01  5.029e+00   0.192   0.8481
## as.factor(byear)1945  2.644e-13  6.339e+00   0.000   1.0000
## as.factor(byear)1946  1.000e+00  5.490e+00   0.182   0.8557
## as.factor(byear)1947  2.000e+00  5.490e+00   0.364   0.7161
## as.factor(byear)1948  2.000e-01  4.910e+00   0.041   0.9676
## as.factor(byear)1949  2.129e-13  6.339e+00   0.000   1.0000
## as.factor(byear)1950 -1.500e+00  5.490e+00  -0.273   0.7850
## as.factor(byear)1952 -1.286e+00  5.505e+00  -0.234   0.8156
## as.factor(byear)1953 -1.786e+00  5.505e+00  -0.324   0.7461
## as.factor(byear)1954 -8.000e+00  6.339e+00  -1.262   0.2087
## as.factor(byear)1955  2.639e-13  5.490e+00   0.000   1.0000
## as.factor(byear)1956 -2.855e-01  4.859e+00  -0.059   0.9532
## as.factor(byear)1957  2.728e-13  6.339e+00   0.000   1.0000
## as.factor(byear)1958  9.048e-01  4.843e+00   0.187   0.8520
## as.factor(byear)1959  2.547e-13  6.339e+00   0.000   1.0000
## as.factor(byear)1960  1.143e+00  5.183e+00   0.221   0.8257
## as.factor(byear)1961  2.500e+00  5.490e+00   0.455   0.6494
## as.factor(byear)1962  2.405e-13  5.176e+00   0.000   1.0000
## as.factor(byear)1963 -2.393e+00  5.016e+00  -0.477   0.6339
## as.factor(byear)1964 -2.643e+00  5.016e+00  -0.527   0.5989
## as.factor(byear)1965  1.986e-13  6.339e+00   0.000   1.0000
## as.factor(byear)1966 -1.750e+00  5.011e+00  -0.349   0.7274
## as.factor(byear)1967  2.543e-13  5.176e+00   0.000   1.0000
## as.factor(byear)1968 -1.214e+00  4.873e+00  -0.249   0.8036
## as.factor(byear)1970  1.286e+00  4.913e+00   0.262   0.7939
## as.factor(byear)1971  2.725e-13  6.339e+00   0.000   1.0000
## as.factor(byear)1972  1.000e+00  5.176e+00   0.193   0.8470
## as.factor(byear)1973 -6.643e+00  5.016e+00  -1.324   0.1871
## as.factor(byear)1974  2.972e+00  4.921e+00   0.604   0.5468
## as.factor(byear)1975 -1.667e+00  5.176e+00  -0.322   0.7478
## as.factor(byear)1976 -8.928e-01  5.016e+00  -0.178   0.8589
## as.factor(byear)1977  1.322e+00  5.050e+00   0.262   0.7939
## as.factor(byear)1978  2.667e+00  5.176e+00   0.515   0.6071
## as.factor(byear)1979 -1.286e+00  4.859e+00  -0.265   0.7917
## as.factor(byear)1980 -1.400e+00  4.910e+00  -0.285   0.7759
## as.factor(byear)1981 -4.283e-01  5.050e+00  -0.085   0.9325
## as.factor(byear)1982  2.576e-13  6.339e+00   0.000   1.0000
## as.factor(byear)1983 -6.284e-01  4.921e+00  -0.128   0.8985
## as.factor(byear)1984  4.072e+00  5.050e+00   0.806   0.4212
```

```
## as.factor(byear)1985 -4.738e-02  5.205e+00  -0.009   0.9927
## as.factor(byear)1986  2.860e-01  5.205e+00   0.055   0.9563
## as.factor(byear)1987  2.429e+00  4.980e+00   0.488   0.6264
## as.factor(byear)1988  1.464e+00  5.029e+00   0.291   0.7712
## as.factor(byear)1989  4.098e-01  4.677e+00   0.088   0.9303
## as.factor(byear)1990  2.943e+00  4.955e+00   0.594   0.5533
## as.factor(byear)1991  1.540e+00  4.728e+00   0.326   0.7451
## as.factor(byear)1992  1.365e+00  4.733e+00   0.288   0.7734
## as.factor(byear)1993  7.145e-01  5.505e+00   0.130   0.8969
## as.factor(byear)1994  1.667e-01  4.841e+00   0.034   0.9726
## as.factor(byear)1996  2.000e+00  4.841e+00   0.413   0.6800
## as.factor(byear)1997 -7.855e-01  5.505e+00  -0.143   0.8867
## as.factor(byear)1999  3.429e+00  6.393e+00   0.536   0.5924
## as.factor(byear)2000  2.229e+00  4.980e+00   0.448   0.6550
## as.factor(byear)2001 -2.238e+00  5.242e+00  -0.427   0.6700
## as.factor(byear)2002 -2.381e+00  5.205e+00  -0.457   0.6480
## as.factor(byear)2003 -8.570e-01  5.183e+00  -0.165   0.8689
## as.factor(byear)2005 -7.571e+00  5.552e+00  -1.364   0.1745
## as.factor(byear)2006  4.289e-01  5.242e+00   0.082   0.9349
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 4.482 on 170 degrees of freedom
##   (64 observations deleted due to missingness)
## Multiple R-squared:  0.3857, Adjusted R-squared:  0.0677
## F-statistic: 1.213 on 88 and 170 DF,  p-value: 0.143
```

```r
#we can make inferences about the fixed effects
plot(coef(timeMod)[-c(1:2)] ~ as.numeric(substr(names(coef(timeMod)[-c(1:2)]),
                                    start = 17, stop = 20)))
```




```
#doesnt actually seem that there is much of a trend in the baseline aggregate outcome
#now, lets add a location fixed effect
twowayMod = lm(politychanget1 ~ nonviol + as.factor(byear) + as.factor(location), #notice the as.factor
              data = data)
summary(twowayMod) #still holds up, but keep in mind the very strong assumptions, especially when the f
```

```
##
## Call:
## lm(formula = politychanget1 ~ nonviol + as.factor(byear) + as.factor(location),
##     data = data)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -5.8541 -0.6554  0.0000  0.5956  6.5973
##
## Coefficients: (4 not defined because of singularities)
##                                          Estimate Std. Error t value
## (Intercept)                            -5.329e+00  6.602e+00  -0.807
## nonviol                                 4.824e+00  1.305e+00   3.697
## as.factor(byear)1901                    8.874e+00  1.086e+01   0.817
## as.factor(byear)1902                   -3.890e+00  8.721e+00  -0.446
## as.factor(byear)1903                    5.329e+00  7.749e+00   0.688
## as.factor(byear)1904                    4.362e+00  8.575e+00   0.509
## as.factor(byear)1905                    8.774e+00  8.293e+00   1.058
## as.factor(byear)1906                    5.329e+00  7.749e+00   0.688
## as.factor(byear)1907                   -2.952e+00  8.334e+00  -0.354
```

```
## as.factor(byear)1908                5.927e+00  8.211e+00   0.722
## as.factor(byear)1910                5.100e+00  8.446e+00   0.604
## as.factor(byear)1911                2.113e+00  7.906e+00   0.267
## as.factor(byear)1912               -5.090e-01  8.678e+00  -0.059
## as.factor(byear)1916                1.177e+01  8.293e+00   1.420
## as.factor(byear)1917                6.443e+00  7.365e+00   0.875
## as.factor(byear)1918                8.661e+00  9.258e+00   0.935
## as.factor(byear)1919                3.752e+00  6.856e+00   0.547
## as.factor(byear)1922                3.113e+00  7.906e+00   0.394
## as.factor(byear)1923                3.907e+00  7.700e+00   0.507
## as.factor(byear)1924                5.236e+00  7.250e+00   0.722
## as.factor(byear)1925               -6.685e+00  8.479e+00  -0.788
## as.factor(byear)1926                2.100e+00  8.446e+00   0.249
## as.factor(byear)1929                5.100e+00  8.446e+00   0.604
## as.factor(byear)1930               -8.812e-01  9.124e+00  -0.097
## as.factor(byear)1931               -7.586e-02  8.284e+00  -0.009
## as.factor(byear)1932                5.230e+00  7.254e+00   0.721
## as.factor(byear)1934                2.087e+00  8.966e+00   0.233
## as.factor(byear)1936               -1.191e+01  8.966e+00  -1.329
## as.factor(byear)1940                1.796e+01  1.187e+01   1.514
## as.factor(byear)1941               -3.812e-01  7.916e+00  -0.048
## as.factor(byear)1943                5.118e+00  8.275e+00   0.618
## as.factor(byear)1944                3.301e+00  6.986e+00   0.473
## as.factor(byear)1945                2.674e+00  8.234e+00   0.325
## as.factor(byear)1946                6.188e-01  7.916e+00   0.078
## as.factor(byear)1947                6.113e+00  7.906e+00   0.773
## as.factor(byear)1948                3.714e+00  7.315e+00   0.508
## as.factor(byear)1949                2.416e+00  8.757e+00   0.276
## as.factor(byear)1950                1.583e+00  7.665e+00   0.206
## as.factor(byear)1952                3.794e-01  7.953e+00   0.048
## as.factor(byear)1953                2.571e+00  7.707e+00   0.334
## as.factor(byear)1954               -1.029e+01  8.258e+00  -1.247
## as.factor(byear)1955                3.209e+00  7.602e+00   0.422
## as.factor(byear)1956                2.363e+00  6.934e+00   0.341
## as.factor(byear)1957               -2.952e+00  1.012e+01  -0.292
## as.factor(byear)1958                1.096e+01  1.039e+01   1.055
## as.factor(byear)1959                3.826e+00  8.005e+00   0.478
## as.factor(byear)1960                6.050e+00  7.453e+00   0.812
## as.factor(byear)1961                3.266e+00  7.372e+00   0.443
## as.factor(byear)1962                1.514e+00  6.910e+00   0.219
## as.factor(byear)1963               -1.735e-02  7.181e+00  -0.002
## as.factor(byear)1964                1.118e+00  7.804e+00   0.143
## as.factor(byear)1965                5.329e+00  7.749e+00   0.688
## as.factor(byear)1966                7.264e-01  7.017e+00   0.104
## as.factor(byear)1967                6.697e+00  7.041e+00   0.951
## as.factor(byear)1968                2.087e+00  6.889e+00   0.303
## as.factor(byear)1970                2.659e+00  6.814e+00   0.390
## as.factor(byear)1971               -2.374e-01  9.485e+00  -0.025
## as.factor(byear)1972                7.626e-01  7.552e+00   0.101
## as.factor(byear)1973               -4.062e+00  6.824e+00  -0.595
## as.factor(byear)1974                6.421e+00  7.071e+00   0.908
## as.factor(byear)1975                5.962e+00  1.187e+01   0.502
## as.factor(byear)1976                1.180e+00  6.970e+00   0.169
## as.factor(byear)1977                3.017e+00  7.092e+00   0.425
```

```
## as.factor(byear)1978                          6.207e-01  7.258e+00   0.086
## as.factor(byear)1979                          2.776e+00  7.137e+00   0.389
## as.factor(byear)1980                          1.009e+00  7.008e+00   0.144
## as.factor(byear)1981                          5.166e+00  7.056e+00   0.732
## as.factor(byear)1982                          5.159e-14  5.738e+00   0.000
## as.factor(byear)1983                          4.734e+00  6.812e+00   0.695
## as.factor(byear)1984                          7.918e+00  7.231e+00   1.095
## as.factor(byear)1985                          3.836e+00  7.230e+00   0.531
## as.factor(byear)1986                          2.915e-03  7.432e+00   0.000
## as.factor(byear)1987                          5.752e-01  7.218e+00   0.080
## as.factor(byear)1988                          5.564e+00  7.205e+00   0.772
## as.factor(byear)1989                          6.970e-01  6.612e+00   0.105
## as.factor(byear)1990                          3.617e+00  7.094e+00   0.510
## as.factor(byear)1991                          4.050e+00  7.018e+00   0.577
## as.factor(byear)1992                          9.240e-14  5.738e+00   0.000
## as.factor(byear)1993                          7.649e+00  7.370e+00   1.038
## as.factor(byear)1994                          5.436e+00  7.045e+00   0.772
## as.factor(byear)1996                          4.151e+00  6.671e+00   0.622
## as.factor(byear)1997                         -1.499e-01  8.315e+00  -0.018
## as.factor(byear)1999                          7.505e+00  7.844e+00   0.957
## as.factor(byear)2000                          8.872e+00  7.263e+00   1.222
## as.factor(byear)2001                         -5.598e+00  7.603e+00  -0.736
## as.factor(byear)2002                          4.050e+00  9.065e+00   0.447
## as.factor(byear)2003                          7.761e-01  6.885e+00   0.113
## as.factor(byear)2005                         -2.274e+01  7.708e+00  -2.950
## as.factor(byear)2006                          1.170e+00  7.544e+00   0.155
## as.factor(location)Albania                   -1.919e-01  5.520e+00  -0.035
## as.factor(location)Algeria                    4.572e+00  4.504e+00   1.015
## as.factor(location)Angola                    -6.329e-01  1.120e+01  -0.057
## as.factor(location)Argentina                  2.794e+00  4.644e+00   0.602
## as.factor(location)Austria                   -4.758e+00  8.211e+00  -0.579
## as.factor(location)Azerbaijan                 1.279e+00  5.828e+00   0.219
## as.factor(location)Bangladesh                 1.979e+00  4.682e+00   0.423
## as.factor(location)Belarus                   -6.654e-01  6.572e+00  -0.101
## as.factor(location)Benin                      6.808e+00  5.520e+00   1.233
## as.factor(location)Bolivia                    9.219e+00  5.496e+00   1.677
## as.factor(location)Brazil                     8.432e-01  5.268e+00   0.160
## as.factor(location)Bulgaria                   6.150e-01  5.060e+00   0.122
## as.factor(location)Burma                     -2.827e-01  4.664e+00  -0.061
## as.factor(location)Burundi                    5.923e+00  5.074e+00   1.167
## as.factor(location)Cambodia                   2.189e+00  5.009e+00   0.437
## as.factor(location)CAR                       -1.069e-01  6.040e+00  -0.018
## as.factor(location)Chad                       2.248e+00  4.999e+00   0.450
## as.factor(location)Chile                      5.810e-01  4.916e+00   0.118
## as.factor(location)China                     -7.840e-01  3.828e+00  -0.205
## as.factor(location)Colombia                   2.914e+00  5.595e+00   0.521
## as.factor(location)Congo-Brazzaville (ROC)    5.479e+00  7.437e+00   0.737
## as.factor(location)Costa Rica                 1.615e+00  6.440e+00   0.251
## as.factor(location)Croatia                           NA         NA      NA
## as.factor(location)Cuba                       1.197e+01  5.818e+00   2.057
## as.factor(location)Czechoslovakia             3.113e+00  4.732e+00   0.658
## as.factor(location)Djibouti                   1.279e+00  5.828e+00   0.219
## as.factor(location)Dominican Republic                NA         NA      NA
## as.factor(location)East Germany              -1.962e+00  5.426e+00  -0.362
```

```
## as.factor(location)East Timor                 2.425e+00  5.130e+00   0.473
## as.factor(location)Egypt                     -5.367e+00  6.343e+00  -0.846
## as.factor(location)El Salvador                3.965e-01  4.673e+00   0.085
## as.factor(location)Ethiopia                   7.922e+00  4.576e+00   1.731
## as.factor(location)Finland                   -3.331e+00  8.535e+00  -0.390
## as.factor(location)France                    -5.633e+00  9.618e+00  -0.586
## as.factor(location)Georgia                    5.041e-01  4.820e+00   0.105
## as.factor(location)Germany                   -3.402e+00  6.990e+00  -0.487
## as.factor(location)Ghana                     -8.367e+00  6.343e+00  -1.319
## as.factor(location)Greece                     2.116e-01  4.717e+00   0.045
## as.factor(location)Guatemala                  7.623e+00  4.677e+00   1.630
## as.factor(location)Guyana                     9.888e+00  6.133e+00   1.612
## as.factor(location)Haiti                     -3.331e+00  6.319e+00  -0.527
## as.factor(location)Hungary                    6.693e+00  4.239e+00   1.579
## as.factor(location)India                      5.064e-01  4.328e+00   0.117
## as.factor(location)Indonesia                  2.655e+00  4.563e+00   0.582
## as.factor(location)Iran                      -5.981e-01  4.632e+00  -0.129
## as.factor(location)Iraq                       1.503e+00  4.195e+00   0.358
## as.factor(location)Israel                    -4.660e+00  6.153e+00  -0.757
## as.factor(location)Italy                      2.212e+00  7.428e+00   0.298
## as.factor(location)Ivory Coast                1.279e+00  8.179e+00   0.156
## as.factor(location)Jordan                     2.670e+00  5.861e+00   0.456
## as.factor(location)Kenya                     -1.490e+00  5.079e+00  -0.293
## as.factor(location)Kyrgyzstan                 2.925e+01  7.132e+00   4.101
## as.factor(location)Laos                      -2.721e+00  6.522e+00  -0.417
## as.factor(location)Lebanon                   -5.633e+00  9.618e+00  -0.586
## as.factor(location)Liberia                    5.673e+00  3.779e+00   1.501
## as.factor(location)Madagascar                -3.545e+00  6.053e+00  -0.586
## as.factor(location)Malawi                     1.451e+01  5.348e+00   2.712
## as.factor(location)Malaysia                   1.615e+00  6.440e+00   0.251
## as.factor(location)Mali                       5.720e+00  4.657e+00   1.228
## as.factor(location)Mexico                     2.288e-01  4.990e+00   0.046
## as.factor(location)Moldova                    5.329e+00  5.208e+00   1.023
## as.factor(location)Mongolia                   8.808e+00  5.520e+00   1.596
## as.factor(location)Morocco                    8.281e+00  7.479e+00   1.107
## as.factor(location)Mozambique                 2.554e+00  6.148e+00   0.415
## as.factor(location)Namibia/South West Africa  9.669e-01  7.766e+00   0.125
## as.factor(location)Natal                             NA         NA      NA
## as.factor(location)Nepal                      1.044e+01  4.429e+00   2.357
## as.factor(location)Nicaragua                  1.201e+01  5.090e+00   2.361
## as.factor(location)Niger                      3.455e+00  6.053e+00   0.571
## as.factor(location)Nigeria                   -3.826e+00  4.422e+00  -0.865
## as.factor(location)Northern Ireland           3.242e+00  5.873e+00   0.552
## as.factor(location)Oman                       4.212e+00  6.930e+00   0.608
## as.factor(location)Ottoman Empire                    NA         NA      NA
## as.factor(location)Pakistan                  -2.882e+00  4.274e+00  -0.674
## as.factor(location)Panama                     1.593e+01  6.170e+00   2.582
## as.factor(location)Papua New Guinea          -2.343e-01  6.262e+00  -0.037
## as.factor(location)Paraguay                   3.216e+00  6.898e+00   0.466
## as.factor(location)Peru                       1.058e+00  4.360e+00   0.243
## as.factor(location)Philippines                5.210e+00  4.583e+00   1.137
## as.factor(location)Poland                     1.232e+00  4.329e+00   0.285
## as.factor(location)Portugal                   8.454e-02  6.218e+00   0.014
## as.factor(location)Romania                    8.281e+00  4.797e+00   1.726
```

```
## as.factor(location)Russia                    -1.444e+00  4.716e+00  -0.306
## as.factor(location)Rwanda                     2.651e+00  4.677e+00   0.567
## as.factor(location)Saudi Arabia               2.288e-01  7.605e+00   0.030
## as.factor(location)Senegal                    6.334e-01  6.343e+00   0.100
## as.factor(location)Serbia                    -1.069e-01  6.040e+00  -0.018
## as.factor(location)Sierra Leone               1.228e+01  5.828e+00   2.107
## as.factor(location)Somalia                    5.329e+00  5.208e+00   1.023
## as.factor(location)South Africa              -3.144e+00  5.704e+00  -0.551
## as.factor(location)South Korea                3.371e+00  4.844e+00   0.696
## as.factor(location)Spain                      3.242e+00  5.873e+00   0.552
## as.factor(location)Sri Lanka                  5.567e+00  6.586e+00   0.845
## as.factor(location)Sudan                      3.658e+00  4.225e+00   0.866
## as.factor(location)Syria                      4.320e+00  5.996e+00   0.720
## as.factor(location)Taiwan                    -2.270e+00  6.293e+00  -0.361
## as.factor(location)Tajikistan                 6.329e+00  5.208e+00   1.215
## as.factor(location)Tanzania                   5.505e+00  5.348e+00   1.029
## as.factor(location)Thailand                   9.247e+00  4.235e+00   2.183
## as.factor(location)Tibet                      1.838e+00  5.355e+00   0.343
## as.factor(location)Turkey                     1.861e-01  4.331e+00   0.043
## as.factor(location)Uganda                     1.034e+00  4.463e+00   0.232
## as.factor(location)Ukraine                    6.103e+00  6.697e+00   0.911
## as.factor(location)Uruguay                    3.967e+00  5.233e+00   0.758
## as.factor(location)USSR                       6.210e+00  6.121e+00   1.015
## as.factor(location)Venezuela                 -3.545e+00  8.341e+00  -0.425
## as.factor(location)Vietnam                   -5.633e+00  9.180e+00  -0.614
## as.factor(location)West Papua                -6.124e-01  7.145e+00  -0.086
## as.factor(location)Western Sahara            -6.329e-01  1.120e+01  -0.057
## as.factor(location)Yemen                      3.733e+00  5.405e+00   0.691
## as.factor(location)Yemen Arab Republic        3.215e+00  5.183e+00   0.620
## as.factor(location)Yemen People's Republic    6.326e+00  6.545e+00   0.967
## as.factor(location)Yugoslavia                -7.910e-01  4.181e+00  -0.189
## as.factor(location)Zaire/DRC                 -6.373e-01  4.427e+00  -0.144
## as.factor(location)Zambia                     1.100e+01  5.333e+00   2.062
## as.factor(location)Zimbabwe                  -3.748e+00  4.934e+00  -0.760
##                                              Pr(>|t|)
## (Intercept)                                  0.422852
## nonviol                                      0.000486 ***
## as.factor(byear)1901                         0.417301
## as.factor(byear)1902                         0.657225
## as.factor(byear)1903                         0.494378
## as.factor(byear)1904                         0.612863
## as.factor(byear)1905                         0.294442
## as.factor(byear)1906                         0.494378
## as.factor(byear)1907                         0.724476
## as.factor(byear)1908                         0.473265
## as.factor(byear)1910                         0.548286
## as.factor(byear)1911                         0.790175
## as.factor(byear)1912                         0.953426
## as.factor(byear)1916                         0.161029
## as.factor(byear)1917                         0.385262
## as.factor(byear)1918                         0.353434
## as.factor(byear)1919                         0.586347
## as.factor(byear)1922                         0.695167
## as.factor(byear)1923                         0.613755
```

```
## as.factor(byear)1924                0.473043
## as.factor(byear)1925                0.433647
## as.factor(byear)1926                0.804484
## as.factor(byear)1929                0.548286
## as.factor(byear)1930                0.923389
## as.factor(byear)1931                0.992725
## as.factor(byear)1932                0.473821
## as.factor(byear)1934                0.816752
## as.factor(byear)1936                0.189157
## as.factor(byear)1940                0.135540
## as.factor(byear)1941                0.961756
## as.factor(byear)1943                0.538680
## as.factor(byear)1944                0.638296
## as.factor(byear)1945                0.746514
## as.factor(byear)1946                0.937964
## as.factor(byear)1947                0.442494
## as.factor(byear)1948                0.613566
## as.factor(byear)1949                0.783627
## as.factor(byear)1950                0.837144
## as.factor(byear)1952                0.962112
## as.factor(byear)1953                0.739934
## as.factor(byear)1954                0.217581
## as.factor(byear)1955                0.674431
## as.factor(byear)1956                0.734464
## as.factor(byear)1957                0.771533
## as.factor(byear)1958                0.295633
## as.factor(byear)1959                0.634500
## as.factor(byear)1960                0.420268
## as.factor(byear)1961                0.659406
## as.factor(byear)1962                0.827334
## as.factor(byear)1963                0.998081
## as.factor(byear)1964                0.886628
## as.factor(byear)1965                0.494378
## as.factor(byear)1966                0.917904
## as.factor(byear)1967                0.345494
## as.factor(byear)1968                0.763013
## as.factor(byear)1970                0.697769
## as.factor(byear)1971                0.980114
## as.factor(byear)1972                0.919919
## as.factor(byear)1973                0.553998
## as.factor(byear)1974                0.367630
## as.factor(byear)1975                0.617265
## as.factor(byear)1976                0.866112
## as.factor(byear)1977                0.672153
## as.factor(byear)1978                0.932137
## as.factor(byear)1979                0.698772
## as.factor(byear)1980                0.885981
## as.factor(byear)1981                0.467038
## as.factor(byear)1982                1.000000
## as.factor(byear)1983                0.489861
## as.factor(byear)1984                0.278038
## as.factor(byear)1985                0.597702
## as.factor(byear)1986                0.999688
## as.factor(byear)1987                0.936755
```

```
## as.factor(byear)1988                          0.443160
## as.factor(byear)1989                          0.916409
## as.factor(byear)1990                          0.612055
## as.factor(byear)1991                          0.566079
## as.factor(byear)1992                          1.000000
## as.factor(byear)1993                          0.303650
## as.factor(byear)1994                          0.443461
## as.factor(byear)1996                          0.536248
## as.factor(byear)1997                          0.985678
## as.factor(byear)1999                          0.342637
## as.factor(byear)2000                          0.226828
## as.factor(byear)2001                          0.464542
## as.factor(byear)2002                          0.656690
## as.factor(byear)2003                          0.910637
## as.factor(byear)2005                          0.004572 **
## as.factor(byear)2006                          0.877236
## as.factor(location)Albania                    0.972383
## as.factor(location)Algeria                    0.314268
## as.factor(location)Angola                     0.955126
## as.factor(location)Argentina                  0.549753
## as.factor(location)Austria                    0.564515
## as.factor(location)Azerbaijan                 0.827044
## as.factor(location)Bangladesh                 0.674150
## as.factor(location)Belarus                    0.919708
## as.factor(location)Benin                      0.222389
## as.factor(location)Bolivia                    0.098868 .
## as.factor(location)Brazil                     0.873389
## as.factor(location)Bulgaria                   0.903687
## as.factor(location)Burma                      0.951870
## as.factor(location)Burundi                    0.247829
## as.factor(location)Cambodia                   0.663666
## as.factor(location)CAR                        0.985943
## as.factor(location)Chad                       0.654579
## as.factor(location)Chile                      0.906336
## as.factor(location)China                      0.838427
## as.factor(location)Colombia                   0.604504
## as.factor(location)Congo-Brazzaville (ROC)    0.464259
## as.factor(location)Costa Rica                 0.802837
## as.factor(location)Croatia                          NA
## as.factor(location)Cuba                       0.044224 *
## as.factor(location)Czechoslovakia             0.513185
## as.factor(location)Djibouti                   0.827044
## as.factor(location)Dominican Republic               NA
## as.factor(location)East Germany               0.718964
## as.factor(location)East Timor                 0.638149
## as.factor(location)Egypt                      0.400989
## as.factor(location)El Salvador                0.932670
## as.factor(location)Ethiopia                   0.088700 .
## as.factor(location)Finland                    0.697745
## as.factor(location)France                     0.560354
## as.factor(location)Georgia                    0.917073
## as.factor(location)Germany                    0.628273
## as.factor(location)Ghana                      0.192341
## as.factor(location)Greece                     0.964369
```

```
## as.factor(location)Guatemala                 0.108536
## as.factor(location)Guyana                    0.112336
## as.factor(location)Haiti                     0.600052
## as.factor(location)Hungary                   0.119822
## as.factor(location)India                     0.907264
## as.factor(location)Indonesia                 0.562930
## as.factor(location)Iran                      0.897717
## as.factor(location)Iraq                      0.721338
## as.factor(location)Israel                    0.451844
## as.factor(location)Italy                     0.766970
## as.factor(location)Ivory Coast               0.876261
## as.factor(location)Jordan                    0.650409
## as.factor(location)Kenya                     0.770267
## as.factor(location)Kyrgyzstan                0.000130 ***
## as.factor(location)Laos                      0.678084
## as.factor(location)Lebanon                   0.560354
## as.factor(location)Liberia                   0.138710
## as.factor(location)Madagascar                0.560372
## as.factor(location)Malawi                    0.008780 **
## as.factor(location)Malaysia                  0.802837
## as.factor(location)Mali                      0.224253
## as.factor(location)Mexico                    0.963586
## as.factor(location)Moldova                   0.310447
## as.factor(location)Mongolia                  0.115973
## as.factor(location)Morocco                   0.272759
## as.factor(location)Mozambique                0.679383
## as.factor(location)Namibia/South West Africa 0.901348
## as.factor(location)Natal                           NA
## as.factor(location)Nepal                     0.021808 *
## as.factor(location)Nicaragua                 0.021633 *
## as.factor(location)Niger                     0.570341
## as.factor(location)Nigeria                   0.390521
## as.factor(location)Northern Ireland          0.583014
## as.factor(location)Oman                      0.545716
## as.factor(location)Ottoman Empire                  NA
## as.factor(location)Pakistan                  0.502849
## as.factor(location)Panama                    0.012374 *
## as.factor(location)Papua New Guinea          0.970281
## as.factor(location)Paraguay                  0.642788
## as.factor(location)Peru                      0.809181
## as.factor(location)Philippines               0.260247
## as.factor(location)Poland                    0.777029
## as.factor(location)Portugal                  0.989199
## as.factor(location)Romania                   0.089602 .
## as.factor(location)Russia                    0.760470
## as.factor(location)Rwanda                    0.573083
## as.factor(location)Saudi Arabia              0.976099
## as.factor(location)Senegal                   0.920803
## as.factor(location)Serbia                    0.985943
## as.factor(location)Sierra Leone              0.039461 *
## as.factor(location)Somalia                   0.310447
## as.factor(location)South Africa              0.583689
## as.factor(location)South Korea               0.489192
## as.factor(location)Spain                     0.583014
```

```
## as.factor(location)Sri Lanka                0.401435
## as.factor(location)Sudan                    0.390191
## as.factor(location)Syria                    0.474146
## as.factor(location)Taiwan                   0.719575
## as.factor(location)Tajikistan               0.229200
## as.factor(location)Tanzania                 0.307575
## as.factor(location)Thailand                 0.033071 *
## as.factor(location)Tibet                    0.732615
## as.factor(location)Turkey                   0.965870
## as.factor(location)Uganda                   0.817641
## as.factor(location)Ukraine                  0.365925
## as.factor(location)Uruguay                  0.451505
## as.factor(location)USSR                     0.314502
## as.factor(location)Venezuela                0.672385
## as.factor(location)Vietnam                  0.541857
## as.factor(location)West Papua               0.931988
## as.factor(location)Western Sahara           0.955126
## as.factor(location)Yemen                    0.492509
## as.factor(location)Yemen Arab Republic      0.537483
## as.factor(location)Yemen People's Republic  0.337735
## as.factor(location)Yugoslavia               0.850589
## as.factor(location)Zaire/DRC                0.886022
## as.factor(location)Zambia                   0.043711 *
## as.factor(location)Zimbabwe                 0.450543
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 4.057 on 58 degrees of freedom
##   (64 observations deleted due to missingness)
## Multiple R-squared:  0.8283, Adjusted R-squared:  0.236
## F-statistic: 1.399 on 200 and 58 DF,  p-value: 0.06703
```

```
#now lets look at a balanced example, which makes more intuitive and mathematical sense
#Bosnian ethnic voting as a function of violence experienced during the war
data2 = read.csv('bosnia.csv')
Log_Casualty.Model <- lm(Ethnic_Vote_Share ~ Log_Casualty,
                         data = data2)
summary(Log_Casualty.Model) #notice the lack of reliable effects
```

```
##
## Call:
## lm(formula = Ethnic_Vote_Share ~ Log_Casualty, data = data2)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -61.526 -10.098   3.915  12.273  18.561
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)   81.2928     0.8418  96.570   <2e-16 ***
## Log_Casualty  -0.6111     0.8462  -0.722    0.471
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 15.18 on 426 degrees of freedom
```

```
## Multiple R-squared:  0.001223,   Adjusted R-squared:  -0.001122
## F-statistic: 0.5215 on 1 and 426 DF,  p-value: 0.4706
```

```
#lets add a province dummy
Log_Casualty.Model2 <- lm(Ethnic_Vote_Share ~ Log_Casualty + as.factor(Municipality),
                          data = data2)
summary(Log_Casualty.Model2) #still nothing, but notice the NAs - why?
```

```
##
## Call:
## lm(formula = Ethnic_Vote_Share ~ Log_Casualty + as.factor(Municipality),
##     data = data2)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -45.067  -4.548   1.650   4.583  50.961
##
## Coefficients: (1 not defined because of singularities)
##                                                    Estimate Std. Error
## (Intercept)                                        87.78648    4.55938
## Log_Casualty                                        1.80880    3.97367
## as.factor(Municipality)Banovici                   -18.38521    6.40974
## as.factor(Municipality)Bihac                      -30.23323    5.86519
## as.factor(Municipality)Bijeljina                    0.91318    6.48500
## as.factor(Municipality)Bileca                       5.66981    7.15734
## as.factor(Municipality)Bosanska Dubica (Kozarska Dubica)   1.88312    6.35099
## as.factor(Municipality)Bosanska Gradiska (Gradiska)        4.66507    6.59876
## as.factor(Municipality)Bosanska Krupa             -12.19123    5.86716
## as.factor(Municipality)Bosanski Brod               -5.79667    5.90768
## as.factor(Municipality)Bosanski Novi (Novi Grad)    3.67511    5.98737
## as.factor(Municipality)Bosanski Petrovac          -18.12054    5.88055
## as.factor(Municipality)Bosansko Grahovo (Grahovo) -17.67652    5.86451
## as.factor(Municipality)Bratunac                     1.88079    8.55328
## as.factor(Municipality)Brcko                      -14.54025    5.88686
## as.factor(Municipality)Breza                      -22.35659    6.00423
## as.factor(Municipality)Bugojno                    -19.56926    5.94165
## as.factor(Municipality)Busovaca                    -8.33076    5.87802
## as.factor(Municipality)Cajnice                      6.81146    6.04717
## as.factor(Municipality)Capljina                     1.84665    6.96078
## as.factor(Municipality)Cazin                      -13.63238    6.06104
## as.factor(Municipality)Celinac                      4.70628    6.22273
## as.factor(Municipality)Centar Sarajevo            -38.50807    5.87365
## as.factor(Municipality)Citluk                      12.60337   10.62360
## as.factor(Municipality)Derventa                    -0.02266    5.95853
## as.factor(Municipality)Doboj                       -7.26418    5.86691
## as.factor(Municipality)Donji Vakuf                -18.36382    6.34860
## as.factor(Municipality)Drvar                      -13.52460    7.06526
## as.factor(Municipality)Foca (Srbinje)               0.84201    7.42823
## as.factor(Municipality)Fojnica                    -11.62344    5.89252
## as.factor(Municipality)Gacko                        3.99828    6.12501
## as.factor(Municipality)Glamoc                      -7.31188    6.16697
## as.factor(Municipality)Gorazde                    -18.93680    6.46800
## as.factor(Municipality)Gornji Vakuf - Uskopolje    -4.21910    5.89522
## as.factor(Municipality)Gradacac                   -20.43093    5.98415
## as.factor(Municipality)Grude                        4.80119   11.19567
```

```
## as.factor(Municipality)Hadzici                          -22.07409    6.17200
## as.factor(Municipality)Han Pijesak                        5.67462    5.87904
## as.factor(Municipality)Ilidza                           -16.94301    5.88311
## as.factor(Municipality)Ilijas                           -20.76151    5.86516
## as.factor(Municipality)Jablanica                        -24.69193    5.86433
## as.factor(Municipality)Jajce                            -10.42958    5.99211
## as.factor(Municipality)Kakanj                           -14.63352    6.58425
## as.factor(Municipality)Kalesija                         -20.03774    5.98062
## as.factor(Municipality)Kalinovik                          2.00610    7.10355
## as.factor(Municipality)Kiseljak                          -4.05129    5.91028
## as.factor(Municipality)Kladanj                          -22.65948    6.09570
## as.factor(Municipality)Kljuc                            -11.49551    6.12761
## as.factor(Municipality)Konjic                           -15.30172    5.86731
## as.factor(Municipality)Kotor Varos                        5.10987    5.94498
## as.factor(Municipality)Kresevo                           -7.43886    5.95411
## as.factor(Municipality)Kupres (FBiH)                      3.01030    6.00465
## as.factor(Municipality)Laktasi                            4.87878    7.07124
## as.factor(Municipality)Livno                             -1.33171   10.63107
## as.factor(Municipality)Ljubinje                           9.77993    7.47684
## as.factor(Municipality)Ljubuski                           6.35017   11.54723
## as.factor(Municipality)Lopare                            -5.93991    5.95335
## as.factor(Municipality)Maglaj                           -19.15586    5.87284
## as.factor(Municipality)Modrica                           -3.15609    5.91771
## as.factor(Municipality)Mostar                           -12.55278    5.87214
## as.factor(Municipality)Mrkonjic Grad                      3.34105    5.91646
## as.factor(Municipality)Neum                               9.95773   12.37966
## as.factor(Municipality)Nevesinje                          0.76051    6.54111
## as.factor(Municipality)Novi Grad Sarajevo               -30.10479    5.87378
## as.factor(Municipality)Novi Travnik                     -12.84643    6.00222
## as.factor(Municipality)Novo Sarajevo                    -32.95022    5.87290
## as.factor(Municipality)Odzak                             -8.64433    6.81897
## as.factor(Municipality)Olovo                            -16.17042    5.95203
## as.factor(Municipality)Orasje                             2.67803    6.26199
## as.factor(Municipality)Pale (RS)                          4.26364    5.98245
## as.factor(Municipality)Posusje                           10.93523   12.98803
## as.factor(Municipality)Prijedor                          -3.50837    6.62554
## as.factor(Municipality)Prnjavor                           2.11269    6.39809
## as.factor(Municipality)Prozor (Prozor-Rama)               4.97342    5.87357
## as.factor(Municipality)Rogatica                          -0.54407    8.25900
## as.factor(Municipality)Rudo                               5.11882    5.87525
## as.factor(Municipality)Samac (Bosanski Samac)             0.85634    5.88997
## as.factor(Municipality)Sanski Most                      -14.02514    5.86649
## as.factor(Municipality)Sekovici                          -0.64380    5.87758
## as.factor(Municipality)Sipovo                             6.31584    6.27157
## as.factor(Municipality)Siroki Brijeg                      3.11603   11.61352
## as.factor(Municipality)Skender Vakuf (Knezevo)            5.02701    6.96033
## as.factor(Municipality)Sokolac                            4.73670    5.93671
## as.factor(Municipality)Srbac                              4.48245    7.78169
## as.factor(Municipality)Srebrenica                         0.33361   10.75618
## as.factor(Municipality)Srebrenik                        -32.35237    6.94356
## as.factor(Municipality)Stari Grad Sarajevo              -26.76183    5.87248
## as.factor(Municipality)Stolac                             3.36583    6.64992
## as.factor(Municipality)Tesanj                           -18.85756    6.00866
## as.factor(Municipality)Teslic                            -1.60026    6.34619
```

```
## as.factor(Municipality)Tomislavgrad                          8.65787   10.04927
## as.factor(Municipality)Travnik                             -10.76784    5.89486
## as.factor(Municipality)Trebinje                              3.30728    6.40765
## as.factor(Municipality)Trnovo (FBiH)                        -9.78708    6.76903
## as.factor(Municipality)Tuzla                               -46.53079    6.56707
## as.factor(Municipality)Ugljevik                              0.81542    5.86506
## as.factor(Municipality)Vares                               -23.91164    5.97918
## as.factor(Municipality)Velika Kladusa                      -47.48446    5.86758
## as.factor(Municipality)Visegrad                              2.91782    7.78931
## as.factor(Municipality)Visoko                              -15.45174    6.08099
## as.factor(Municipality)Vitez                                -7.82968    6.21051
## as.factor(Municipality)Vlasenica                             4.45992    7.91786
## as.factor(Municipality)Vogosca                             -22.47008    5.97720
## as.factor(Municipality)Zavidovici                          -17.43838    6.00070
## as.factor(Municipality)Zenica                              -22.28474    6.60188
## as.factor(Municipality)Zepce                                -2.32357    6.05466
## as.factor(Municipality)Zivince                             -25.69799    7.07663
## as.factor(Municipality)Zvornik                                    NA         NA
##                                                          t value Pr(>|t|)
## (Intercept)                                               19.254  < 2e-16 ***
## Log_Casualty                                               0.455 0.649277
## as.factor(Municipality)Banovici                           -2.868 0.004400 **
## as.factor(Municipality)Bihac                              -5.155 4.45e-07 ***
## as.factor(Municipality)Bijeljina                           0.141 0.888106
## as.factor(Municipality)Bileca                              0.792 0.428849
## as.factor(Municipality)Bosanska Dubica (Kozarska Dubica)   0.297 0.767034
## as.factor(Municipality)Bosanska Gradiska (Gradiska)        0.707 0.480103
## as.factor(Municipality)Bosanska Krupa                     -2.078 0.038515 *
## as.factor(Municipality)Bosanski Brod                      -0.981 0.327228
## as.factor(Municipality)Bosanski Novi (Novi Grad)           0.614 0.539776
## as.factor(Municipality)Bosanski Petrovac                  -3.081 0.002238 **
## as.factor(Municipality)Bosansko Grahovo (Grahovo)         -3.014 0.002782 **
## as.factor(Municipality)Bratunac                            0.220 0.826095
## as.factor(Municipality)Brcko                              -2.470 0.014033 *
## as.factor(Municipality)Breza                              -3.723 0.000232 ***
## as.factor(Municipality)Bugojno                            -3.294 0.001100 **
## as.factor(Municipality)Busovaca                           -1.417 0.157373
## as.factor(Municipality)Cajnice                             1.126 0.260843
## as.factor(Municipality)Capljina                            0.265 0.790953
## as.factor(Municipality)Cazin                              -2.249 0.025179 *
## as.factor(Municipality)Celinac                             0.756 0.450021
## as.factor(Municipality)Centar Sarajevo                    -6.556 2.21e-10 ***
## as.factor(Municipality)Citluk                              1.186 0.236359
## as.factor(Municipality)Derventa                           -0.004 0.996968
## as.factor(Municipality)Doboj                              -1.238 0.216562
## as.factor(Municipality)Donji Vakuf                        -2.893 0.004082 **
## as.factor(Municipality)Drvar                              -1.914 0.056479 .
## as.factor(Municipality)Foca (Srbinje)                      0.113 0.909822
## as.factor(Municipality)Fojnica                            -1.973 0.049402 *
## as.factor(Municipality)Gacko                               0.653 0.514366
## as.factor(Municipality)Glamoc                             -1.186 0.236636
## as.factor(Municipality)Gorazde                            -2.928 0.003658 **
## as.factor(Municipality)Gornji Vakuf - Uskopolje           -0.716 0.474709
## as.factor(Municipality)Gradacac                           -3.414 0.000722 ***
```

```
## as.factor(Municipality)Grude                          0.429 0.668325
## as.factor(Municipality)Hadzici                       -3.576 0.000402 ***
## as.factor(Municipality)Han Pijesak                    0.965 0.335157
## as.factor(Municipality)Ilidza                        -2.880 0.004245 **
## as.factor(Municipality)Ilijas                        -3.540 0.000460 ***
## as.factor(Municipality)Jablanica                     -4.211 3.31e-05 ***
## as.factor(Municipality)Jajce                         -1.741 0.082720 .
## as.factor(Municipality)Kakanj                        -2.223 0.026946 *
## as.factor(Municipality)Kalesija                      -3.350 0.000903 ***
## as.factor(Municipality)Kalinovik                      0.282 0.777812
## as.factor(Municipality)Kiseljak                      -0.685 0.493545
## as.factor(Municipality)Kladanj                       -3.717 0.000238 ***
## as.factor(Municipality)Kljuc                         -1.876 0.061560 .
## as.factor(Municipality)Konjic                        -2.608 0.009534 **
## as.factor(Municipality)Kotor Varos                    0.860 0.390691
## as.factor(Municipality)Kresevo                       -1.249 0.212442
## as.factor(Municipality)Kupres (FBiH)                  0.501 0.616483
## as.factor(Municipality)Laktasi                        0.690 0.490726
## as.factor(Municipality)Livno                         -0.125 0.900392
## as.factor(Municipality)Ljubinje                       1.308 0.191799
## as.factor(Municipality)Ljubuski                       0.550 0.582750
## as.factor(Municipality)Lopare                        -0.998 0.319156
## as.factor(Municipality)Maglaj                        -3.262 0.001226 **
## as.factor(Municipality)Modrica                       -0.533 0.594175
## as.factor(Municipality)Mostar                        -2.138 0.033297 *
## as.factor(Municipality)Mrkonjic Grad                  0.565 0.572669
## as.factor(Municipality)Neum                           0.804 0.421783
## as.factor(Municipality)Nevesinje                      0.116 0.907514
## as.factor(Municipality)Novi Grad Sarajevo            -5.125 5.14e-07 ***
## as.factor(Municipality)Novi Travnik                  -2.140 0.033086 *
## as.factor(Municipality)Novo Sarajevo                 -5.611 4.36e-08 ***
## as.factor(Municipality)Odzak                         -1.268 0.205828
## as.factor(Municipality)Olovo                         -2.717 0.006949 **
## as.factor(Municipality)Orasje                         0.428 0.669182
## as.factor(Municipality)Pale (RS)                      0.713 0.476555
## as.factor(Municipality)Posusje                        0.842 0.400445
## as.factor(Municipality)Prijedor                      -0.530 0.596809
## as.factor(Municipality)Prnjavor                       0.330 0.741460
## as.factor(Municipality)Prozor (Prozor-Rama)           0.847 0.397768
## as.factor(Municipality)Rogatica                      -0.066 0.947518
## as.factor(Municipality)Rudo                           0.871 0.384268
## as.factor(Municipality)Samac (Bosanski Samac)         0.145 0.884495
## as.factor(Municipality)Sanski Most                   -2.391 0.017391 *
## as.factor(Municipality)Sekovici                      -0.110 0.912847
## as.factor(Municipality)Sipovo                         1.007 0.314664
## as.factor(Municipality)Siroki Brijeg                  0.268 0.788633
## as.factor(Municipality)Skender Vakuf (Knezevo)        0.722 0.470674
## as.factor(Municipality)Sokolac                        0.798 0.425538
## as.factor(Municipality)Srbac                          0.576 0.565001
## as.factor(Municipality)Srebrenica                     0.031 0.975277
## as.factor(Municipality)Srebrenik                     -4.659 4.65e-06 ***
## as.factor(Municipality)Stari Grad Sarajevo           -4.557 7.38e-06 ***
## as.factor(Municipality)Stolac                         0.506 0.613102
## as.factor(Municipality)Tesanj                        -3.138 0.001856 **
```

```
## as.factor(Municipality)Teslic                                -0.252 0.801078
## as.factor(Municipality)Tomislavgrad                           0.862 0.389583
## as.factor(Municipality)Travnik                               -1.827 0.068681 .
## as.factor(Municipality)Trebinje                               0.516 0.606108
## as.factor(Municipality)Trnovo (FBiH)                         -1.446 0.149192
## as.factor(Municipality)Tuzla                                 -7.085 8.83e-12 ***
## as.factor(Municipality)Ugljevik                               0.139 0.889513
## as.factor(Municipality)Vares                                 -3.999 7.89e-05 ***
## as.factor(Municipality)Velika Kladusa                        -8.093 1.22e-14 ***
## as.factor(Municipality)Visegrad                               0.375 0.708211
## as.factor(Municipality)Visoko                                -2.541 0.011524 *
## as.factor(Municipality)Vitez                                 -1.261 0.208327
## as.factor(Municipality)Vlasenica                              0.563 0.573642
## as.factor(Municipality)Vogosca                               -3.759 0.000202 ***
## as.factor(Municipality)Zavidovici                            -2.906 0.003915 **
## as.factor(Municipality)Zenica                                -3.376 0.000827 ***
## as.factor(Municipality)Zepce                                 -0.384 0.701406
## as.factor(Municipality)Zivince                               -3.631 0.000328 ***
## as.factor(Municipality)Zvornik                                   NA       NA
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 9.576 on 321 degrees of freedom
## Multiple R-squared:  0.7005, Adjusted R-squared:  0.6016
## F-statistic: 7.084 on 106 and 321 DF,  p-value: < 2.2e-16
```

```
#add temporal effects
Log_Casualty.Model3 <- lm(Ethnic_Vote_Share ~ Log_Casualty + as.factor(Municipality) + as.factor(Year),
                          data = data2)
summary(Log_Casualty.Model3) #still nothing
```

```
##
## Call:
## lm(formula = Ethnic_Vote_Share ~ Log_Casualty + as.factor(Municipality) +
##     as.factor(Year), data = data2)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -46.879  -4.009   0.625   4.205  52.609
##
## Coefficients: (1 not defined because of singularities)
##                                                    Estimate Std. Error
## (Intercept)                                        86.13840    4.52502
## Log_Casualty                                        1.80880    3.88413
## as.factor(Municipality)Banovici                   -18.38521    6.26530
## as.factor(Municipality)Bihac                      -30.23323    5.73302
## as.factor(Municipality)Bijeljina                    0.91318    6.33887
## as.factor(Municipality)Bileca                       5.66981    6.99606
## as.factor(Municipality)Bosanska Dubica (Kozarska Dubica)   1.88312    6.20787
## as.factor(Municipality)Bosanska Gradiska (Gradiska)        4.66507    6.45006
## as.factor(Municipality)Bosanska Krupa             -12.19123    5.73495
## as.factor(Municipality)Bosanski Brod               -5.79667    5.77456
## as.factor(Municipality)Bosanski Novi (Novi Grad)    3.67511    5.85245
## as.factor(Municipality)Bosanski Petrovac          -18.12054    5.74803
## as.factor(Municipality)Bosansko Grahovo (Grahovo) -17.67652    5.73236
```

```
## as.factor(Municipality)Bratunac                          1.88079    8.36054
## as.factor(Municipality)Brcko                           -14.54025    5.75420
## as.factor(Municipality)Breza                           -22.35659    5.86893
## as.factor(Municipality)Bugojno                         -19.56926    5.80776
## as.factor(Municipality)Busovaca                         -8.33076    5.74557
## as.factor(Municipality)Cajnice                           6.81146    5.91091
## as.factor(Municipality)Capljina                          1.84665    6.80392
## as.factor(Municipality)Cazin                           -13.63238    5.92446
## as.factor(Municipality)Celinac                           4.70628    6.08250
## as.factor(Municipality)Centar Sarajevo                 -38.50807    5.74129
## as.factor(Municipality)Citluk                           12.60337   10.38421
## as.factor(Municipality)Derventa                         -0.02266    5.82426
## as.factor(Municipality)Doboj                            -7.26418    5.73471
## as.factor(Municipality)Donji Vakuf                     -18.36382    6.20554
## as.factor(Municipality)Drvar                           -13.52460    6.90605
## as.factor(Municipality)Foca (Srbinje)                    0.84201    7.26084
## as.factor(Municipality)Fojnica                         -11.62344    5.75973
## as.factor(Municipality)Gacko                             3.99828    5.98699
## as.factor(Municipality)Glamoc                           -7.31188    6.02800
## as.factor(Municipality)Gorazde                         -18.93680    6.32225
## as.factor(Municipality)Gornji Vakuf - Uskopolje         -4.21910    5.76238
## as.factor(Municipality)Gradacac                        -20.43093    5.84931
## as.factor(Municipality)Grude                             4.80119   10.94339
## as.factor(Municipality)Hadzici                         -22.07409    6.03292
## as.factor(Municipality)Han Pijesak                       5.67462    5.74656
## as.factor(Municipality)Ilidza                          -16.94301    5.75054
## as.factor(Municipality)Ilijas                          -20.76151    5.73300
## as.factor(Municipality)Jablanica                       -24.69193    5.73219
## as.factor(Municipality)Jajce                           -10.42958    5.85708
## as.factor(Municipality)Kakanj                          -14.63352    6.43588
## as.factor(Municipality)Kalesija                        -20.03774    5.84585
## as.factor(Municipality)Kalinovik                         2.00610    6.94348
## as.factor(Municipality)Kiseljak                         -4.05129    5.77710
## as.factor(Municipality)Kladanj                         -22.65948    5.95834
## as.factor(Municipality)Kljuc                           -11.49551    5.98953
## as.factor(Municipality)Konjic                          -15.30172    5.73509
## as.factor(Municipality)Kotor Varos                       5.10987    5.81102
## as.factor(Municipality)Kresevo                          -7.43886    5.81994
## as.factor(Municipality)Kupres (FBiH)                     3.01030    5.86934
## as.factor(Municipality)Laktasi                           4.87878    6.91190
## as.factor(Municipality)Livno                            -1.33171   10.39151
## as.factor(Municipality)Ljubinje                          9.77993    7.30836
## as.factor(Municipality)Ljubuski                          6.35017   11.28703
## as.factor(Municipality)Lopare                           -5.93991    5.81920
## as.factor(Municipality)Maglaj                          -19.15586    5.74050
## as.factor(Municipality)Modrica                          -3.15609    5.78436
## as.factor(Municipality)Mostar                          -12.55278    5.73982
## as.factor(Municipality)Mrkonjic Grad                     3.34105    5.78313
## as.factor(Municipality)Neum                              9.95773   12.10070
## as.factor(Municipality)Nevesinje                         0.76051    6.39371
## as.factor(Municipality)Novi Grad Sarajevo              -30.10479    5.74142
## as.factor(Municipality)Novi Travnik                    -12.84643    5.86697
## as.factor(Municipality)Novo Sarajevo                   -32.95022    5.74056
## as.factor(Municipality)Odzak                            -8.64433    6.66531
```

```
## as.factor(Municipality)Olovo                                -16.17042    5.81791
## as.factor(Municipality)Orasje                                 2.67803    6.12088
## as.factor(Municipality)Pale (RS)                              4.26364    5.84765
## as.factor(Municipality)Posusje                               10.93523   12.69536
## as.factor(Municipality)Prijedor                              -3.50837    6.47624
## as.factor(Municipality)Prnjavor                               2.11269    6.25391
## as.factor(Municipality)Prozor (Prozor-Rama)                   4.97342    5.74122
## as.factor(Municipality)Rogatica                              -0.54407    8.07289
## as.factor(Municipality)Rudo                                   5.11882    5.74285
## as.factor(Municipality)Samac (Bosanski Samac)                 0.85634    5.75725
## as.factor(Municipality)Sanski Most                          -14.02514    5.73429
## as.factor(Municipality)Sekovici                              -0.64380    5.74514
## as.factor(Municipality)Sipovo                                 6.31584    6.13024
## as.factor(Municipality)Siroki Brijeg                          3.11603   11.35182
## as.factor(Municipality)Skender Vakuf (Knezevo)                5.02701    6.80348
## as.factor(Municipality)Sokolac                                4.73670    5.80293
## as.factor(Municipality)Srbac                                  4.48245    7.60633
## as.factor(Municipality)Srebrenica                             0.33361   10.51380
## as.factor(Municipality)Srebrenik                            -32.35237    6.78709
## as.factor(Municipality)Stari Grad Sarajevo                  -26.76183    5.74015
## as.factor(Municipality)Stolac                                 3.36583    6.50007
## as.factor(Municipality)Tesanj                               -18.85756    5.87326
## as.factor(Municipality)Teslic                                -1.60026    6.20319
## as.factor(Municipality)Tomislavgrad                           8.65787    9.82282
## as.factor(Municipality)Travnik                              -10.76784    5.76202
## as.factor(Municipality)Trebinje                               3.30728    6.26326
## as.factor(Municipality)Trnovo (FBiH)                         -9.78708    6.61650
## as.factor(Municipality)Tuzla                                -46.53079    6.41909
## as.factor(Municipality)Ugljevik                               0.81542    5.73289
## as.factor(Municipality)Vares                                -23.91164    5.84444
## as.factor(Municipality)Velika Kladusa                       -47.48446    5.73536
## as.factor(Municipality)Visegrad                               2.91782    7.61379
## as.factor(Municipality)Visoko                               -15.45174    5.94396
## as.factor(Municipality)Vitez                                 -7.82968    6.07057
## as.factor(Municipality)Vlasenica                              4.45992    7.73944
## as.factor(Municipality)Vogosca                              -22.47008    5.84251
## as.factor(Municipality)Zavidovici                           -17.43838    5.86548
## as.factor(Municipality)Zenica                               -22.28474    6.45311
## as.factor(Municipality)Zepce                                 -2.32357    5.91822
## as.factor(Municipality)Zivince                              -25.69799    6.91717
## as.factor(Municipality)Zvornik                                     NA         NA
## as.factor(Year)2006                                           3.46014    1.27975
## as.factor(Year)2010                                          -0.51993    1.27975
## as.factor(Year)2014                                           3.65210    1.27975
##                                                            t value Pr(>|t|)
## (Intercept)                                                 19.036  < 2e-16 ***
## Log_Casualty                                                 0.466 0.641757
## as.factor(Municipality)Banovici                             -2.934 0.003585 **
## as.factor(Municipality)Bihac                                -5.274 2.48e-07 ***
## as.factor(Municipality)Bijeljina                             0.144 0.885544
## as.factor(Municipality)Bileca                                0.810 0.418300
## as.factor(Municipality)Bosanska Dubica (Kozarska Dubica)     0.303 0.761826
## as.factor(Municipality)Bosanska Gradiska (Gradiska)          0.723 0.470052
## as.factor(Municipality)Bosanska Krupa                       -2.126 0.034292 *
```

```
## as.factor(Municipality)Bosanski Brod                    -1.004 0.316224
## as.factor(Municipality)Bosanski Novi (Novi Grad)         0.628 0.530481
## as.factor(Municipality)Bosanski Petrovac                -3.152 0.001773 **
## as.factor(Municipality)Bosansko Grahovo (Grahovo)       -3.084 0.002224 **
## as.factor(Municipality)Bratunac                          0.225 0.822154
## as.factor(Municipality)Brcko                            -2.527 0.011992 *
## as.factor(Municipality)Breza                            -3.809 0.000167 ***
## as.factor(Municipality)Bugojno                          -3.370 0.000846 ***
## as.factor(Municipality)Busovaca                         -1.450 0.148059
## as.factor(Municipality)Cajnice                           1.152 0.250041
## as.factor(Municipality)Capljina                          0.271 0.786252
## as.factor(Municipality)Cazin                            -2.301 0.022036 *
## as.factor(Municipality)Celinac                           0.774 0.439659
## as.factor(Municipality)Centar Sarajevo                  -6.707 9.08e-11 ***
## as.factor(Municipality)Citluk                            1.214 0.225761
## as.factor(Municipality)Derventa                         -0.004 0.996898
## as.factor(Municipality)Doboj                            -1.267 0.206188
## as.factor(Municipality)Donji Vakuf                      -2.959 0.003315 **
## as.factor(Municipality)Drvar                            -1.958 0.051061 .
## as.factor(Municipality)Foca (Srbinje)                    0.116 0.907753
## as.factor(Municipality)Fojnica                          -2.018 0.044425 *
## as.factor(Municipality)Gacko                             0.668 0.504728
## as.factor(Municipality)Glamoc                           -1.213 0.226035
## as.factor(Municipality)Gorazde                          -2.995 0.002957 **
## as.factor(Municipality)Gornji Vakuf - Uskopolje         -0.732 0.464598
## as.factor(Municipality)Gradacac                         -3.493 0.000546 ***
## as.factor(Municipality)Grude                             0.439 0.661155
## as.factor(Municipality)Hadzici                          -3.659 0.000296 ***
## as.factor(Municipality)Han Pijesak                       0.987 0.324158
## as.factor(Municipality)Ilidza                           -2.946 0.003453 **
## as.factor(Municipality)Ilijas                           -3.621 0.000341 ***
## as.factor(Municipality)Jablanica                        -4.308 2.20e-05 ***
## as.factor(Municipality)Jajce                            -1.781 0.075920 .
## as.factor(Municipality)Kakanj                           -2.274 0.023648 *
## as.factor(Municipality)Kalesija                         -3.428 0.000689 ***
## as.factor(Municipality)Kalinovik                         0.289 0.772832
## as.factor(Municipality)Kiseljak                         -0.701 0.483649
## as.factor(Municipality)Kladanj                          -3.803 0.000171 ***
## as.factor(Municipality)Kljuc                            -1.919 0.055845 .
## as.factor(Municipality)Konjic                           -2.668 0.008019 **
## as.factor(Municipality)Kotor Varos                       0.879 0.379880
## as.factor(Municipality)Kresevo                          -1.278 0.202123
## as.factor(Municipality)Kupres (FBiH)                     0.513 0.608387
## as.factor(Municipality)Laktasi                           0.706 0.480797
## as.factor(Municipality)Livno                            -0.128 0.898109
## as.factor(Municipality)Ljubinje                          1.338 0.181792
## as.factor(Municipality)Ljubuski                          0.563 0.574099
## as.factor(Municipality)Lopare                           -1.021 0.308152
## as.factor(Municipality)Maglaj                           -3.337 0.000947 ***
## as.factor(Municipality)Modrica                          -0.546 0.585707
## as.factor(Municipality)Mostar                           -2.187 0.029473 *
## as.factor(Municipality)Mrkonjic Grad                     0.578 0.563860
## as.factor(Municipality)Neum                              0.823 0.411178
## as.factor(Municipality)Nevesinje                         0.119 0.905393
```

```
## as.factor(Municipality)Novi Grad Sarajevo                -5.243 2.88e-07 ***
## as.factor(Municipality)Novi Travnik                      -2.190 0.029278 *
## as.factor(Municipality)Novo Sarajevo                     -5.740 2.21e-08 ***
## as.factor(Municipality)Odzak                             -1.297 0.195601
## as.factor(Municipality)Olovo                             -2.779 0.005770 **
## as.factor(Municipality)Orasje                             0.438 0.662028
## as.factor(Municipality)Pale (RS)                          0.729 0.466464
## as.factor(Municipality)Posusje                            0.861 0.389691
## as.factor(Municipality)Prijedor                          -0.542 0.588384
## as.factor(Municipality)Prnjavor                           0.338 0.735723
## as.factor(Municipality)Prozor (Prozor-Rama)               0.866 0.386997
## as.factor(Municipality)Rogatica                          -0.067 0.946310
## as.factor(Municipality)Rudo                               0.891 0.373422
## as.factor(Municipality)Samac (Bosanski Samac)             0.149 0.881852
## as.factor(Municipality)Sanski Most                       -2.446 0.014993 *
## as.factor(Municipality)Sekovici                          -0.112 0.910847
## as.factor(Municipality)Sipovo                             1.030 0.303663
## as.factor(Municipality)Siroki Brijeg                      0.274 0.783882
## as.factor(Municipality)Skender Vakuf (Knezevo)            0.739 0.460520
## as.factor(Municipality)Sokolac                            0.816 0.414962
## as.factor(Municipality)Srbac                              0.589 0.556075
## as.factor(Municipality)Srebrenica                         0.032 0.974707
## as.factor(Municipality)Srebrenik                         -4.767 2.85e-06 ***
## as.factor(Municipality)Stari Grad Sarajevo               -4.662 4.61e-06 ***
## as.factor(Municipality)Stolac                             0.518 0.604948
## as.factor(Municipality)Tesanj                            -3.211 0.001459 **
## as.factor(Municipality)Teslic                            -0.258 0.796594
## as.factor(Municipality)Tomislavgrad                       0.881 0.378765
## as.factor(Municipality)Travnik                           -1.869 0.062575 .
## as.factor(Municipality)Trebinje                           0.528 0.597837
## as.factor(Municipality)Trnovo (FBiH)                     -1.479 0.140078
## as.factor(Municipality)Tuzla                             -7.249 3.21e-12 ***
## as.factor(Municipality)Ugljevik                           0.142 0.886984
## as.factor(Municipality)Vares                             -4.091 5.44e-05 ***
## as.factor(Municipality)Velika Kladusa                    -8.279 3.47e-15 ***
## as.factor(Municipality)Visegrad                           0.383 0.701806
## as.factor(Municipality)Visoko                            -2.600 0.009769 **
## as.factor(Municipality)Vitez                             -1.290 0.198065
## as.factor(Municipality)Vlasenica                          0.576 0.564848
## as.factor(Municipality)Vogosca                           -3.846 0.000145 ***
## as.factor(Municipality)Zavidovici                        -2.973 0.003174 **
## as.factor(Municipality)Zenica                            -3.453 0.000629 ***
## as.factor(Municipality)Zepce                             -0.393 0.694868
## as.factor(Municipality)Zivince                           -3.715 0.000240 ***
## as.factor(Municipality)Zvornik                               NA       NA
## as.factor(Year)2006                                       2.704 0.007225 **
## as.factor(Year)2010                                      -0.406 0.684814
## as.factor(Year)2014                                       2.854 0.004604 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 9.361 on 318 degrees of freedom
## Multiple R-squared:  0.7166, Adjusted R-squared:  0.6194
## F-statistic: 7.375 on 109 and 318 DF,  p-value: < 2.2e-16
```

```
cbind(coef(Log_Casualty.Model)[2],
      coef(Log_Casualty.Model2)[2],
      coef(Log_Casualty.Model3)[2])
```

```
##                    [,1]     [,2]     [,3]
## Log_Casualty -0.611099 1.808797 1.808797
```

```
#the coefficient gets larger, even though there are very few degrees of freedom - why?
#we are no longer strictly controlling for heterogeneity, but exploring/exploiting province-year-level
```

Difference-in-Difference Estimator

- DiD estimators have traditionally been used to analyze the effect of a treatment at different times
- There is absolutely no reason not to use them for continuous treatments though
- Basically, we interact temporal fixed effects (but not the first, or baseline year) with the variable of interest (and include the constituent terms of time), and include unit fixed effects
- This is an ideal model for the above Bosnian data
- However, we need to assume parallel trends, i.e. the units (municipalities) have parallel trends in the outcome if it were not for treatment

```
dummy.matrix <- as.matrix(cbind(as.numeric(data2$Year == 2006), as.numeric(data2$Year==2010), as.numeri
Log_Casualty.Model.did <- lm(Ethnic_Vote_Share ~ Log_Casualty:dummy.matrix+dummy.matrix+
                  Municipality-1, data2) #why is there a minus 1?
summary(Log_Casualty.Model.did) #we see an effect, but decreasing in magnitude and reliability (keep th
```

```
##
## Call:
## lm(formula = Ethnic_Vote_Share ~ Log_Casualty:dummy.matrix +
##     dummy.matrix + Municipality - 1, data = data2)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -46.380  -4.067   0.755   4.056  52.935
##
## Coefficients:
##                                                Estimate Std. Error t value
## dummy.matrix1                                    1.9319     1.4614   1.322
## dummy.matrix2                                   -1.5266     1.4614  -1.045
## dummy.matrix3                                    3.4499     1.4614   2.361
## MunicipalityBanja Luka                          86.7888     4.7517  18.265
## MunicipalityBanovici                            68.4850     4.7356  14.462
## MunicipalityBihac                               56.9111     4.7319  12.027
## MunicipalityBijeljina                           87.7649     4.7386  18.521
## MunicipalityBileca                              92.3855     4.7720  19.360
## MunicipalityBosanska Dubica (Kozarska Dubica)   88.7685     4.7333  18.754
## MunicipalityBosanska Gradiska (Gradiska)        91.4906     4.7436  19.287
## MunicipalityBosanska Krupa                      74.9614     4.7330  15.838
## MunicipalityBosanski Brod                       81.2644     4.7247  17.200
## MunicipalityBosanski Novi (Novi Grad)           90.6859     4.7239  19.197
## MunicipalityBosanski Petrovac                   69.0579     4.7369  14.579
## MunicipalityBosansko Grahovo (Grahovo)          69.4523     4.7300  14.683
## MunicipalityBratunac                            89.6493     5.0078  17.902
## MunicipalityBrcko                               72.5412     4.7258  15.350
## MunicipalityBreza                               64.6460     4.7240  13.685
## MunicipalityBugojno                             67.4672     4.7240  14.282
```

```
## MunicipalityBusovaca                          78.7622    4.7266  16.664
## MunicipalityCajnice                           94.0958    4.7602  19.767
## MunicipalityCapljina                          88.5984    4.7613  18.608
## MunicipalityCazin                             73.3454    4.7248  15.524
## MunicipalityCelinac                           91.6281    4.7289  19.376
## MunicipalityCentar Sarajevo                   48.5921    4.7272  10.279
## MunicipalityCitluk                            98.8344    5.0385  19.616
## MunicipalityDerventa                          87.0037    4.7239  18.418
## MunicipalityDoboj                             79.8876    4.7329  16.879
## MunicipalityDonji Vakuf                       68.5222    4.7332  14.477
## MunicipalityDrvar                             73.2077    4.7669  15.358
## MunicipalityFoca (Srbinje)                    88.4406    4.8955  18.066
## MunicipalityFojnica                           75.4518    4.7254  15.967
## MunicipalityGacko                             91.3124    4.7688  19.148
## MunicipalityGlamoc                            79.6275    4.7272  16.844
## MunicipalityGorazde                           68.4752    4.8034  14.256
## MunicipalityGornji Vakuf - Uskopolje          82.9763    4.7398  17.506
## MunicipalityGradacac                          66.5815    4.7239  14.095
## MunicipalityGrude                             90.9631    5.0940  17.857
## MunicipalityHadzici                           65.2560    4.7737  13.670
## MunicipalityHan Pijesak                       92.8509    4.7366  19.603
## MunicipalityIlidza                            70.2388    4.7375  14.826
## MunicipalityIlijas                            66.3826    4.7319  14.029
## MunicipalityJablanica                         62.4439    4.7308  13.199
## MunicipalityJajce                             76.5789    4.7239  16.211
## MunicipalityKakanj                            72.1953    4.7429  15.222
## MunicipalityKalesija                          66.9765    4.7238  14.178
## MunicipalityKalinovik                         89.5486    4.8643  18.410
## MunicipalityKiseljak                          83.0076    4.7246  17.569
## MunicipalityKladanj                           64.3049    4.7255  13.608
## MunicipalityKljuc                             75.8195    4.7690  15.898
## MunicipalityKonjic                            71.8513    4.7331  15.181
## MunicipalityKotor Varos                       92.3433    4.7475  19.451
## MunicipalityKresevo                           79.5900    4.7239  16.848
## MunicipalityKupres (FBiH)                     90.2758    4.7552  18.985
## MunicipalityLaktasi                           91.6100    4.7672  19.217
## MunicipalityLivno                             84.8984    5.0392  16.848
## MunicipalityLjubinje                          96.4411    4.7906  20.131
## MunicipalityLjubuski                          92.4702    5.1294  18.027
## MunicipalityLopare                            81.0894    4.7239  17.166
## MunicipalityMaglaj                            67.9458    4.7273  14.373
## MunicipalityModrica                           83.8970    4.7244  17.758
## MunicipalityMostar                            74.5502    4.7274  15.770
## MunicipalityMrkonjic Grad                     90.3951    4.7244  19.134
## MunicipalityNeum                              95.9805    5.2175  18.396
## MunicipalityNevesinje                         88.1897    4.8105  18.333
## MunicipalityNovi Grad Sarajevo                57.0631    4.7352  12.051
## MunicipalityNovi Travnik                      74.1571    4.7240  15.698
## MunicipalityNovo Sarajevo                     54.1513    4.7273  11.455
## MunicipalityOdzak                             78.1349    4.7540  16.436
## MunicipalityOlovo                             70.8597    4.7239  15.000
## MunicipalityOrasje                            89.5881    4.7301  18.940
## MunicipalityPale (RS)                         91.5181    4.7524  19.257
## MunicipalityPosusje                           96.8880    5.2854  18.331
```

```
## MunicipalityPrijedor                              83.9398     4.8186  17.420
## MunicipalityPrnjavor                              88.9858     4.7351  18.793
## MunicipalityProzor (Prozor-Rama)                  92.1410     4.7352  19.459
## MunicipalityRogatica                              87.1826     4.9777  17.515
## MunicipalityRudo                                  92.2162     4.7269  19.509
## MunicipalitySamac (Bosanski Samac)                87.9343     4.7256  18.608
## MunicipalitySanski Most                           73.1251     4.7327  15.451
## MunicipalitySekovici                              86.4499     4.7267  18.290
## MunicipalitySipovo                                93.2232     4.7305  19.707
## MunicipalitySiroki Brijeg                         89.2283     5.1363  17.372
## MunicipalitySkender Vakuf (Knezevo)               91.7788     4.7613  19.276
## MunicipalitySokolac                               91.9648     4.7464  19.376
## MunicipalitySrbac                                 91.0950     4.8098  18.940
## MunicipalitySrebrenica                            88.3865     5.2514  16.831
## MunicipalitySrebrenik                             54.4026     4.7604  11.428
## MunicipalityStari Grad Sarajevo                   60.4037     4.7349  12.757
## MunicipalityStolac                                90.1802     4.7459  19.002
## MunicipalityTesanj                                68.1429     4.7240  14.425
## MunicipalityTeslic                                85.2864     4.7331  18.019
## MunicipalityTomislavgrad                          94.9600     4.9857  19.046
## MunicipalityTravnik                               76.3050     4.7253  16.148
## MunicipalityTrebinje                              90.1780     4.7355  19.043
## MunicipalityTrnovo (FBiH)                         77.6914     4.8323  16.077
## MunicipalityTuzla                                 40.3019     4.7421   8.499
## MunicipalityUgljevik                              87.9589     4.7318  18.589
## MunicipalityVares                                 63.1034     4.7238  13.358
## MunicipalityVelika Kladusa                        39.6295     4.7284   8.381
## MunicipalityVisegrad                              90.5742     4.9308  18.369
## MunicipalityVisoko                                71.5182     4.7251  15.136
## MunicipalityVitez                                 79.5126     4.7777  16.642
## MunicipalityVlasenica                             92.1360     4.9435  18.638
## MunicipalityVogosca                               64.7817     4.7518  13.633
## MunicipalityZavidovici                            69.5659     4.7240  14.726
## MunicipalityZenica                                64.5401     4.7437  13.605
## MunicipalityZepce                                 84.6568     4.7247  17.918
## MunicipalityZivince                               61.0322     4.7675  12.802
## MunicipalityZvornik                               87.4790     4.8326  18.102
## Log_Casualty:dummy.matrix1                         3.1353     1.4690   2.134
## Log_Casualty:dummy.matrix2                         2.0652     1.4690   1.406
## Log_Casualty:dummy.matrix3                         0.4148     1.4690   0.282
##                                                 Pr(>|t|)
## dummy.matrix1                                    0.1871
## dummy.matrix2                                    0.2970
## dummy.matrix3                                    0.0188 *
## MunicipalityBanja Luka                          < 2e-16 ***
## MunicipalityBanovici                            < 2e-16 ***
## MunicipalityBihac                               < 2e-16 ***
## MunicipalityBijeljina                           < 2e-16 ***
## MunicipalityBileca                              < 2e-16 ***
## MunicipalityBosanska Dubica (Kozarska Dubica)   < 2e-16 ***
## MunicipalityBosanska Gradiska (Gradiska)        < 2e-16 ***
## MunicipalityBosanska Krupa                      < 2e-16 ***
## MunicipalityBosanski Brod                       < 2e-16 ***
## MunicipalityBosanski Novi (Novi Grad)           < 2e-16 ***
```

```
## MunicipalityBosanski Petrovac                  < 2e-16 ***
## MunicipalityBosansko Grahovo (Grahovo)         < 2e-16 ***
## MunicipalityBratunac                           < 2e-16 ***
## MunicipalityBrcko                              < 2e-16 ***
## MunicipalityBreza                              < 2e-16 ***
## MunicipalityBugojno                            < 2e-16 ***
## MunicipalityBusovaca                           < 2e-16 ***
## MunicipalityCajnice                            < 2e-16 ***
## MunicipalityCapljina                           < 2e-16 ***
## MunicipalityCazin                              < 2e-16 ***
## MunicipalityCelinac                            < 2e-16 ***
## MunicipalityCentar Sarajevo                    < 2e-16 ***
## MunicipalityCitluk                             < 2e-16 ***
## MunicipalityDerventa                           < 2e-16 ***
## MunicipalityDoboj                              < 2e-16 ***
## MunicipalityDonji Vakuf                        < 2e-16 ***
## MunicipalityDrvar                              < 2e-16 ***
## MunicipalityFoca (Srbinje)                     < 2e-16 ***
## MunicipalityFojnica                            < 2e-16 ***
## MunicipalityGacko                              < 2e-16 ***
## MunicipalityGlamoc                             < 2e-16 ***
## MunicipalityGorazde                            < 2e-16 ***
## MunicipalityGornji Vakuf - Uskopolje           < 2e-16 ***
## MunicipalityGradacac                           < 2e-16 ***
## MunicipalityGrude                              < 2e-16 ***
## MunicipalityHadzici                            < 2e-16 ***
## MunicipalityHan Pijesak                        < 2e-16 ***
## MunicipalityIlidza                             < 2e-16 ***
## MunicipalityIlijas                             < 2e-16 ***
## MunicipalityJablanica                          < 2e-16 ***
## MunicipalityJajce                              < 2e-16 ***
## MunicipalityKakanj                             < 2e-16 ***
## MunicipalityKalesija                           < 2e-16 ***
## MunicipalityKalinovik                          < 2e-16 ***
## MunicipalityKiseljak                           < 2e-16 ***
## MunicipalityKladanj                            < 2e-16 ***
## MunicipalityKljuc                              < 2e-16 ***
## MunicipalityKonjic                             < 2e-16 ***
## MunicipalityKotor Varos                        < 2e-16 ***
## MunicipalityKresevo                            < 2e-16 ***
## MunicipalityKupres (FBiH)                      < 2e-16 ***
## MunicipalityLaktasi                            < 2e-16 ***
## MunicipalityLivno                              < 2e-16 ***
## MunicipalityLjubinje                           < 2e-16 ***
## MunicipalityLjubuski                           < 2e-16 ***
## MunicipalityLopare                             < 2e-16 ***
## MunicipalityMaglaj                             < 2e-16 ***
## MunicipalityModrica                            < 2e-16 ***
## MunicipalityMostar                             < 2e-16 ***
## MunicipalityMrkonjic Grad                      < 2e-16 ***
## MunicipalityNeum                               < 2e-16 ***
## MunicipalityNevesinje                          < 2e-16 ***
## MunicipalityNovi Grad Sarajevo                 < 2e-16 ***
## MunicipalityNovi Travnik                       < 2e-16 ***
```

```
## MunicipalityNovo Sarajevo                       < 2e-16 ***
## MunicipalityOdzak                               < 2e-16 ***
## MunicipalityOlovo                               < 2e-16 ***
## MunicipalityOrasje                              < 2e-16 ***
## MunicipalityPale (RS)                           < 2e-16 ***
## MunicipalityPosusje                             < 2e-16 ***
## MunicipalityPrijedor                            < 2e-16 ***
## MunicipalityPrnjavor                            < 2e-16 ***
## MunicipalityProzor (Prozor-Rama)                < 2e-16 ***
## MunicipalityRogatica                            < 2e-16 ***
## MunicipalityRudo                                < 2e-16 ***
## MunicipalitySamac (Bosanski Samac)              < 2e-16 ***
## MunicipalitySanski Most                         < 2e-16 ***
## MunicipalitySekovici                            < 2e-16 ***
## MunicipalitySipovo                              < 2e-16 ***
## MunicipalitySiroki Brijeg                       < 2e-16 ***
## MunicipalitySkender Vakuf (Knezevo)             < 2e-16 ***
## MunicipalitySokolac                             < 2e-16 ***
## MunicipalitySrbac                               < 2e-16 ***
## MunicipalitySrebrenica                          < 2e-16 ***
## MunicipalitySrebrenik                           < 2e-16 ***
## MunicipalityStari Grad Sarajevo                 < 2e-16 ***
## MunicipalityStolac                              < 2e-16 ***
## MunicipalityTesanj                              < 2e-16 ***
## MunicipalityTeslic                              < 2e-16 ***
## MunicipalityTomislavgrad                        < 2e-16 ***
## MunicipalityTravnik                             < 2e-16 ***
## MunicipalityTrebinje                            < 2e-16 ***
## MunicipalityTrnovo (FBiH)                       < 2e-16 ***
## MunicipalityTuzla                              7.77e-16 ***
## MunicipalityUgljevik                            < 2e-16 ***
## MunicipalityVares                               < 2e-16 ***
## MunicipalityVelika Kladusa                     1.77e-15 ***
## MunicipalityVisegrad                            < 2e-16 ***
## MunicipalityVisoko                              < 2e-16 ***
## MunicipalityVitez                               < 2e-16 ***
## MunicipalityVlasenica                           < 2e-16 ***
## MunicipalityVogosca                             < 2e-16 ***
## MunicipalityZavidovici                          < 2e-16 ***
## MunicipalityZenica                              < 2e-16 ***
## MunicipalityZepce                               < 2e-16 ***
## MunicipalityZivince                             < 2e-16 ***
## MunicipalityZvornik                             < 2e-16 ***
## Log_Casualty:dummy.matrix1                       0.0336 *
## Log_Casualty:dummy.matrix2                       0.1608
## Log_Casualty:dummy.matrix3                       0.7779
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 9.318 on 315 degrees of freedom
## Multiple R-squared:  0.9906, Adjusted R-squared:  0.9872
## F-statistic: 293.4 on 113 and 315 DF,  p-value: < 2.2e-16
```

```
summary(Log_Casualty.Model.did)$r.squared # R-squared: 0.9905888
```

```
## [1] 0.9905888
```

```
#what's wrong with this R-squared?
```

Lagged Dependent Variable (LDV) Models

Correcting Standard Errors

- There are two main adjustments; robust clustered standard errors (RCSE) and panel corrected standard errors (PCSE)
- The latter takes time into effect as a measure of distance, the former is agnostic about the effects but still corrects for each 'cluster'
- RCSE are extremely popular, and you will be asked for revisions that include them
- Generally speaking, though, they suffer the same problems as robust standard errors
- Furthermore, it is WIDELY assumed that they will increase SEs, but this is very often not true in practice
- Let's look at the previous DiD model for RCSE, and the earlier model for PCSE (does not assume balance, but properties in unbalanced settings are questionable)

```
library(sandwich)
library(multiwayvcov)
library(lmtest)
```

```
## Loading required package: zoo
```

```
##
## Attaching package: 'zoo'
```

```
## The following objects are masked from 'package:base':
##
##     as.Date, as.Date.numeric
```

```
vcovCL1 <- cluster.vcov(Log_Casualty.Model.did, ~as.factor(data2$Municipality) + as.factor(data2$Year))
coeftest(Log_Casualty.Model.did, vcovCL1) #notice the standard errors actually decreased
```

```
##
## t test of coefficients:
##
##                                                Estimate Std. Error t value
## dummy.matrix1                                   1.93186    1.41332  1.3669
## dummy.matrix2                                  -1.52659    1.35127 -1.1297
## dummy.matrix3                                   3.44992    1.04712  3.2947
## MunicipalityBanja Luka                         86.78883    4.93940 17.5707
## MunicipalityBanovici                           68.48499    3.96755 17.2613
## MunicipalityBihac                              56.91108    5.03957 11.2929
## MunicipalityBijeljina                          87.76491    3.32888 26.3647
## MunicipalityBileca                             92.38550    2.72309 33.9267
## MunicipalityBosanska Dubica (Kozarska Dubica) 88.76852    3.49133 25.4254
## MunicipalityBosanska Gradiska (Gradiska)       91.49062    1.94866 46.9504
## MunicipalityBosanska Krupa                     74.96136    4.05713 18.4764
## MunicipalityBosanski Brod                      81.26440    4.41998 18.3857
## MunicipalityBosanski Novi (Novi Grad)          90.68592    1.68411 53.8479
## MunicipalityBosanski Petrovac                  69.05789    6.20115 11.1363
## MunicipalityBosansko Grahovo (Grahovo)         69.45233   12.39451  5.6035
## MunicipalityBratunac                           89.64930    1.69955 52.7488
```

```
## MunicipalityBrcko                          72.54118    2.17763 33.3120
## MunicipalityBreza                          64.64597    1.98467 32.5727
## MunicipalityBugojno                        67.46725    4.53366 14.8814
## MunicipalityBusovaca                       78.76224    1.37960 57.0908
## MunicipalityCajnice                        94.09579    1.57632 59.6933
## MunicipalityCapljina                       88.59836    1.43960 61.5437
## MunicipalityCazin                          73.34541    5.53988 13.2395
## MunicipalityCelinac                        91.62805    2.14258 42.7653
## MunicipalityCentar Sarajevo                48.59208    2.07983 23.3635
## MunicipalityCitluk                         98.83444    2.01386 49.0770
## MunicipalityDerventa                       87.00367    4.05818 21.4391
## MunicipalityDoboj                          79.88757    2.61926 30.5000
## MunicipalityDonji Vakuf                    68.52222    4.13249 16.5814
## MunicipalityDrvar                          73.20769   12.28161  5.9608
## MunicipalityFoca (Srbinje)                 88.44062    1.85853 47.5862
## MunicipalityFojnica                        75.45176    3.26960 23.0767
## MunicipalityGacko                          91.31237    1.47697 61.8242
## MunicipalityGlamoc                         79.62754    5.31667 14.9770
## MunicipalityGorazde                        68.47520    4.50827 15.1888
## MunicipalityGornji Vakuf - Uskopolje       82.97627    3.09864 26.7783
## MunicipalityGradacac                       66.58152    3.09173 21.5353
## MunicipalityGrude                          90.96309    2.46862 36.8477
## MunicipalityHadzici                        65.25595    2.93086 22.2651
## MunicipalityHan Pijesak                    92.85093    2.30068 40.3580
## MunicipalityIlidza                         70.23880    2.56002 27.4369
## MunicipalityIlijas                         66.38264    2.68898 24.6869
## MunicipalityJablanica                      62.44393    1.21812 51.2624
## MunicipalityJajce                          76.57887    1.74651 43.8467
## MunicipalityKakanj                         72.19527    1.53014 47.1821
## MunicipalityKalesija                       66.97654    5.28747 12.6670
## MunicipalityKalinovik                      89.54859    2.45627 36.4572
## MunicipalityKiseljak                       83.00762    2.25691 36.7794
## MunicipalityKladanj                        64.30487    3.90524 16.4663
## MunicipalityKljuc                          75.81950    3.24105 23.3935
## MunicipalityKonjic                         71.85133    3.55819 20.1932
## MunicipalityKotor Varos                    92.34326    1.88512 48.9854
## MunicipalityKresevo                        79.59005    2.45819 32.3775
## MunicipalityKupres (FBiH)                  90.27575    2.38722 37.8163
## MunicipalityLaktasi                        91.60998    3.27798 27.9471
## MunicipalityLivno                          84.89844    2.20113 38.5704
## MunicipalityLjubinje                       96.44111    1.90200 50.7051
## MunicipalityLjubuski                       92.47025    2.75926 33.5127
## MunicipalityLopare                         81.08944    1.99290 40.6892
## MunicipalityMaglaj                         67.94578    3.66480 18.5401
## MunicipalityModrica                        83.89697    4.48543 18.7043
## MunicipalityMostar                         74.55021    2.75664 27.0439
## MunicipalityMrkonjic Grad                  90.39507    1.02509 88.1822
## MunicipalityNeum                           95.98045    1.84201 52.1065
## MunicipalityNevesinje                      88.18974    1.53776 57.3496
## MunicipalityNovi Grad Sarajevo             57.06311    2.60226 21.9283
## MunicipalityNovi Travnik                   74.15709    2.46519 30.0817
## MunicipalityNovo Sarajevo                  54.15131    1.81948 29.7620
## MunicipalityOdzak                          78.13492    1.28140 60.9761
## MunicipalityOlovo                          70.85972    2.25953 31.3603
```

```
## MunicipalityOrasje                                89.58812    1.50182 59.6529
## MunicipalityPale (RS)                             91.51813    2.47658 36.9534
## MunicipalityPosusje                               96.88801    2.72504 35.5547
## MunicipalityPrijedor                              83.93980    3.82551 21.9421
## MunicipalityPrnjavor                              88.98584    4.55394 19.5404
## MunicipalityProzor (Prozor-Rama)                  92.14095    0.96909 95.0802
## MunicipalityRogatica                              87.18256    2.77778 31.3857
## MunicipalityRudo                                  92.21619    2.14201 43.0512
## MunicipalitySamac (Bosanski Samac)                87.93426    2.63060 33.4274
## MunicipalitySanski Most                           73.12510    1.96819 37.1535
## MunicipalitySekovici                              86.44986    5.39970 16.0101
## MunicipalitySipovo                                93.22317    2.81133 33.1598
## MunicipalitySiroki Brijeg                         89.22828    3.14343 28.3856
## MunicipalitySkender Vakuf (Knezevo)               91.77880    2.49188 36.8311
## MunicipalitySokolac                               91.96482    2.49133 36.9140
## MunicipalitySrbac                                 91.09502    4.29096 21.2295
## MunicipalitySrebrenica                            88.38652    2.24707 39.3342
## MunicipalitySrebrenik                             54.40261    1.96315 27.7119
## MunicipalityStari Grad Sarajevo                   60.40365    3.27551 18.4410
## MunicipalityStolac                                90.18016    1.76810 51.0040
## MunicipalityTesanj                                68.14292    2.53975 26.8306
## MunicipalityTeslic                                85.28642    3.29099 25.9151
## MunicipalityTomislavgrad                          94.96004    1.89123 50.2108
## MunicipalityTravnik                               76.30498    1.49541 51.0261
## MunicipalityTrebinje                              90.17801    2.91126 30.9756
## MunicipalityTrnovo (FBiH)                         77.69139    5.93635 13.0874
## MunicipalityTuzla                                 40.30187    2.68076 15.0338
## MunicipalityUgljevik                              87.95893    1.33703 65.7870
## MunicipalityVares                                 63.10339    3.62345 17.4153
## MunicipalityVelika Kladusa                        39.62946   13.58911  2.9163
## MunicipalityVisegrad                              90.57424    2.18270 41.4964
## MunicipalityVisoko                                71.51820    3.54301 20.1857
## MunicipalityVitez                                 79.51261    1.84673 43.0558
## MunicipalityVlasenica                             92.13604    1.72439 53.4310
## MunicipalityVogosca                               64.78167    2.69794 24.0116
## MunicipalityZavidovici                            69.56587    5.33960 13.0283
## MunicipalityZenica                                64.54012    2.33455 27.6456
## MunicipalityZepce                                 84.65681    1.94164 43.6007
## MunicipalityZivince                               61.03222    4.05836 15.0386
## MunicipalityZvornik                               87.47898    1.57449 55.5604
## Log_Casualty:dummy.matrix1                         3.13527    0.89983  3.4843
## Log_Casualty:dummy.matrix2                         2.06516    0.91761  2.2506
## Log_Casualty:dummy.matrix3                         0.41477    0.82743  0.5013
##                                                   Pr(>|t|)
## dummy.matrix1                                     0.1726343
## dummy.matrix2                                     0.2594451
## dummy.matrix3                                     0.0010976 **
## MunicipalityBanja Luka                            < 2.2e-16 ***
## MunicipalityBanovici                              < 2.2e-16 ***
## MunicipalityBihac                                 < 2.2e-16 ***
## MunicipalityBijeljina                             < 2.2e-16 ***
## MunicipalityBileca                                < 2.2e-16 ***
## MunicipalityBosanska Dubica (Kozarska Dubica)     < 2.2e-16 ***
## MunicipalityBosanska Gradiska (Gradiska)          < 2.2e-16 ***
```

```
## MunicipalityBosanska Krupa                    < 2.2e-16 ***
## MunicipalityBosanski Brod                     < 2.2e-16 ***
## MunicipalityBosanski Novi (Novi Grad)         < 2.2e-16 ***
## MunicipalityBosanski Petrovac                 < 2.2e-16 ***
## MunicipalityBosansko Grahovo (Grahovo)        4.587e-08 ***
## MunicipalityBratunac                          < 2.2e-16 ***
## MunicipalityBrcko                             < 2.2e-16 ***
## MunicipalityBreza                             < 2.2e-16 ***
## MunicipalityBugojno                           < 2.2e-16 ***
## MunicipalityBusovaca                          < 2.2e-16 ***
## MunicipalityCajnice                           < 2.2e-16 ***
## MunicipalityCapljina                          < 2.2e-16 ***
## MunicipalityCazin                             < 2.2e-16 ***
## MunicipalityCelinac                           < 2.2e-16 ***
## MunicipalityCentar Sarajevo                   < 2.2e-16 ***
## MunicipalityCitluk                            < 2.2e-16 ***
## MunicipalityDerventa                          < 2.2e-16 ***
## MunicipalityDoboj                             < 2.2e-16 ***
## MunicipalityDonji Vakuf                       < 2.2e-16 ***
## MunicipalityDrvar                             6.725e-09 ***
## MunicipalityFoca (Srbinje)                    < 2.2e-16 ***
## MunicipalityFojnica                           < 2.2e-16 ***
## MunicipalityGacko                             < 2.2e-16 ***
## MunicipalityGlamoc                            < 2.2e-16 ***
## MunicipalityGorazde                           < 2.2e-16 ***
## MunicipalityGornji Vakuf - Uskopolje          < 2.2e-16 ***
## MunicipalityGradacac                          < 2.2e-16 ***
## MunicipalityGrude                             < 2.2e-16 ***
## MunicipalityHadzici                           < 2.2e-16 ***
## MunicipalityHan Pijesak                       < 2.2e-16 ***
## MunicipalityIlidza                            < 2.2e-16 ***
## MunicipalityIlijas                            < 2.2e-16 ***
## MunicipalityJablanica                         < 2.2e-16 ***
## MunicipalityJajce                             < 2.2e-16 ***
## MunicipalityKakanj                            < 2.2e-16 ***
## MunicipalityKalesija                          < 2.2e-16 ***
## MunicipalityKalinovik                         < 2.2e-16 ***
## MunicipalityKiseljak                          < 2.2e-16 ***
## MunicipalityKladanj                           < 2.2e-16 ***
## MunicipalityKljuc                             < 2.2e-16 ***
## MunicipalityKonjic                            < 2.2e-16 ***
## MunicipalityKotor Varos                       < 2.2e-16 ***
## MunicipalityKresevo                           < 2.2e-16 ***
## MunicipalityKupres (FBiH)                     < 2.2e-16 ***
## MunicipalityLaktasi                           < 2.2e-16 ***
## MunicipalityLivno                             < 2.2e-16 ***
## MunicipalityLjubinje                          < 2.2e-16 ***
## MunicipalityLjubuski                          < 2.2e-16 ***
## MunicipalityLopare                            < 2.2e-16 ***
## MunicipalityMaglaj                            < 2.2e-16 ***
## MunicipalityModrica                           < 2.2e-16 ***
## MunicipalityMostar                            < 2.2e-16 ***
## MunicipalityMrkonjic Grad                     < 2.2e-16 ***
## MunicipalityNeum                              < 2.2e-16 ***
```

```
## MunicipalityNevesinje                          < 2.2e-16 ***
## MunicipalityNovi Grad Sarajevo                 < 2.2e-16 ***
## MunicipalityNovi Travnik                       < 2.2e-16 ***
## MunicipalityNovo Sarajevo                      < 2.2e-16 ***
## MunicipalityOdzak                              < 2.2e-16 ***
## MunicipalityOlovo                              < 2.2e-16 ***
## MunicipalityOrasje                             < 2.2e-16 ***
## MunicipalityPale (RS)                          < 2.2e-16 ***
## MunicipalityPosusje                            < 2.2e-16 ***
## MunicipalityPrijedor                           < 2.2e-16 ***
## MunicipalityPrnjavor                           < 2.2e-16 ***
## MunicipalityProzor (Prozor-Rama)               < 2.2e-16 ***
## MunicipalityRogatica                           < 2.2e-16 ***
## MunicipalityRudo                               < 2.2e-16 ***
## MunicipalitySamac (Bosanski Samac)             < 2.2e-16 ***
## MunicipalitySanski Most                        < 2.2e-16 ***
## MunicipalitySekovici                           < 2.2e-16 ***
## MunicipalitySipovo                             < 2.2e-16 ***
## MunicipalitySiroki Brijeg                      < 2.2e-16 ***
## MunicipalitySkender Vakuf (Knezevo)            < 2.2e-16 ***
## MunicipalitySokolac                            < 2.2e-16 ***
## MunicipalitySrbac                              < 2.2e-16 ***
## MunicipalitySrebrenica                         < 2.2e-16 ***
## MunicipalitySrebrenik                          < 2.2e-16 ***
## MunicipalityStari Grad Sarajevo                < 2.2e-16 ***
## MunicipalityStolac                             < 2.2e-16 ***
## MunicipalityTesanj                             < 2.2e-16 ***
## MunicipalityTeslic                             < 2.2e-16 ***
## MunicipalityTomislavgrad                       < 2.2e-16 ***
## MunicipalityTravnik                            < 2.2e-16 ***
## MunicipalityTrebinje                           < 2.2e-16 ***
## MunicipalityTrnovo (FBiH)                      < 2.2e-16 ***
## MunicipalityTuzla                              < 2.2e-16 ***
## MunicipalityUgljevik                           < 2.2e-16 ***
## MunicipalityVares                              < 2.2e-16 ***
## MunicipalityVelika Kladusa                     0.0037968 **
## MunicipalityVisegrad                           < 2.2e-16 ***
## MunicipalityVisoko                             < 2.2e-16 ***
## MunicipalityVitez                              < 2.2e-16 ***
## MunicipalityVlasenica                          < 2.2e-16 ***
## MunicipalityVogosca                            < 2.2e-16 ***
## MunicipalityZavidovici                         < 2.2e-16 ***
## MunicipalityZenica                             < 2.2e-16 ***
## MunicipalityZepce                              < 2.2e-16 ***
## MunicipalityZivince                            < 2.2e-16 ***
## MunicipalityZvornik                            < 2.2e-16 ***
## Log_Casualty:dummy.matrix1                     0.0005634 ***
## Log_Casualty:dummy.matrix2                     0.0251005 *
## Log_Casualty:dummy.matrix3                     0.6165272
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
#?cluster.vcov
#now lets try pcse for the first set of models
```

```
library(pcse)
```

```
##
## Attaching package: 'pcse'
```

```
## The following object is masked from 'package:sandwich':
##
##     vcovPC
```

```
data.1 = na.omit(data[, c('politychanget1',
                          'nonviol',
                          'byear',
                          'location')])
twowayMod = lm(politychanget1 ~ nonviol + as.factor(byear) + as.factor(location),
               data = data.1)
# vcovPC1 = pcse(twowayMod,
#       groupN = data.1$location,
#       groupT = data.1$byear,
#       pairwise = T) #takes some time
# coeftest(twowayMod, vcovPC1) #does not work - any idea why? think about how the data is assumed relat
```

Mixed (Random and Fixed) Effects

- We can use these in much the same way (and a lot more) as FEs
- Random effects have a distributional assumption
- This distribution buys us a lot of things
  - We can borrow information from other units to find a generalized pattern across units
  - The statistical power is much higher
  - The power means we can get false positives, but generally only under mis-specification
  - We can directly estimate the variation of the underlying distribution, meaning we can inspect which levels need variation accounted for
  - We no longer make the assumption of separability, and estimate the covariation of the parameters
- The distribution, in general, assumes that the population under study is representative of the group-of-interest, in that the effects are random realizations of the randomly distributed population (and temporal) heterogeneity (prevalancy kind of)
- We will generally want to go Bayesian, for a number of reasons we will cover later, but basically it allows for much more control over the model and a much more flexible DGP
- Random effects do not require balance
- You can model units that only have one observation
- You can model a small number of units
- You can model a small number of observations
- You can add predictors to the random effects for more precision (contextual effects)
- You can also model any slope coefficient randomly, allowing it to vary at any desired level
- Assumes that errors are uncorrelated with regressors
- For now, let's look at the first models in an RE specification

```
library(lme4)
```

```
## Loading required package: Matrix
```

```
REMod = lmer(politychanget1 ~ nonviol + (1|location),
             data = data.1)
summary(REMod) #if you look at the variation of random effects, location is not warranted
```

```
## Linear mixed model fit by REML ['lmerMod']
## Formula: politychanget1 ~ nonviol + (1 | location)
```

```
##    Data: data.1
##
## REML criterion at convergence: 1483.9
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -4.2593 -0.5136  0.0068  0.2342  2.7996
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  location (Intercept)  1.06    1.030
##  Residual             17.16    4.142
## Number of obs: 259, groups:  location, 117
##
## Fixed effects:
##             Estimate Std. Error t value
## (Intercept) -0.02993    0.33985  -0.088
## nonviol      3.95755    0.56247   7.036
##
## Correlation of Fixed Effects:
##         (Intr)
## nonviol -0.564
```

```
#now let's check time
REMod2 = lmer(politychanget1 ~ nonviol + (1|byear),
              data = data.1)
```

```
## boundary (singular) fit: see help('isSingular')
```

```
summary(REMod2) #no variation - no need for any heterogeneous exploration (though you might need to for
```

```
## Linear mixed model fit by REML ['lmerMod']
## Formula: politychanget1 ~ nonviol + (1 | byear)
##    Data: data.1
##
## REML criterion at convergence: 1484.7
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -4.1787 -0.6632  0.0151  0.2494  2.8524
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  byear    (Intercept)  0.00    0.000
##  Residual             18.21    4.267
## Number of obs: 259, groups:  byear, 88
##
## Fixed effects:
##             Estimate Std. Error t value
## (Intercept) -0.06433    0.32629  -0.197
## nonviol      3.89387    0.55977   6.956
##
## Correlation of Fixed Effects:
##         (Intr)
## nonviol -0.583
## optimizer (nloptwrap) convergence code: 0 (OK)
```

```
## boundary (singular) fit: see help('isSingular')
```

Hausman Test

- The null hypothesis is that the preferred model is random effects vs. the alternative the fixed effects
- Tests whether the unique errors are correlated with the regressors, the null hypothesis is they are not

```
#only works for uncoupled data, e.g.:
library(plm)
# phtest(politychanget1 ~ nonviol,
#              data = data.1,
#        model = c("within", "random"),
#        index = c('byear', 'location'))
REmod = plm(Ethnic_Vote_Share ~ Log_Casualty,
                          data = data2,
            index = 'Year',
    model='random')
FEmod = plm(Ethnic_Vote_Share ~ Log_Casualty,
                          data = data2,
    index='Year',
    model='within')
phtest(FEmod, REmod)
```

```
##
##  Hausman Test
##
## data:  Ethnic_Vote_Share ~ Log_Casualty
## chisq = 1.2666e-14, df = 1, p-value = 1
## alternative hypothesis: one model is inconsistent
```

```
#compare the models; why would we get this p-value?
```