Statistics 330 Paper

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Abstract

There is no institution in modern day politics more important than elections. Regardless of whether a regime is democratic (where elections are free and fair) or autocratic, election are a staple of today's political world, providing (some) legitimacy to those who win them. Thus, one of the central puzzles in the social sciences is why some parties win more votes than others. In this paper, we fit several statistical models to predict party vote share, finding that party strength is the best predictor of a party's success in elections.

1 Problem and Motivation

There is no institution in modern day politics more important than elections. Since the 1990s, almost every country in the world has switched to using elections to decide which party or candidate is in government. Even in autocratic regimes like contemporary China and Russia use elections to justify the incumbents' stays in power, even if the results are pre-determined.

Given the importance of elections, tools and variables that predict elections are valuable. In this paper, we create several statistical models that predict the vote share of elections' primary actors: political parties. In doing so, we identify several factors that strongly influence voter share. Additionally, we explore how the effect of predictors of vote share change depending on the level of democracy in the country.

1.1 Data Description

To fit our models, we use data from the Varieties of Democracy database (V-Dem). V-Dem is the largest database on democracy and parties in the world, covering country-level democracy data in every country from 1789 to now and party-level data from 1970 to now. Every variable we use in our data comes from V-Dem, allowing us to cover over 1600 parties in 165 countries over the a 50 year period. For our models, our unit of analysis is a party-year observation. For example, the United States Republican Party in 2000 is an observation in our analysis.

We consider several predictors of party vote share. Regarding party factors, we include the measures of ideology, anti-pluralism (how favorably they view democracy), if the party is a pariah (i.e., and outcast), party brand continuity (new party, reformed party, same party as last election), and party strength. We also include several country factors, including, compulsory voting (none, mild enforcement, medium enforcement, and strong enforcement), election type, and quality of democracy. Because of scholar's recent focus on party strength (i.e., the party's organizational capacity to mobilize its voters), we are particularly interested in it's effect on vote share.

For our dependent variable, we use a party's raw vote percentage and multiply it by the registered voter turnout. We do this for easier comparison between cases, as we expect some parties to not only increase their raw vote share, but to encourage higher voter turnout.

1.2 Questions of Interest

We are interested in two questions. First, what variables best predict the a party's vote share? A branch of this question is what is the effect of party strength on party vote share?

The second question is related to the first. How does the relationship between party strength and vote share change given the countries level of democracy?

1.3 Regression Methods

To answer the first question, we use forward, backward, and sequential stepwise model selection to choose our predictors. After checking assumptions, re-selecting variables, and transforming our variables to meet the regression assumptions, we came to this formula:

$VoteShare^{-1} = \beta_0 + \beta_1 \text{Party Strength} + \beta_2 \text{Ideology} + \beta_3 \text{Democracy Score} + \beta_4 \text{AntiPluralism} + \beta_5 \text{Pariah} + \beta_6(\text{PartyBrand Continuity} = \text{Reformed Party}) + \beta_7(\text{PartyBrand Continuity} = \text{Same Party}) + \beta_8(\text{Compulsory Voting} = \text{Mild Enforcement}) + \beta_9(\text{Compulsory Voting} = \text{Medium Enforcement}) + \beta_{10}(\text{Compulsory Voting} = \text{Strong Enforcement}) + \text{Error}$

Using the same processes, we came to the following formula for the interaction model between democracy and party strength:

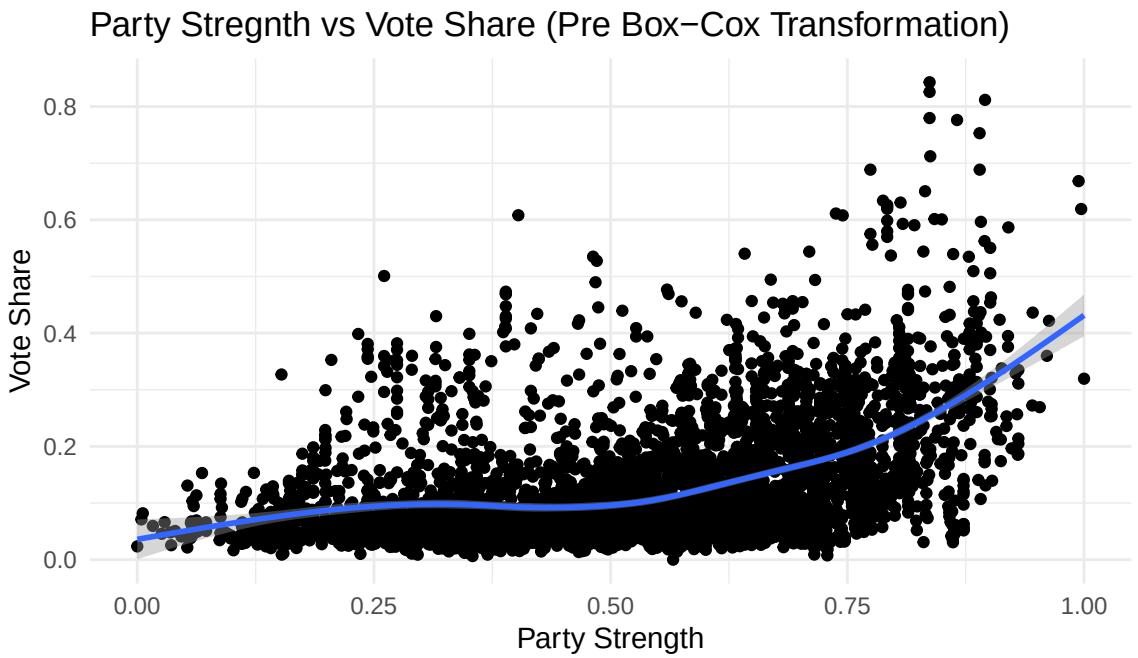
$VoteShare^{-1} = \beta_0 + \beta_1 \text{Party Strength} + \beta_2 \text{Ideology} + \beta_3 \text{Democracy Score} + \beta_4 \text{AntiPluralism} + \beta_5 \text{Pariah} + \beta_6(\text{PartyBrand Continuity} = \text{Reformed Party}) + \beta_7(\text{PartyBrand Continuity} = \text{Same Party}) + \beta_8(\text{Compulsory Voting} = \text{Mild Enforcement}) + \beta_9(\text{Compulsory Voting} = \text{Medium Enforcement}) + \beta_{10}(\text{Compulsory Voting} = \text{Strong Enforcement}) + \beta_{11}(\text{Party Strength} \times \text{Democracy Score}) + \text{Error}$

For our analysis, we report the results of three models: a baseline OLS model to compare effect of vote share, a logistical regression model using the same formula as the baseline to compare effect on control of government, and an interaction OLS model on vote share again. You can find the full results and methodology in the appendix.

2 Analyses, Results, and Interpretation

To start our analysis for our first question, we first look at the relationship between our main independent variable, party strength, and our outcome variable, party vote share.

```
`geom_smooth()` using method = 'gam' and formula = 'y ~ s(x, bs = "cs")'
```

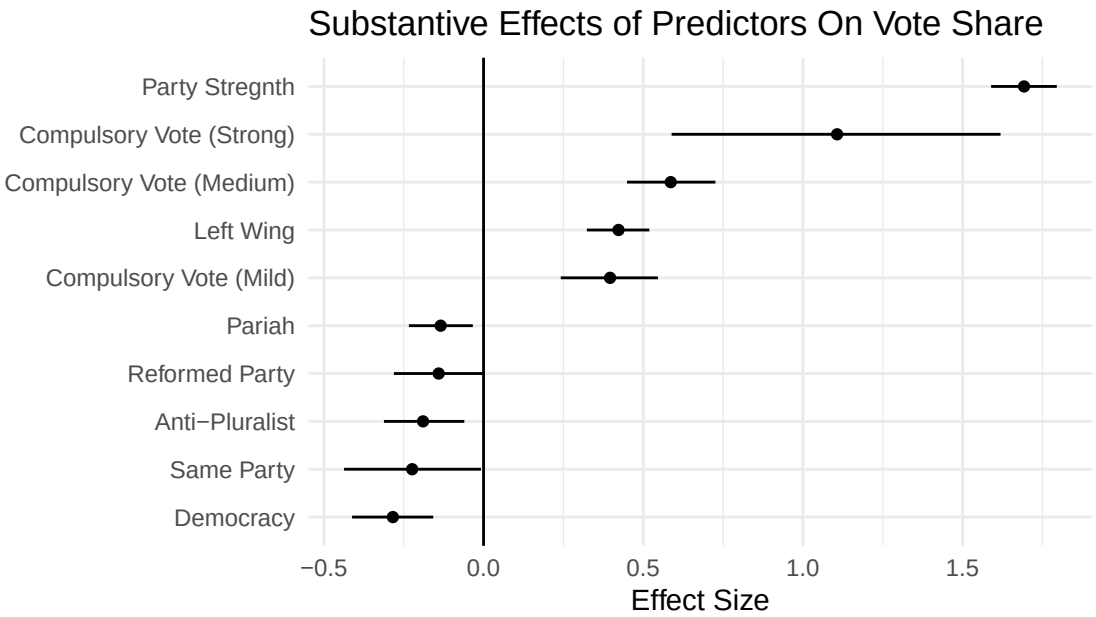


As one can see, there is strong, non-linear, and positive relationship between vote share and party strength. To more rigorously test this relationship, we fit a OLS regression.

As mentioned in the regression methods subsection, we utilize forward, backward, and sequential stepwise model selection in order to find the variables that have an effect on party vote share. The result tells us that the best predictors of party vote share are: party strength, compulsory voting, ideology, democracy score, anti-pluralism, pariah status, and party brand continuity. To remedy a violation of the normality assumption, we apply a Box Cox transformation and rerun the stepwise function and assumption checks to ensure we have a quality model. We found that this model largely met the assumptions of linearity, normality of errors, constant variance, influential observations, and multicollinearity. You can the results for our model selection and how we checked assumptions in the appendix.

Satisfied by the model, we may begin to make inferences. Below, we plot the mean effect of each of our variables and the 95% confidence interval for their respective effects. We do this so we can test the effect of each coefficient. In general, the null hypotheses is that, holding all else constant, there is no relationship between a given predictor and the outcome variable. The alternative is that there is a relationship, holding all else constant.

For ease of interpretation, we multiply the effects by negative one, since the transformed vote share variable is difficult to interpret otherwise. In all the plots, a positive effect mean the variable is positively associated with vote share.



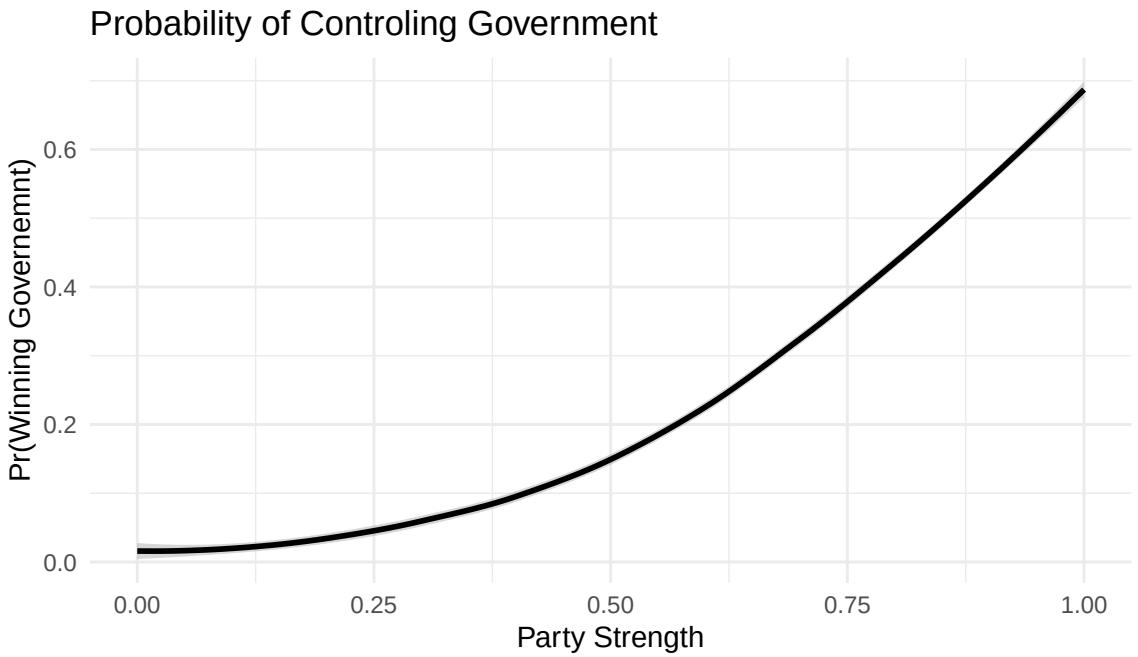
We find that party strength has the highest predicted effect on vote share of all the predictors in our model. Compulsory vote and left wing both have positive, significant effects. Meanwhile, pariah, reformed party, anti-pluralist, same party, and democracy all have negative effects on vote share.

For global diagnostics, we find that the model itself is significant, which is no surprise considering nearly all the coefficients are significant. We also find that the model predicts around 23 percent of the variance in vote share, a feat that is actually quite impressive considering what is typical of social science models.

As a robustness check, we also fit a logistical regression model predicting the probability of a party winning control of the government. Once again, party strength was the strongest predictor. The plot below shows the probability of winning control of the government give different values of party strength.

```
`geom_smooth()` using method = 'loess' and formula = 'y ~ x'
```

As shown by the previous plot, party strength is a robust predictor of party vote share, so much so that it significantly increases the probability of winning control of the government, holding all else equal. Meanwhile, party ideology, anti-pluralism, and pariah status also have significant effects of winning control of the government. We therefore reject the null hypothesis for these predictors. You can see the full results of our analysis, as well as diagnostic checks for both models, in the appendix.



For our second question, we began by plotting the vote share against party strength and added a color scale to indicate the levels of democracy for each observation.

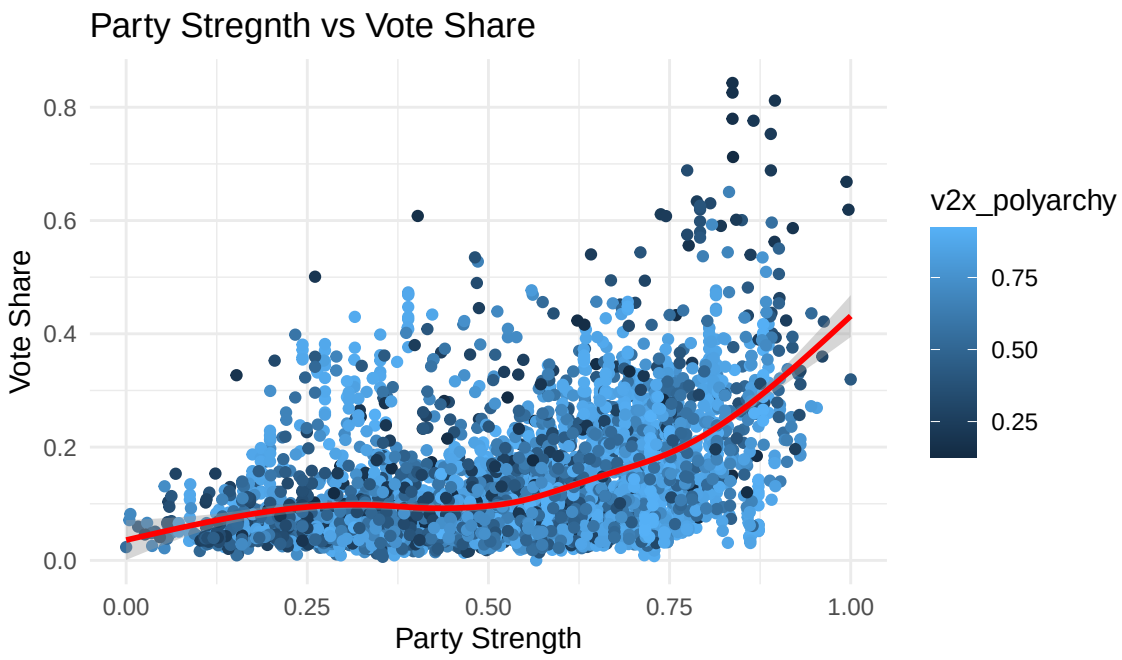
```
`geom_smooth()` using method = 'gam' and formula = 'y ~ s(x, bs = "cs")'
```

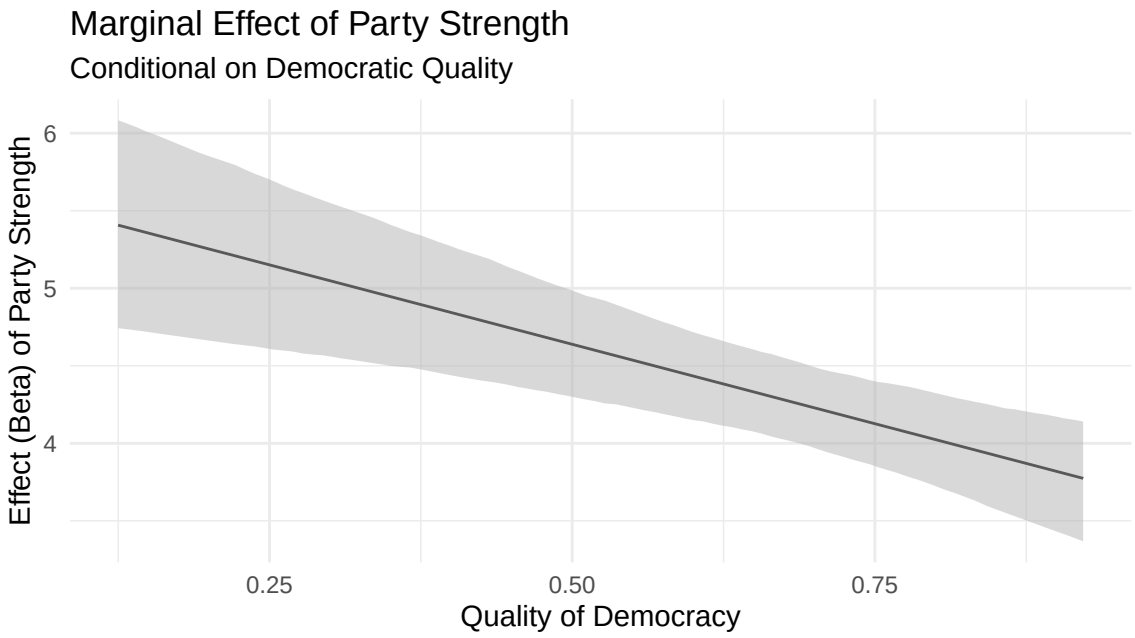
We suspect an interaction effect between level of democracy and party strength. It appears that as a country becomes more democratic, party strength matters less. This makes sense, since performance in government matters more in democratic systems than in autocracies. To more thoroughly investigate these results, we fit another OLS regression using the same transformed vote share outcome variable. Below is a marginal effects plot showing the coefficient size of party strength given various levels of democracy.

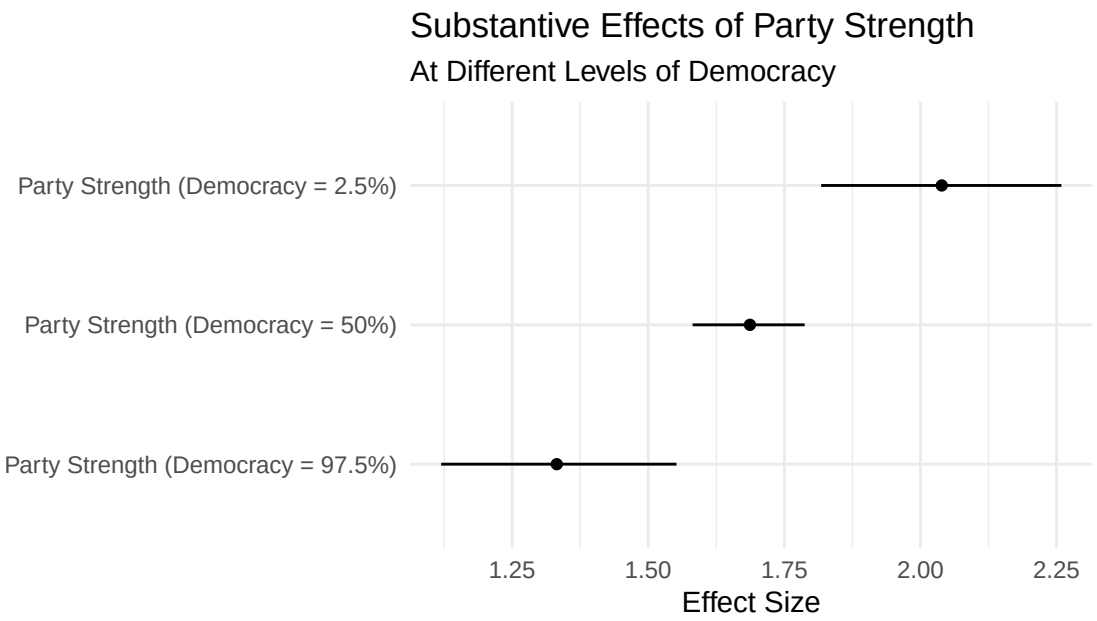
For this particular question, the null hypothesis is that the effect of party strength is not moderated by level of democracy. The alternative is that there is a moderating effect.

An additional plot shows the substantive effects of party strength at differing levels of democracy.

The effect of party strength differs significantly depending on the level of democracy in the country. Holding all else constant, as democracy increases, the effect of party strength on party vote share decreases. In countries without free and fair elections, otherwise called autocracies, party strength has a much larger effect. In democracies, the effect of party strength is diminished, probably because performance in government and meaningful accountability


Party Stregnth vs Vote Share
Vote Share
0.0
0.2
0.4
0.6
0.8
0.00
0.25
0.50
0.75
1.00
Party Strength
v2x_polyarchy
0.75
0.50
0.25


Marginal Effect of Party Strength
Conditional on Democratic Quality
Effect (Beta) of Party Strength
4
5
6
0.25
0.50
0.75
Quality of Democracy



make elections more volatile. This interaction effect is significantly different from zero, so we reject the null hypothesis and conclude that there is a real moderating effect between party strength and level of democracy.

This model's diagnostics were sightly better. The model significance was slightly higher than the non-interaction model, while the variation explained by the model is higher than the non-interaction model, even after accounting for the number of predictors in the interaction model, around 25 percent.

As a final robustness check, we check the significance of the interaction term as a whole. After running a partial F-test, we can confirm that the interaction effect is important and should be included in our model.

3 Conclusions

In conclusion, our model and its results clearly indicate that party strength is an important indicator in a party's vote share, the total amount of votes a party receives in proportion to the population. We also found that the degree of democracy existing in a country also significantly affects this turnout inversely; the more democratic a state is, the lesser the effect it has on a party's vote share, likely due to changing priorities for voters that come with free and fair elections.

There do exist a few minor weaknesses in our model. While our Box Cox transformation drastically improved the normality of the errors in our data, it is still not perfect, so there may be slight inaccuracy introduced with our analysis.

We also must acknowledge that our observations are not identically and independently distributed. The importance of this is that our observations are of political parties across the many countries in the world. Most nations have more than one party that competes for the population's votes so naturally one party's vote share is going to affect that of the others. Therefore, the observations are not independent. However, that is an often times natural consequence of using observational data, so there is not much we can do about that using the methods we are familiar with.

Finally, we also recognize that because of the nature of politics and governance, it is possible that certain parties have advantages over others that stem from winning office. For example, a party that wins office one year could potentially use the government's resources in order to increase their party vote share for the next election. Essentially, the outcome of one election may affect the predictors of the next, indicating potential reverse causality.

4 Contributions

Ethan wrote the conclusion, formatted the regression model into LATEX, and helped with the analysis.

Alex wrote the analysis and interpretation sections of the paper, and worked on the analysis, primary fitting the logit regression.

Grant wrote the introduction and questions sections and worked on data wrangling and the analysis and visualizations.

APPENDIX

First, a summary of the data so you can understand what is happening

```
dat <- read.csv("~/R Projects/three30/partyinst_data_330.csv") %>%
  mutate(COW = factor(COWcode.x), leg_elect = factor(v2eltype_0), exe_elect = factor(v2elt
  na.omit()


#### Here are the names of the variables we will be using:
#### COW - a numerical indicator given to each country
#### v2elvaptrn - Voting Age Turnout
#### v2elvaptrn - Registered turnout
```

```
#### leg_elect - legislative elections
#### exe_elect - execitive elections
#### v2xpa_antiplural - party's anti-pluralism measure
#### v2pavote - party vote share
#### v2paseatshare - party seat share
#### v2paelcont - party brand continuity
#### v2papariah - party's pariah measure
#### v2pariglef - Party left right scale
#### elect_system - electoral system
#### v2x_polyarchy - Democracy score
#### piendla - Party institutioanlization ****
#### psla - Party stregnth ****
#### vap_vs - Percent of the VAP turnout that a party got ****
#### reg_vs - Percent of the Registered turn out a party got ****

summary(dat)
```

```
  COWcode.x     v2x_polyarchy      v2elvaptrn       v2eltrnout      v2eltype_0
Min.   : 20.0   Min.   :0.1250   Min.   : 13.88   Min.   :21.01   Min.   :1
1st Qu.:211.0   1st Qu.:0.5270   1st Qu.: 56.68   1st Qu.:61.31   1st Qu.:1
Median :352.0   Median :0.7690   Median : 68.96   Median :73.31   Median :1
Mean   :387.8   Mean   :0.6872   Mean   : 67.28   Mean   :71.67   Mean   :1
3rd Qu.:517.0   3rd Qu.:0.8670   3rd Qu.: 79.22   3rd Qu.:83.62   3rd Qu.:1
Max.   :950.0   Max.   :0.9220   Max.   :104.31   Max.   :98.80   Max.   :1

  v2eltype_6       v2elcomvot       v2elparlel   v2xpa_antiplural
Min.   :0.0000   Min.   :0.0000   Min.   :0.00   Min.   :0.0120
1st Qu.:0.0000   1st Qu.:0.0000   1st Qu.:1.00   1st Qu.:0.0490
Median :0.0000   Median :0.0000   Median :1.00   Median :0.1790
Mean   :0.2562   Mean   :0.4184   Mean   :1.04   Mean   :0.3011
3rd Qu.:1.0000   3rd Qu.:1.0000   3rd Qu.:1.00   3rd Qu.:0.5002
Max.   :1.0000   Max.   :3.0000   Max.   :3.00   Max.   :1.0000

   v2pavote      v2paseatshare    v2paelcont   v2papariah
Min.   : 0.000   Min.   :  0.00   0:3340     Min.   :-4.0880
1st Qu.: 7.575   1st Qu.:  6.70   1: 604     1st Qu.:-0.6030
Median :13.100   Median : 13.00   2: 236     Median : 0.6770
Mean   :18.367   Mean   : 19.54              Mean   : 0.2881
3rd Qu.:26.000   3rd Qu.: 28.40              3rd Qu.: 1.5180
Max.   :91.000   Max.   :100.00              Max.   : 2.0660

   piendla             psla          v2pariglef         v2pagovsup
```

```
 Min.   :0.02253   Min.   :0.0000   Min.   :-4.10600   Min.   :0.000
 1st Qu.:0.42357   1st Qu.:0.3836   1st Qu.:-0.96150   1st Qu.:1.000
 Median :0.54664   Median :0.5515   Median : 0.14000   Median :3.000
 Mean   :0.52513   Mean   :0.5312   Mean   : 0.06453   Mean   :1.944
 3rd Qu.:0.64867   3rd Qu.:0.6887   3rd Qu.: 1.23200   3rd Qu.:3.000
 Max.   :0.92210   Max.   :1.0000   Max.   : 4.17400   Max.   :4.000

      gov              COW       leg_elect exe_elect elect_system
 Min.   :0.0000   211    : 116   0:   0    0:3109    0:3103
 1st Qu.:0.0000   130    : 114   1:4180    1:1071    1: 438
 Median :0.0000   390    :  98                       2: 606
 Mean   :0.1993   380    :  90                       3:  33
 3rd Qu.:0.0000   325    :  83
 Max.   :1.0000   740    :  83
                  (Other):3596
    reg_vs
 Min.   :0.00000
 1st Qu.:0.05238
 Median :0.09367
 Mean   :0.13266
 3rd Qu.:0.17898
 Max.   :0.84284
```

```
#### The VAP vote share variable, seems suspect (fraud maybe?), so there may be some codin
```

Here is our model selections methodology:

```
## Stepwise model selection
attach(dat)
```

```
The following objects are masked from dat_center:

    COW, COWcode.x, elect_system, exe_elect, gov, leg_elect, piendla,
    psla, reg_vs, v2elcomvot, v2elparlel, v2eltrnout, v2eltype_0,
    v2eltype_6, v2elvaptrn, v2paelcont, v2pagovsup, v2papariah,
    v2pariglef, v2paseatshare, v2pavote, v2x_polyarchy,
    v2xpa_antiplural

The following objects are masked from dat_new:
```

```
    COW, COWcode.x, elect_system, exe_elect, gov, leg_elect, piendla,
    psla, reg_vs, v2elcomvot, v2elparlel, v2eltrnout, v2eltype_0,
    v2eltype_6, v2elvaptrn, v2paelcont, v2pagovsup, v2papariah,
    v2pariglef, v2paseatshare, v2pavote, v2x_polyarchy,
    v2xpa_antiplural

The following objects are masked from dat (pos = 5):

    COW, COWcode.x, elect_system, exe_elect, gov, leg_elect, piendla,
    psla, reg_vs, v2elcomvot, v2elparlel, v2eltrnout, v2eltype_0,
    v2eltype_6, v2elvaptrn, v2paelcont, v2pagovsup, v2papariah,
    v2pariglef, v2paseatshare, v2pavote, v2x_polyarchy,
    v2xpa_antiplural
```

```r
base_model <- lm(reg_vs ~ 1)
full_model <- lm(reg_vs ~ elect_system + v2pariglef + psla + v2papariah + exe_elect + v2pa

car::vif(full_model)
```

```
                    GVIF Df GVIF^(1/(2*Df))
elect_system     1.182357  3        1.028312
v2pariglef       1.056522  1        1.027872
psla             1.214403  1        1.102000
v2papariah       1.151020  1        1.072856
exe_elect        1.147033  1        1.070996
v2paelcont       1.176495  2        1.041472
v2xpa_antiplural 1.875132  1        1.369355
v2x_polyarchy    1.825730  1        1.351196
```

```r
forward <- step(base_model,
                direction = "forward",
                k = 2,
                scope = list(lower = base_model, upper = full_model))
```

```
Start:  AIC=-18443.68
reg_vs ~ 1

                  Df Sum of Sq    RSS    AIC
+ psla             1    9.3191 41.345 -19291
```

```
+ v2paelcont        2    1.4033 49.261 -18557
+ elect_system      3    0.7247 49.940 -18498
+ v2xpa_antiplural  1    0.1881 50.476 -18457
+ v2pariglef        1    0.0859 50.579 -18449
+ v2x_polyarchy     1    0.0608 50.604 -18447
+ v2papariah        1    0.0424 50.622 -18445
<none>                         50.664 -18444
+ exe_elect         1    0.0024 50.662 -18442

Step:  AIC=-19291.32
reg_vs ~ psla

                   Df Sum of Sq    RSS    AIC
+ elect_system      3   0.85760 40.488 -19373
+ v2x_polyarchy     1   0.53999 40.805 -19344
+ v2pariglef        1   0.39644 40.949 -19330
+ v2xpa_antiplural  1   0.39597 40.949 -19330
+ v2papariah        1   0.14867 41.197 -19304
+ exe_elect         1   0.10890 41.237 -19300
+ v2paelcont        2   0.07095 41.274 -19295
<none>                         41.345 -19291

Step:  AIC=-19372.93
reg_vs ~ psla + elect_system

                   Df Sum of Sq    RSS    AIC
+ v2x_polyarchy     1   0.64001 39.848 -19438
+ v2xpa_antiplural  1   0.38050 40.107 -19410
+ v2pariglef        1   0.35380 40.134 -19408
+ v2papariah        1   0.18279 40.305 -19390
+ v2paelcont        2   0.06228 40.426 -19375
<none>                         40.488 -19373
+ exe_elect         1   0.00967 40.478 -19372

Step:  AIC=-19437.54
reg_vs ~ psla + elect_system + v2x_polyarchy

                   Df Sum of Sq    RSS    AIC
+ v2pariglef        1   0.34443 39.503 -19472
+ v2paelcont        2   0.08242 39.765 -19442
+ v2papariah        1   0.05967 39.788 -19442
+ v2xpa_antiplural  1   0.01977 39.828 -19438
<none>                         39.848 -19438
```

```
+ exe_elect         1   0.00260 39.845 -19436

Step:  AIC=-19471.82
reg_vs ~ psla + elect_system + v2x_polyarchy + v2pariglef

                   Df Sum of Sq    RSS    AIC
+ v2papariah        1  0.096469 39.407 -19480
+ v2paelcont        2  0.089314 39.414 -19477
<none>                          39.503 -19472
+ exe_elect         1  0.005852 39.498 -19470
+ v2xpa_antiplural  1  0.004288 39.499 -19470

Step:  AIC=-19480.04
reg_vs ~ psla + elect_system + v2x_polyarchy + v2pariglef + v2papariah

                   Df Sum of Sq    RSS    AIC
+ v2paelcont        2  0.089198 39.318 -19486
<none>                          39.407 -19480
+ exe_elect         1  0.008068 39.399 -19479
+ v2xpa_antiplural  1  0.000046 39.407 -19478

Step:  AIC=-19485.52
reg_vs ~ psla + elect_system + v2x_polyarchy + v2pariglef + v2papariah +
    v2paelcont

                   Df Sum of Sq    RSS    AIC
<none>                          39.318 -19486
+ exe_elect         1 0.0064218 39.311 -19484
+ v2xpa_antiplural  1 0.0003123 39.317 -19484
```

```r
back <- step(full_model,
             direction = "backward",
             k = 2,
             scope = list(lower = base_model, upper = full_model))
```

```
Start:  AIC=-19482.21
reg_vs ~ elect_system + v2pariglef + psla + v2papariah + exe_elect +
    v2paelcont + v2xpa_antiplural + v2x_polyarchy

                   Df Sum of Sq    RSS    AIC
- v2xpa_antiplural  1    0.0001 39.311 -19484
```

```
- exe_elect         1    0.0062 39.317 -19484
<none>                         39.311 -19482
- v2paelcont        2    0.0877 39.399 -19477
- v2papariah        1    0.0947 39.406 -19474
- v2x_polyarchy     1    0.3347 39.646 -19449
- v2pariglef        1    0.3850 39.696 -19444
- elect_system      3    0.8860 40.197 -19395
- psla              1    8.8698 48.181 -18634

Step:  AIC=-19484.2
reg_vs ~ elect_system + v2pariglef + psla + v2papariah + exe_elect +
    v2paelcont + v2x_polyarchy

                Df Sum of Sq    RSS    AIC
- exe_elect      1    0.0064 39.318 -19486
<none>                       39.311 -19484
- v2paelcont     2    0.0876 39.399 -19479
- v2papariah     1    0.0983 39.410 -19476
- v2pariglef     1    0.3922 39.704 -19445
- v2x_polyarchy  1    0.5097 39.821 -19432
- elect_system   3    0.8866 40.198 -19397
- psla           1    8.8948 48.206 -18634

Step:  AIC=-19485.52
reg_vs ~ elect_system + v2pariglef + psla + v2papariah + v2paelcont +
    v2x_polyarchy

                Df Sum of Sq    RSS    AIC
<none>                       39.318 -19486
- v2paelcont     2    0.0892 39.407 -19480
- v2papariah     1    0.0964 39.414 -19477
- v2pariglef     1    0.3884 39.706 -19446
- v2x_polyarchy  1    0.5048 39.823 -19434
- elect_system   3    0.9080 40.226 -19396
- psla           1    8.9672 48.285 -18629
```

```r
both <- step(base_model,
             direction = "both",
             k = 2,
             scope = list(lower = base_model, upper = full_model))
```

```
Start:  AIC=-18443.68
```

```
reg_vs ~ 1

                   Df Sum of Sq    RSS    AIC
+ psla              1    9.3191 41.345 -19291
+ v2paelcont        2    1.4033 49.261 -18557
+ elect_system      3    0.7247 49.940 -18498
+ v2xpa_antiplural  1    0.1881 50.476 -18457
+ v2pariglef        1    0.0859 50.579 -18449
+ v2x_polyarchy     1    0.0608 50.604 -18447
+ v2papariah        1    0.0424 50.622 -18445
<none>                         50.664 -18444
+ exe_elect         1    0.0024 50.662 -18442

Step:  AIC=-19291.32
reg_vs ~ psla

                   Df Sum of Sq    RSS    AIC
+ elect_system      3    0.8576 40.488 -19373
+ v2x_polyarchy     1    0.5400 40.805 -19344
+ v2pariglef        1    0.3964 40.949 -19330
+ v2xpa_antiplural  1    0.3960 40.949 -19330
+ v2papariah        1    0.1487 41.197 -19304
+ exe_elect         1    0.1089 41.237 -19300
+ v2paelcont        2    0.0709 41.274 -19295
<none>                         41.345 -19291
- psla              1    9.3191 50.664 -18444

Step:  AIC=-19372.93
reg_vs ~ psla + elect_system

                   Df Sum of Sq    RSS    AIC
+ v2x_polyarchy     1    0.6400 39.848 -19438
+ v2xpa_antiplural  1    0.3805 40.107 -19410
+ v2pariglef        1    0.3538 40.134 -19408
+ v2papariah        1    0.1828 40.305 -19390
+ v2paelcont        2    0.0623 40.426 -19375
<none>                         40.488 -19373
+ exe_elect         1    0.0097 40.478 -19372
- elect_system      3    0.8576 41.345 -19291
- psla              1    9.4520 49.940 -18498

Step:  AIC=-19437.54
reg_vs ~ psla + elect_system + v2x_polyarchy
```

```
                   Df Sum of Sq    RSS    AIC
+ v2pariglef        1    0.3444 39.503 -19472
+ v2paelcont        2    0.0824 39.765 -19442
+ v2papariah        1    0.0597 39.788 -19442
+ v2xpa_antiplural  1    0.0198 39.828 -19438
<none>                         39.848 -19438
+ exe_elect         1    0.0026 39.845 -19436
- v2x_polyarchy     1    0.6400 40.488 -19373
- elect_system      3    0.9576 40.805 -19344
- psla              1   10.0317 49.880 -18501

Step:  AIC=-19471.82
reg_vs ~ psla + elect_system + v2x_polyarchy + v2pariglef

                   Df Sum of Sq    RSS    AIC
+ v2papariah        1    0.0965 39.407 -19480
+ v2paelcont        2    0.0893 39.414 -19477
<none>                         39.503 -19472
+ exe_elect         1    0.0059 39.498 -19470
+ v2xpa_antiplural  1    0.0043 39.499 -19470
- v2pariglef        1    0.3444 39.848 -19438
- v2x_polyarchy     1    0.6306 40.134 -19408
- elect_system      3    0.9177 40.421 -19382
- psla              1   10.3195 49.823 -18504

Step:  AIC=-19480.04
reg_vs ~ psla + elect_system + v2x_polyarchy + v2pariglef + v2papariah

                   Df Sum of Sq    RSS    AIC
+ v2paelcont        2    0.0892 39.318 -19486
<none>                         39.407 -19480
+ exe_elect         1    0.0081 39.399 -19479
+ v2xpa_antiplural  1    0.0000 39.407 -19478
- v2papariah        1    0.0965 39.503 -19472
- v2pariglef        1    0.3812 39.788 -19442
- v2x_polyarchy     1    0.4848 39.892 -19431
- elect_system      3    0.9375 40.344 -19388
- psla              1   10.3853 49.792 -18504

Step:  AIC=-19485.52
reg_vs ~ psla + elect_system + v2x_polyarchy + v2pariglef + v2papariah +
    v2paelcont
```

```
                   Df Sum of Sq    RSS    AIC
<none>                          39.318 -19486
+ exe_elect         1    0.0064 39.311 -19484
+ v2xpa_antiplural  1    0.0003 39.317 -19484
- v2paelcont        2    0.0892 39.407 -19480
- v2papariah        1    0.0964 39.414 -19477
- v2pariglef        1    0.3884 39.706 -19446
- v2x_polyarchy     1    0.5048 39.823 -19434
- elect_system      3    0.9080 40.226 -19396
- psla              1    8.9672 48.285 -18629
```

```
forward
```

```
Call:
lm(formula = reg_vs ~ psla + elect_system + v2x_polyarchy + v2pariglef +
    v2papariah + v2paelcont)

Coefficients:
  (Intercept)           psla  elect_system1  elect_system2  elect_system3
     0.027821       0.256712       0.024796       0.037849       0.054959
v2x_polyarchy     v2pariglef     v2papariah    v2paelcont1    v2paelcont2
    -0.054333       0.006713      -0.003638      -0.007241      -0.018432
```

```
back
```

```
Call:
lm(formula = reg_vs ~ elect_system + v2pariglef + psla + v2papariah +
    v2paelcont + v2x_polyarchy)

Coefficients:
  (Intercept)  elect_system1  elect_system2  elect_system3     v2pariglef
     0.027821       0.024796       0.037849       0.054959       0.006713
         psla     v2papariah    v2paelcont1    v2paelcont2  v2x_polyarchy
     0.256712      -0.003638      -0.007241      -0.018432      -0.054333
```

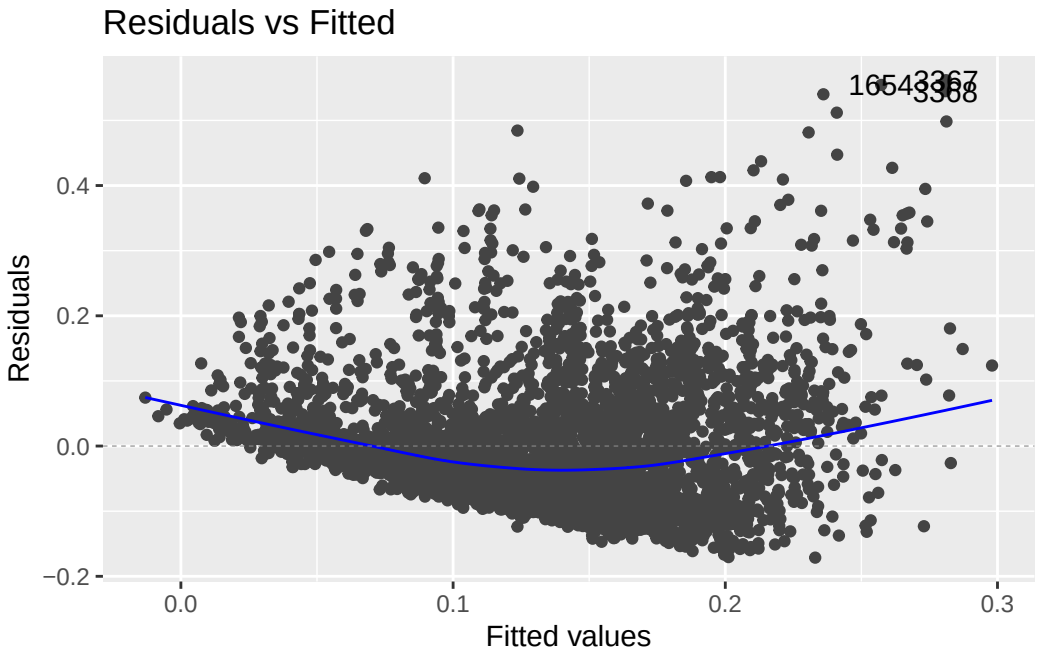
```
both
```

```
Call:
lm(formula = reg_vs ~ psla + elect_system + v2x_polyarchy + v2pariglef +
    v2papariah + v2paelcont)

Coefficients:
  (Intercept)           psla  elect_system1  elect_system2  elect_system3
     0.027821       0.256712       0.024796       0.037849       0.054959
v2x_polyarchy     v2pariglef     v2papariah    v2paelcont1    v2paelcont2
    -0.054333       0.006713      -0.003638      -0.007241      -0.018432
```

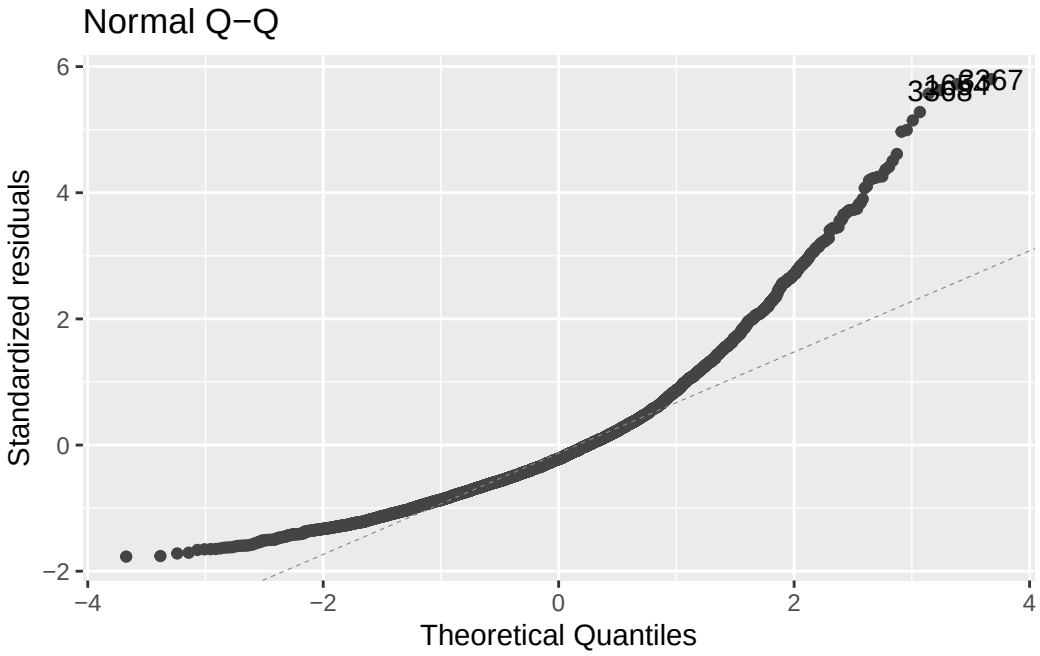
```r
#### The best formula from all three stepwise selections is this:

f1 <- reg_vs ~ psla + elect_system + v2x_polyarchy + v2pariglef +
  v2papariah + v2paelcont
```

Next is fitting the model and looking at the assumption

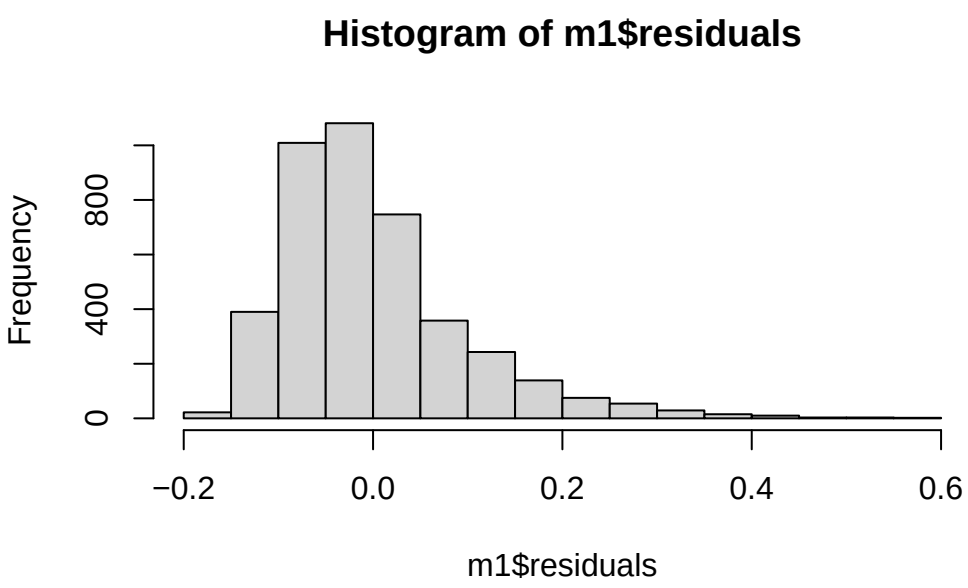
```r
m1 <- lm(f1)

autoplot(m1, which = 1, nrow = 1, ncol = 1)
```



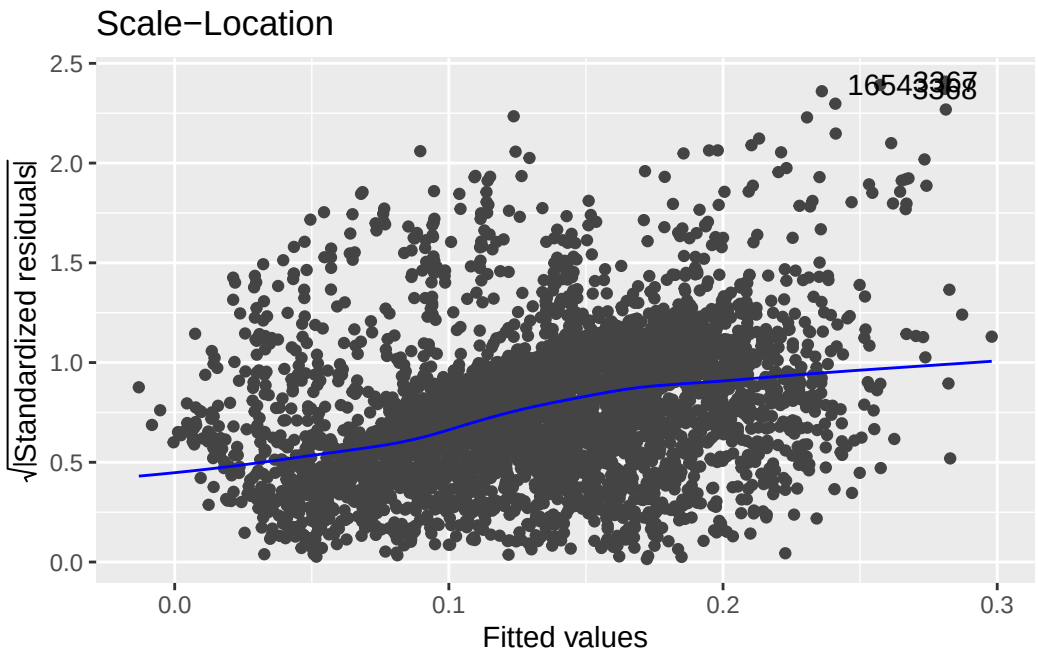
```
#### Linearity looks suprisingly good here.

autoplot(m1, which = 2, nrow = 1, ncol = 1)
```



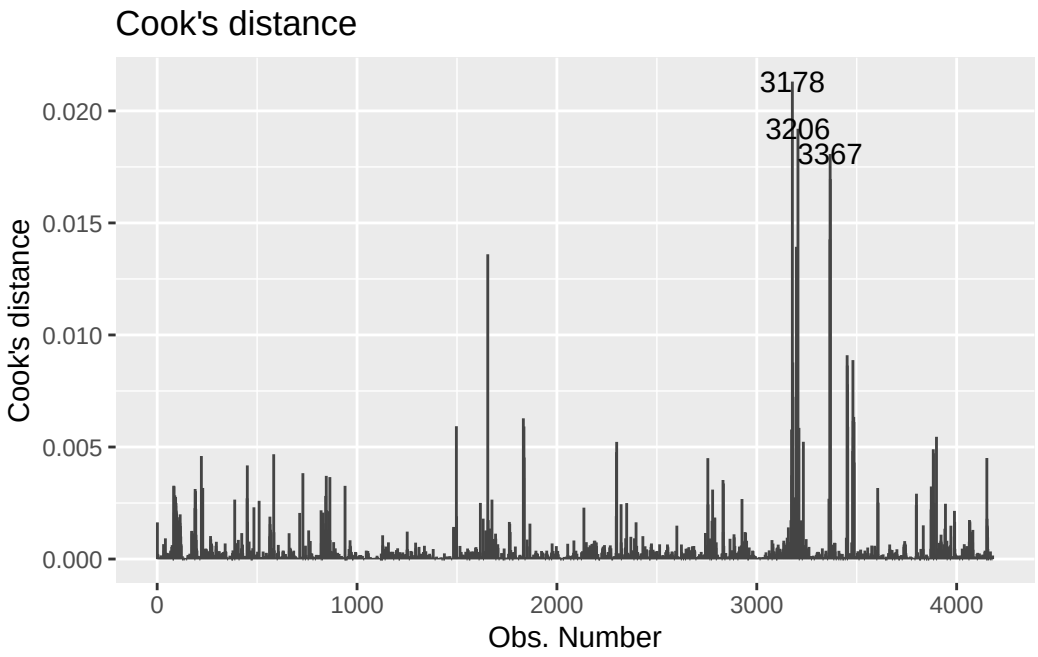

```
hist(m1$residuals)
```




```
#### Errors are not normal!

autoplot(m1, which = 3, nrow = 1, ncol = 1)
```




```
#### There might be some heterogeneity, but its pretty good here.

autoplot(m1, which = 4, nrow = 1, ncol = 1)
```



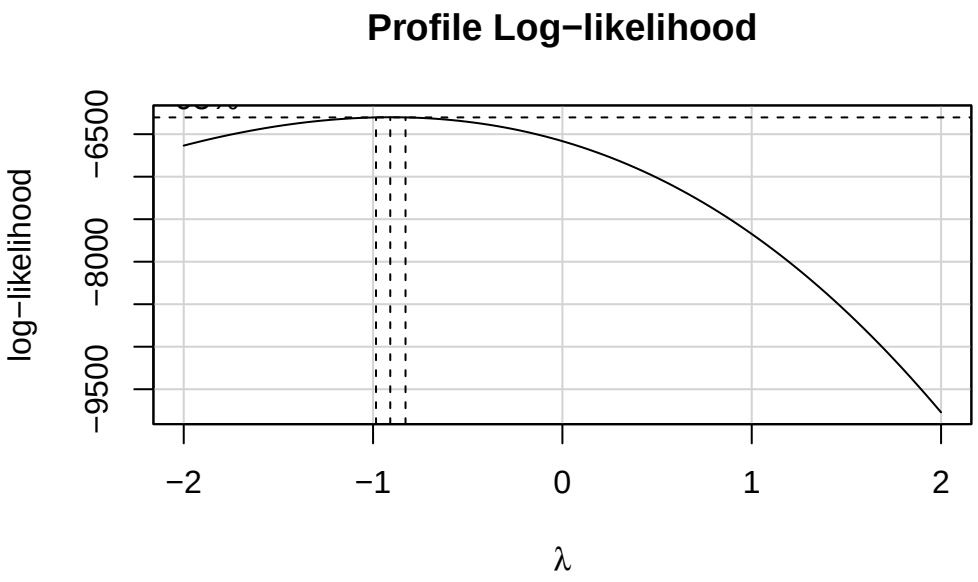

```
#### Cooks Distance looks pretty good
```

We needed a Box Cox transformation. This code gave us an optimal transformation.

```
f1
```

```
reg_vs ~ psla + elect_system + v2x_polyarchy + v2pariglef + v2papariah +
    v2paelcont
```

```
bc_results <- boxCox((reg_vs+.1) ~ psla + elect_system + v2x_polyarchy + v2pariglef + v2pa
                         v2paelcont)
```




```
#### It looks like we should mutate the DV and make it reg_vs^-1

dat_new <- dat %>%
  mutate(reg_vs = (reg_vs + .1)^(-1))
```

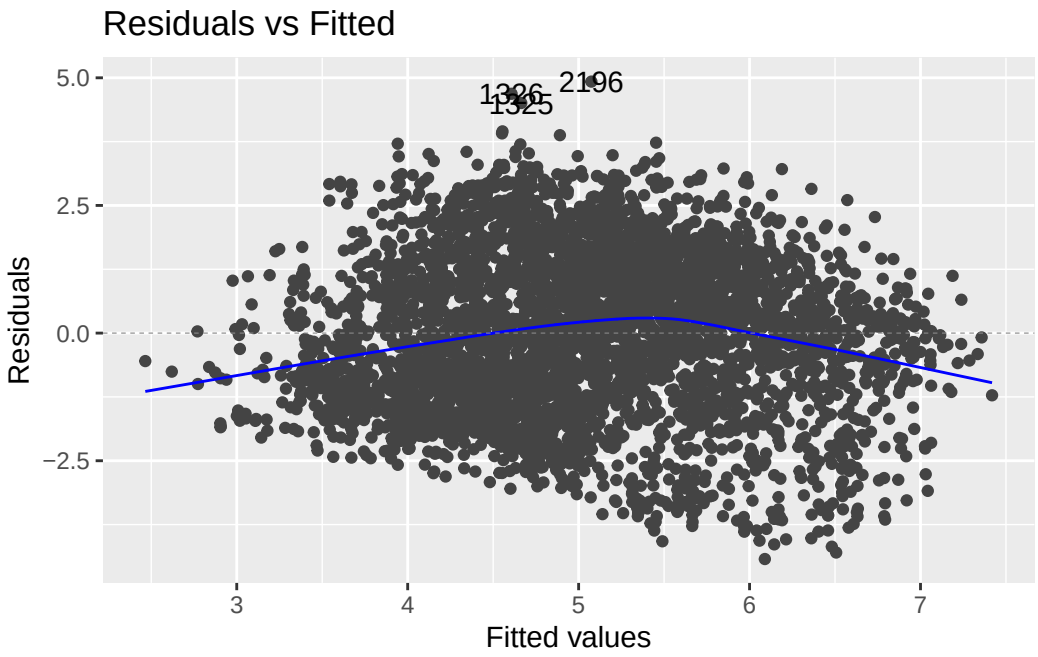
Recheck assumptions to see if this helped

```
attach(dat_new)
```

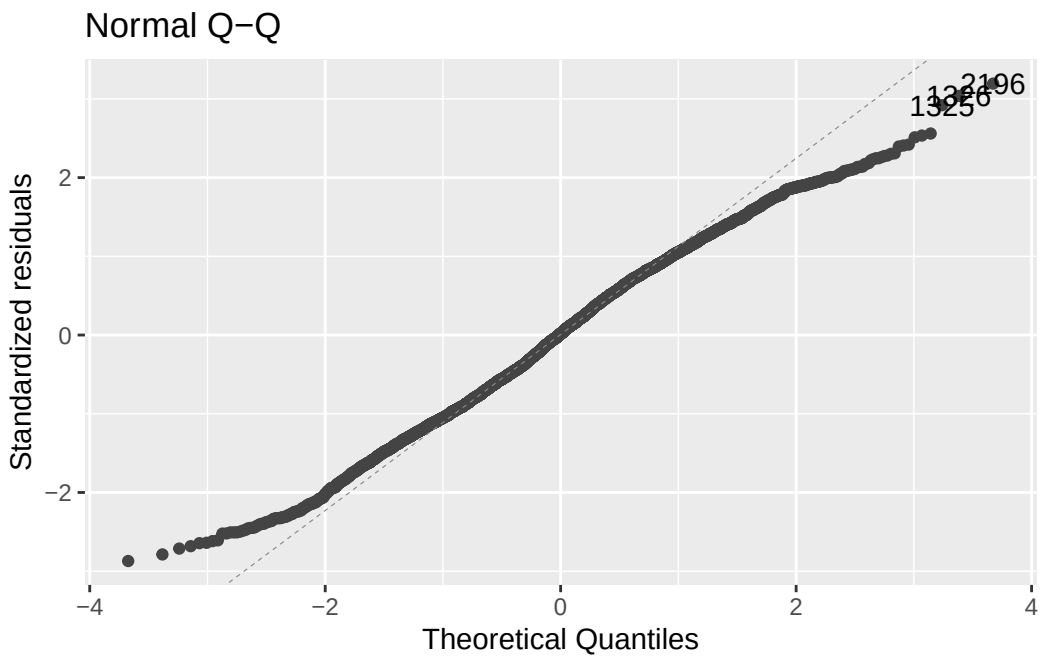
```
The following objects are masked from dat (pos = 3):

    COW, COWcode.x, elect_system, exe_elect, gov, leg_elect, piendla,
    psla, reg_vs, v2elcomvot, v2elparlel, v2eltrnout, v2eltype_0,
    v2eltype_6, v2elvaptrn, v2paelcont, v2pagovsup, v2papariah,
    v2pariglef, v2paseatshare, v2pavote, v2x_polyarchy,
    v2xpa_antiplural

The following objects are masked from dat_center:

    COW, COWcode.x, elect_system, exe_elect, gov, leg_elect, piendla,
    psla, reg_vs, v2elcomvot, v2elparlel, v2eltrnout, v2eltype_0,
```

```
    v2eltype_6, v2elvaptrn, v2paelcont, v2pagovsup, v2papariah,
    v2pariglef, v2paseatshare, v2pavote, v2x_polyarchy,
    v2xpa_antiplural

The following objects are masked from dat_new (pos = 5):

    COW, COWcode.x, elect_system, exe_elect, gov, leg_elect, piendla,
    psla, reg_vs, v2elcomvot, v2elparlel, v2eltrnout, v2eltype_0,
    v2eltype_6, v2elvaptrn, v2paelcont, v2pagovsup, v2papariah,
    v2pariglef, v2paseatshare, v2pavote, v2x_polyarchy,
    v2xpa_antiplural

The following objects are masked from dat (pos = 6):

    COW, COWcode.x, elect_system, exe_elect, gov, leg_elect, piendla,
    psla, reg_vs, v2elcomvot, v2elparlel, v2eltrnout, v2eltype_0,
    v2eltype_6, v2elvaptrn, v2paelcont, v2pagovsup, v2papariah,
    v2pariglef, v2paseatshare, v2pavote, v2x_polyarchy,
    v2xpa_antiplural
```

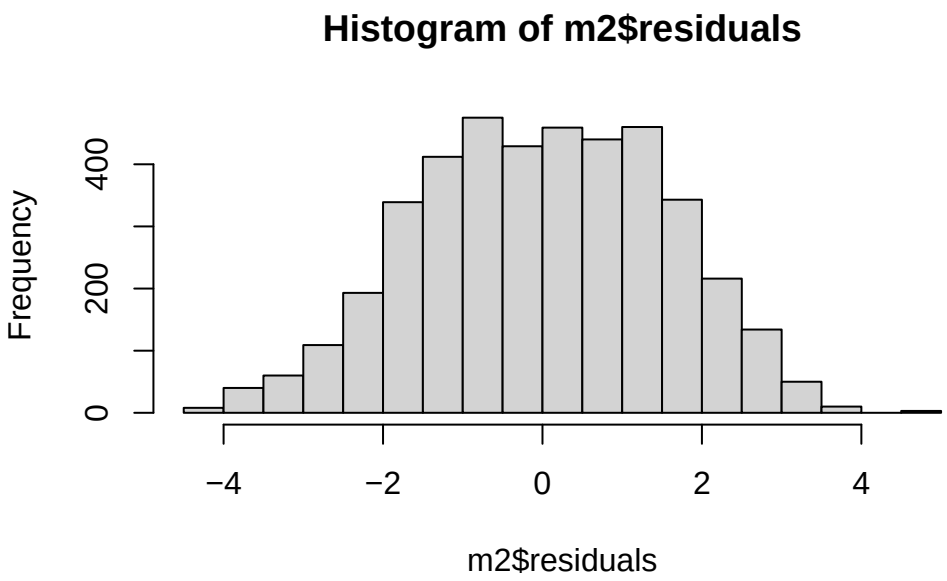
```r
m2 <- lm(f1)

autoplot(m2, which = 1, nrow = 1, ncol = 1)
```



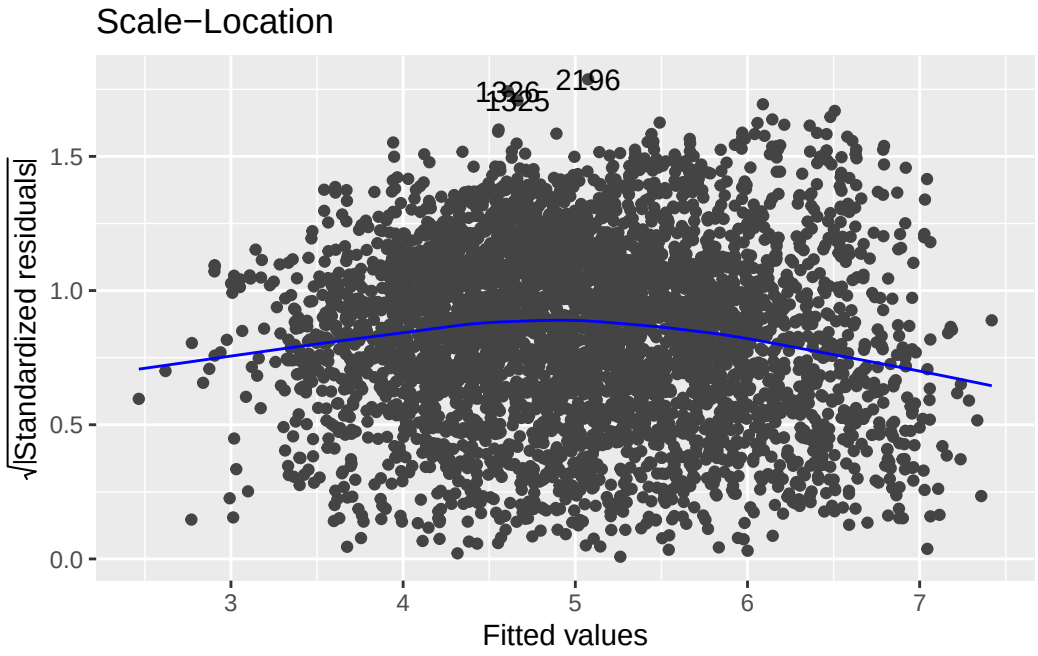

```
#### Linearity looks suprisingly good here.

autoplot(m2, which = 2, nrow = 1, ncol = 1)
```



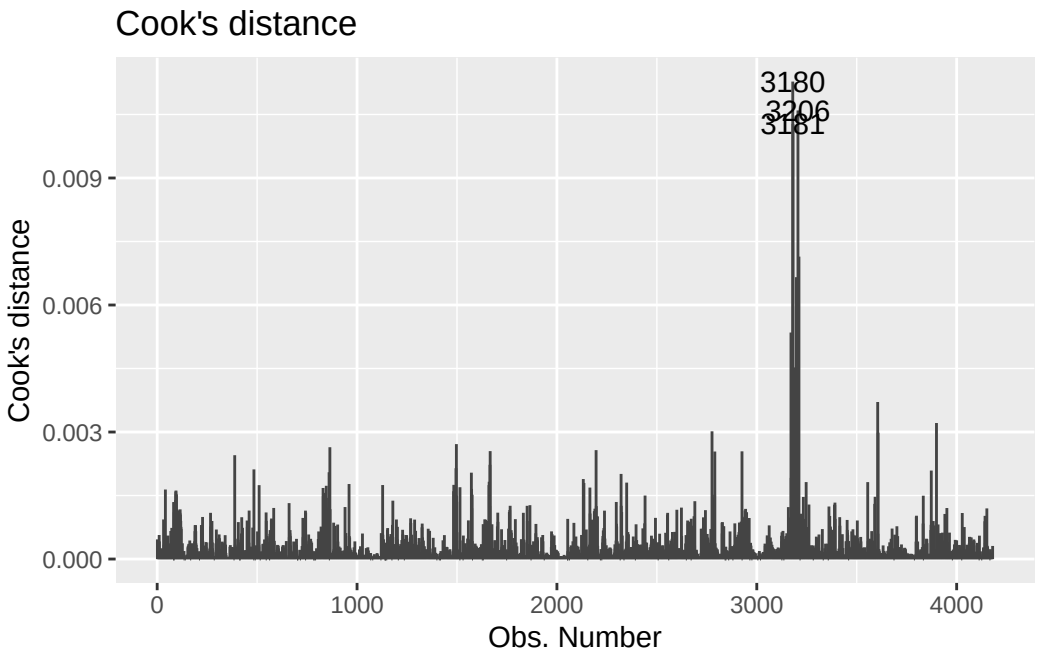

```
hist(m2$residuals)
```



```
#### Errors are more normal!

autoplot(m2, which = 3, nrow = 1, ncol = 1)
```




```
#### There might be some heterogeneity, but its pretty good here.

autoplot(m2, which = 4, nrow = 1, ncol = 1)
```




```
#### Cooks Distance looks pretty good
```

To ensure that we have the best model here, lets rerun this with the stepwise selection

```
base_model <- lm(reg_vs ~ 1)
full_model <- lm(reg_vs ~ elect_system + v2pariglef + psla + v2papariah + exe_elect + v2pa

forward <- step(base_model,
                direction = "forward",
                k = 2,
                scope = list(lower = base_model, upper = full_model))
```

```
Start:  AIC=4762.29
reg_vs ~ 1

                  Df Sum of Sq   RSS    AIC
+ psla             1   2667.60 10387 3808.8
+ v2paelcont       2    433.67 12621 4625.1
+ elect_system     3    181.05 12874 4709.9
+ v2pariglef       1     52.79 13002 4747.3
+ v2x_polyarchy    1     11.13 13043 4760.7
<none>                         13054 4762.3
```

```
+ exe_elect         1      3.77 13051 4763.1
+ v2xpa_antiplural  1      0.62 13054 4764.1
+ v2papariah        1      0.54 13054 4764.1

Step:  AIC=3808.79
reg_vs ~ psla

                   Df Sum of Sq   RSS    AIC
+ elect_system      3   233.272 10154 3719.8
+ v2pariglef        1   168.310 10219 3742.5
+ v2x_polyarchy     1    23.334 10364 3801.4
+ exe_elect         1    19.974 10367 3802.7
+ v2paelcont        2    17.099 10370 3805.9
+ v2xpa_antiplural  1     6.269 10381 3808.3
+ v2papariah        1     5.295 10382 3808.7
<none>                         10387 3808.8

Step:  AIC=3719.84
reg_vs ~ psla + elect_system

                   Df Sum of Sq     RSS    AIC
+ v2pariglef        1   155.227  9998.4 3657.4
+ v2x_polyarchy     1    34.550 10119.1 3707.6
+ v2papariah        1     9.198 10144.5 3718.1
+ v2paelcont        2    10.646 10143.0 3719.5
+ v2xpa_antiplural  1     5.253 10148.4 3719.7
<none>                         10153.7 3719.8
+ exe_elect         1     0.465 10153.2 3721.7

Step:  AIC=3657.45
reg_vs ~ psla + elect_system + v2pariglef

                   Df Sum of Sq    RSS    AIC
+ v2x_polyarchy     1    33.110 9965.3 3645.6
+ v2papariah        1    18.972 9979.5 3651.5
+ v2paelcont        2    12.374 9986.1 3656.3
<none>                         9998.4 3657.4
+ v2xpa_antiplural  1     0.957 9997.5 3659.0
+ exe_elect         1     0.017 9998.4 3659.4

Step:  AIC=3645.58
reg_vs ~ psla + elect_system + v2pariglef + v2x_polyarchy
```

```
                   Df Sum of Sq    RSS    AIC
+ v2xpa_antiplural  1   12.2209 9953.1 3642.5
+ v2paelcont        2   16.0779 9949.2 3642.8
+ v2papariah        1    9.3837 9955.9 3643.6
<none>                          9965.3 3645.6
+ exe_elect         1    0.9103 9964.4 3647.2

Step:  AIC=3642.45
reg_vs ~ psla + elect_system + v2pariglef + v2x_polyarchy + v2xpa_antiplural

             Df Sum of Sq    RSS    AIC
+ v2papariah  1    15.865 9937.2 3637.8
+ v2paelcont  2    17.252 9935.8 3639.2
<none>                    9953.1 3642.5
+ exe_elect   1     0.422 9952.7 3644.3

Step:  AIC=3637.79
reg_vs ~ psla + elect_system + v2pariglef + v2x_polyarchy + v2xpa_antiplural +
    v2papariah

             Df Sum of Sq    RSS    AIC
+ v2paelcont  2   17.6362 9919.6 3634.4
<none>                    9937.2 3637.8
+ exe_elect   1    0.5496 9936.7 3639.6

Step:  AIC=3634.36
reg_vs ~ psla + elect_system + v2pariglef + v2x_polyarchy + v2xpa_antiplural +
    v2papariah + v2paelcont

            Df Sum of Sq    RSS    AIC
<none>                   9919.6 3634.4
+ exe_elect  1    0.3452 9919.3 3636.2
```

```r
back <- step(full_model,
             direction = "backward",
             k = 2,
             scope = list(lower = base_model, upper = full_model))
```

```
Start:  AIC=3636.22
reg_vs ~ elect_system + v2pariglef + psla + v2papariah + exe_elect +
    v2paelcont + v2xpa_antiplural + v2x_polyarchy
```

```
                   Df Sum of Sq     RSS    AIC
- exe_elect         1      0.35  9919.6 3634.4
<none>                          9919.3 3636.2
- v2paelcont        2     17.43  9936.7 3639.6
- v2papariah        1     16.35  9935.6 3641.1
- v2xpa_antiplural  1     19.66  9938.9 3642.5
- v2x_polyarchy     1     47.08  9966.3 3654.0
- v2pariglef        1    176.83 10096.1 3708.1
- elect_system      3    223.39 10142.6 3723.3
- psla              1   2464.31 12383.6 4561.7

Step:  AIC=3634.36
reg_vs ~ elect_system + v2pariglef + psla + v2papariah + v2paelcont +
    v2xpa_antiplural + v2x_polyarchy

                   Df Sum of Sq     RSS    AIC
<none>                          9919.6 3634.4
- v2paelcont        2     17.64  9937.2 3637.8
- v2papariah        1     16.25  9935.8 3639.2
- v2xpa_antiplural  1     20.22  9939.8 3640.9
- v2x_polyarchy     1     46.73  9966.3 3652.0
- v2pariglef        1    176.51 10096.1 3706.1
- elect_system      3    234.15 10153.8 3725.9
- psla              1   2481.10 12400.7 4565.5
```

```r
both <- step(base_model,
             direction = "both",
             k = 2,
             scope = list(lower = base_model, upper = full_model))
```

```
Start:  AIC=4762.29
reg_vs ~ 1

                   Df Sum of Sq   RSS    AIC
+ psla              1   2667.60 10387 3808.8
+ v2paelcont        2    433.67 12621 4625.1
+ elect_system      3    181.05 12874 4709.9
+ v2pariglef        1     52.79 13002 4747.3
+ v2x_polyarchy     1     11.13 13043 4760.7
<none>                        13054 4762.3
```

```
+ exe_elect         1      3.77 13051 4763.1
+ v2xpa_antiplural  1      0.62 13054 4764.1
+ v2papariah        1      0.54 13054 4764.1

Step:  AIC=3808.79
reg_vs ~ psla

                   Df Sum of Sq   RSS    AIC
+ elect_system      3    233.27 10154 3719.8
+ v2pariglef        1    168.31 10219 3742.5
+ v2x_polyarchy     1     23.33 10364 3801.4
+ exe_elect         1     19.97 10367 3802.7
+ v2paelcont        2     17.10 10370 3805.9
+ v2xpa_antiplural  1      6.27 10381 3808.3
+ v2papariah        1      5.30 10382 3808.7
<none>                         10387 3808.8
- psla              1   2667.60 13054 4762.3

Step:  AIC=3719.84
reg_vs ~ psla + elect_system

                   Df Sum of Sq     RSS    AIC
+ v2pariglef        1    155.23  9998.4 3657.4
+ v2x_polyarchy     1     34.55 10119.1 3707.6
+ v2papariah        1      9.20 10144.5 3718.1
+ v2paelcont        2     10.65 10143.0 3719.5
+ v2xpa_antiplural  1      5.25 10148.4 3719.7
<none>                         10153.7 3719.8
+ exe_elect         1      0.46 10153.2 3721.7
- elect_system      3    233.27 10386.9 3808.8
- psla              1   2719.83 12873.5 4709.9

Step:  AIC=3657.45
reg_vs ~ psla + elect_system + v2pariglef

                   Df Sum of Sq     RSS    AIC
+ v2x_polyarchy     1     33.11  9965.3 3645.6
+ v2papariah        1     18.97  9979.5 3651.5
+ v2paelcont        2     12.37  9986.1 3656.3
<none>                         9998.4 3657.4
+ v2xpa_antiplural  1      0.96  9997.5 3659.0
+ exe_elect         1      0.02  9998.4 3659.4
- v2pariglef        1    155.23 10153.7 3719.8
```

```
- elect_system      3    220.19 10218.6 3742.5
- psla              1   2832.64 12831.1 4698.1

Step:  AIC=3645.58
reg_vs ~ psla + elect_system + v2pariglef + v2x_polyarchy

                   Df Sum of Sq     RSS    AIC
+ v2xpa_antiplural  1     12.22  9953.1 3642.5
+ v2paelcont        2     16.08  9949.2 3642.8
+ v2papariah        1      9.38  9955.9 3643.6
<none>                           9965.3 3645.6
+ exe_elect         1      0.91  9964.4 3647.2
- v2x_polyarchy     1     33.11  9998.4 3657.4
- v2pariglef        1    153.79 10119.1 3707.6
- elect_system      3    231.59 10196.9 3735.6
- psla              1   2852.78 12818.1 4695.9

Step:  AIC=3642.45
reg_vs ~ psla + elect_system + v2pariglef + v2x_polyarchy + v2xpa_antiplural

                   Df Sum of Sq     RSS    AIC
+ v2papariah        1     15.86  9937.2 3637.8
+ v2paelcont        2     17.25  9935.8 3639.2
<none>                           9953.1 3642.5
+ exe_elect         1      0.42  9952.7 3644.3
- v2xpa_antiplural  1     12.22  9965.3 3645.6
- v2x_polyarchy     1     44.37  9997.5 3659.0
- v2pariglef        1    162.52 10115.6 3708.2
- elect_system      3    237.38 10190.5 3735.0
- psla              1   2864.82 12817.9 4697.8

Step:  AIC=3637.79
reg_vs ~ psla + elect_system + v2pariglef + v2x_polyarchy + v2xpa_antiplural +
    v2papariah

                   Df Sum of Sq     RSS    AIC
+ v2paelcont        2     17.64  9919.6 3634.4
<none>                           9937.2 3637.8
+ exe_elect         1      0.55  9936.7 3639.6
- v2papariah        1     15.86  9953.1 3642.5
- v2xpa_antiplural  1     18.70  9955.9 3643.6
- v2x_polyarchy     1     42.00  9979.2 3653.4
- v2pariglef        1    173.83 10111.1 3708.3
```

```
- elect_system      3    242.90 10180.1 3732.7
- psla              1   2879.81 12817.0 4699.5

Step:  AIC=3634.36
reg_vs ~ psla + elect_system + v2pariglef + v2x_polyarchy + v2xpa_antiplural +
    v2papariah + v2paelcont

                   Df Sum of Sq     RSS    AIC
<none>                           9919.6 3634.4
+ exe_elect         1      0.35  9919.3 3636.2
- v2paelcont        2     17.64  9937.2 3637.8
- v2papariah        1     16.25  9935.8 3639.2
- v2xpa_antiplural  1     20.22  9939.8 3640.9
- v2x_polyarchy     1     46.73  9966.3 3652.0
- v2pariglef        1    176.51 10096.1 3706.1
- elect_system      3    234.15 10153.8 3725.9
- psla              1   2481.10 12400.7 4565.5
```

```
forward
```

```
Call:
lm(formula = reg_vs ~ psla + elect_system + v2pariglef + v2x_polyarchy +
    v2xpa_antiplural + v2papariah + v2paelcont)

Coefficients:
     (Intercept)              psla     elect_system1     elect_system2
         6.87189          -4.27579          -0.39810          -0.58638
   elect_system3        v2pariglef     v2x_polyarchy  v2xpa_antiplural
        -1.10528          -0.14492           0.65962           0.32292
      v2papariah       v2paelcont1       v2paelcont2
         0.04857           0.14113           0.22338
```

```
back
```

```
Call:
lm(formula = reg_vs ~ elect_system + v2pariglef + psla + v2papariah +
    v2paelcont + v2xpa_antiplural + v2x_polyarchy)
```

```
Coefficients:
     (Intercept)     elect_system1     elect_system2     elect_system3
         6.87189          -0.39810          -0.58638          -1.10528
      v2pariglef              psla        v2papariah       v2paelcont1
         -0.14492          -4.27579           0.04857           0.14113
     v2paelcont2  v2xpa_antiplural     v2x_polyarchy
         0.22338           0.32292           0.65962
```

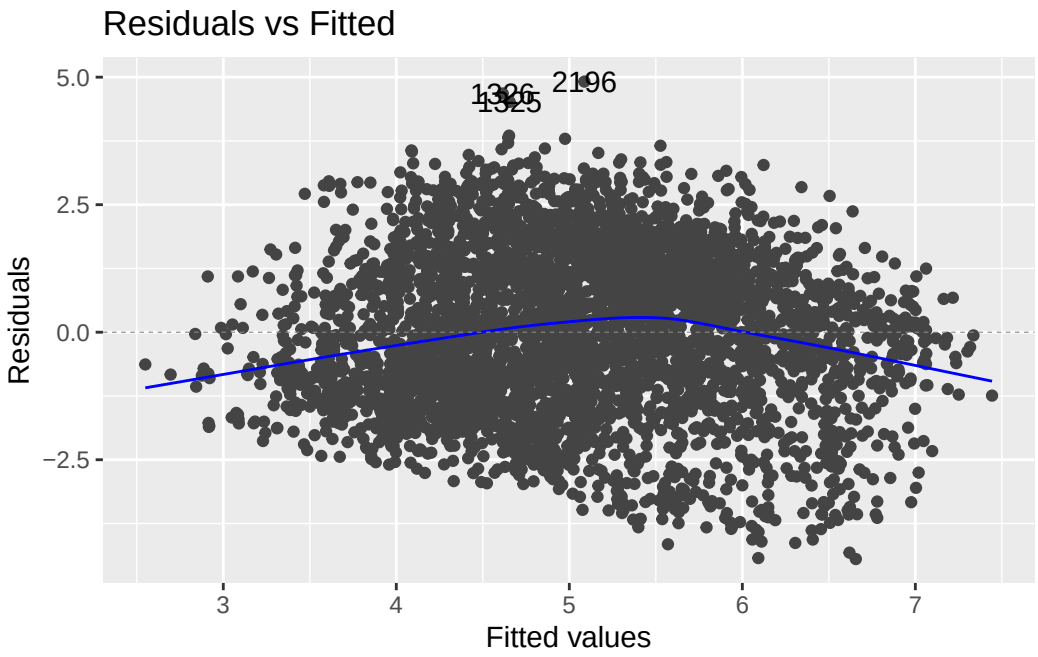
```
both
```

```
Call:
lm(formula = reg_vs ~ psla + elect_system + v2pariglef + v2x_polyarchy +
    v2xpa_antiplural + v2papariah + v2paelcont)

Coefficients:
     (Intercept)              psla     elect_system1     elect_system2
         6.87189          -4.27579          -0.39810          -0.58638
   elect_system3        v2pariglef     v2x_polyarchy  v2xpa_antiplural
        -1.10528          -0.14492           0.65962           0.32292
      v2papariah       v2paelcont1       v2paelcont2
         0.04857           0.14113           0.22338
```

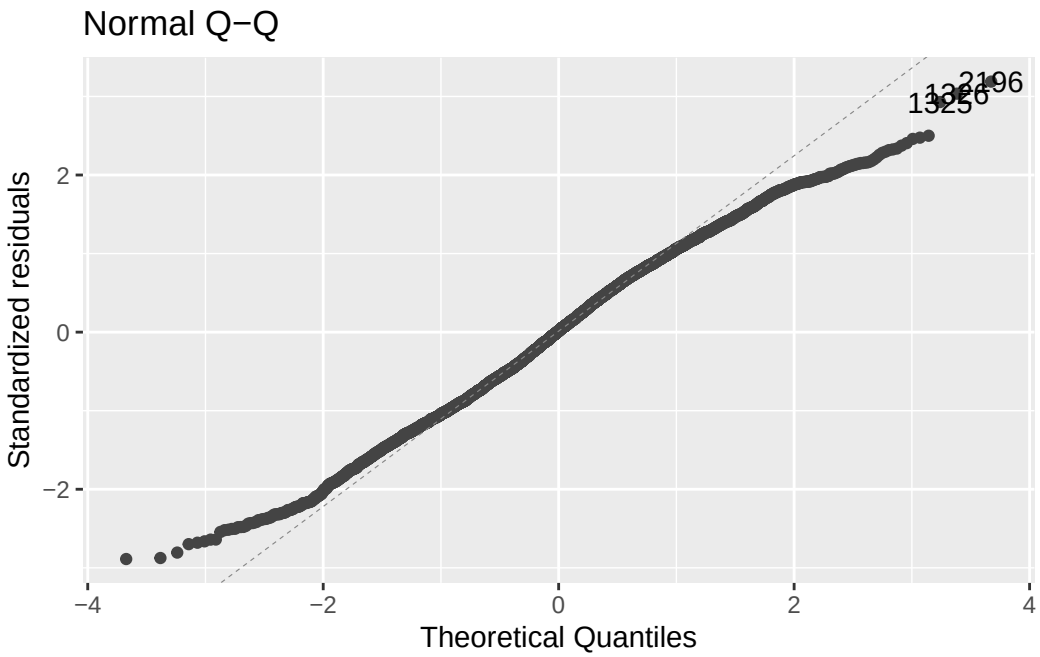
```
#### All of the selection methods choose this model, so we will go with that:

f2 <- reg_vs ~ psla + elect_system + v2pariglef + v2x_polyarchy +
  v2xpa_antiplural + v2papariah + v2paelcont
```

Recheck assumptions to see if the model is up to snuff.

```
m3 <- lm(f2)

autoplot(m3, which = 1, nrow = 1, ncol = 1)
```



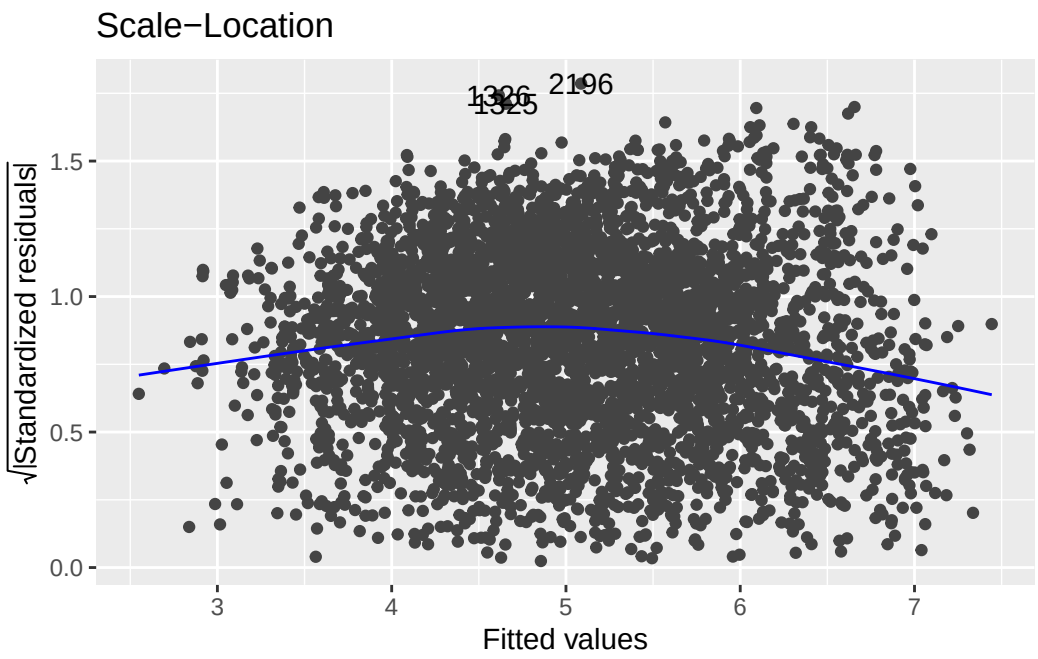

```
#### Linearity looks good here.

autoplot(m3, which = 2, nrow = 1, ncol = 1)
```



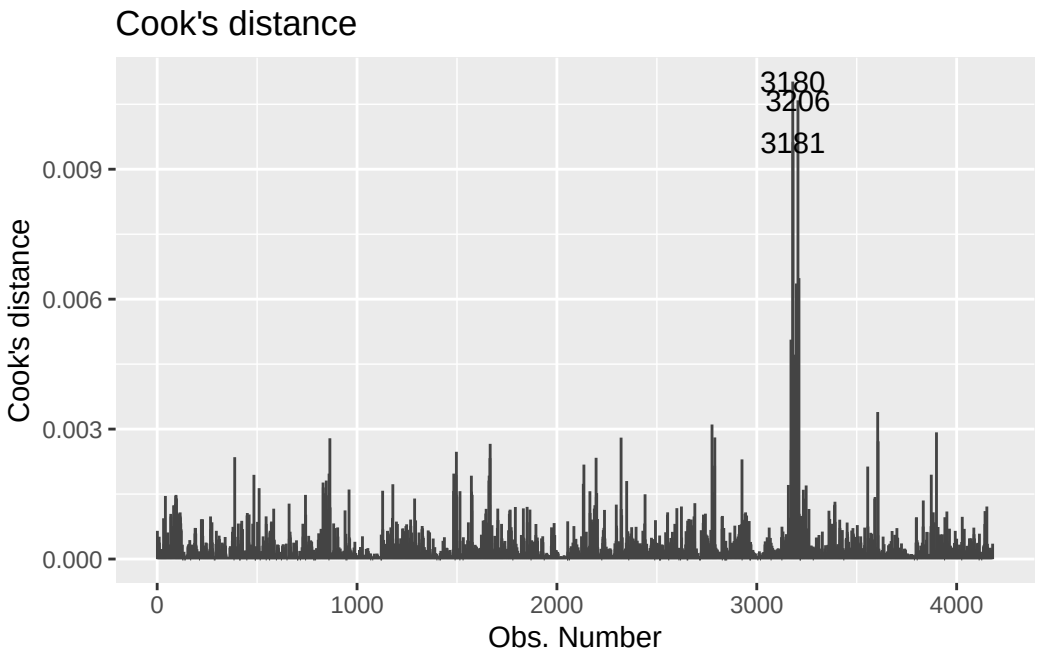

```
shapiro.test(m3$residuals)
```

```
    Shapiro-Wilk normality test

data:  m3$residuals
W = 0.99383, p-value = 2.093e-12
```

```
#### Errors are more normal than the other models. Best we are probaly going to get.

autoplot(m3, which = 3, nrow = 1, ncol = 1)
```




```
#### There might be some heterogeneity, but its pretty good here.

autoplot(m3, which = 4, nrow = 1, ncol = 1)
```




```
#### no outliers

car::vif(m3)
```

```
                    GVIF Df GVIF^(1/(2*Df))
psla            1.208220  1        1.099191
elect_system    1.097085  3        1.015563
v2pariglef      1.055315  1        1.027285
v2x_polyarchy   1.812839  1        1.346417
v2xpa_antiplural 1.862623  1        1.364779
v2papariah      1.150434  1        1.072583
v2paelcont      1.174909  2        1.041121
```

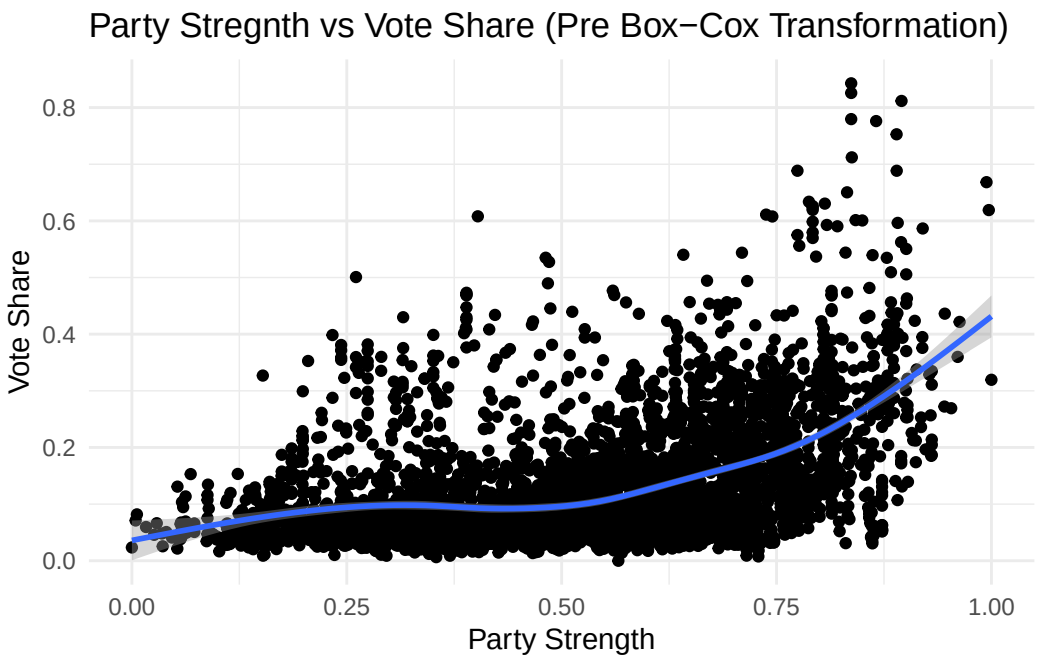
```
#### No multicolinearity!
```

Now for exploratory data analysis

```
ggplot(data = dat, aes(x = psla, y = reg_vs)) +
  geom_point() +
  geom_smooth() +
  labs(title = "Party Stregnth vs Vote Share (Pre Box-Cox Transformation)", x = "Party Str
```

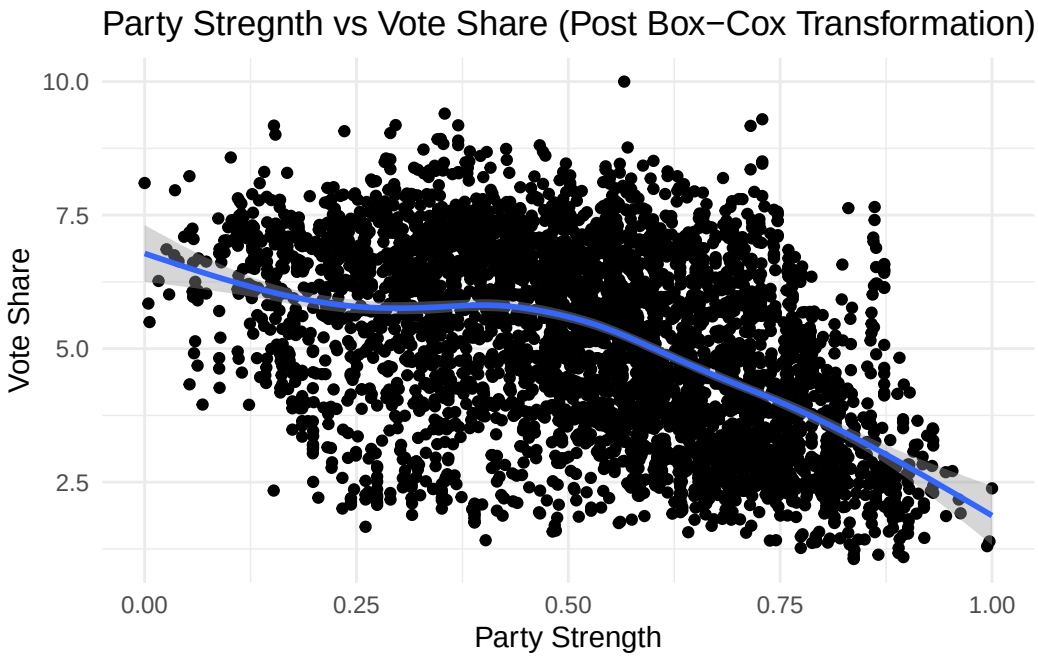
```
    theme_minimal()
```

```
`geom_smooth()` using method = 'gam' and formula = 'y ~ s(x, bs = "cs")'
```



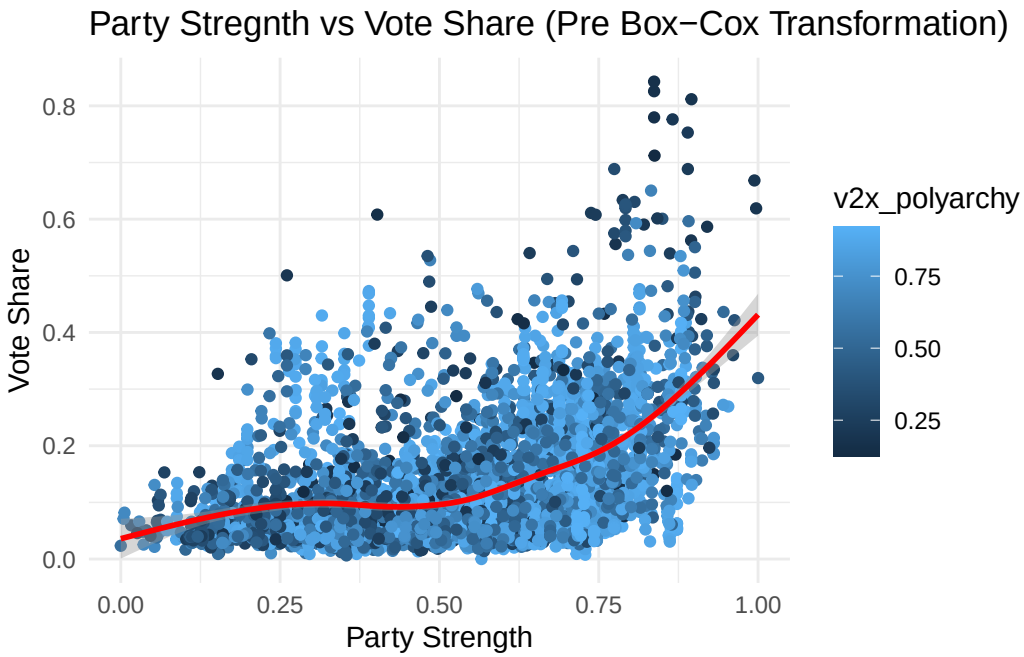

```
ggplot(data = dat_new, aes(x = psla, y = reg_vs)) +
  geom_point() +
  geom_smooth() +
  labs(title = "Party Stregnth vs Vote Share (Post Box-Cox Transformation)", x = "Party St
  theme_minimal()
```

```
`geom_smooth()` using method = 'gam' and formula = 'y ~ s(x, bs = "cs")'
```



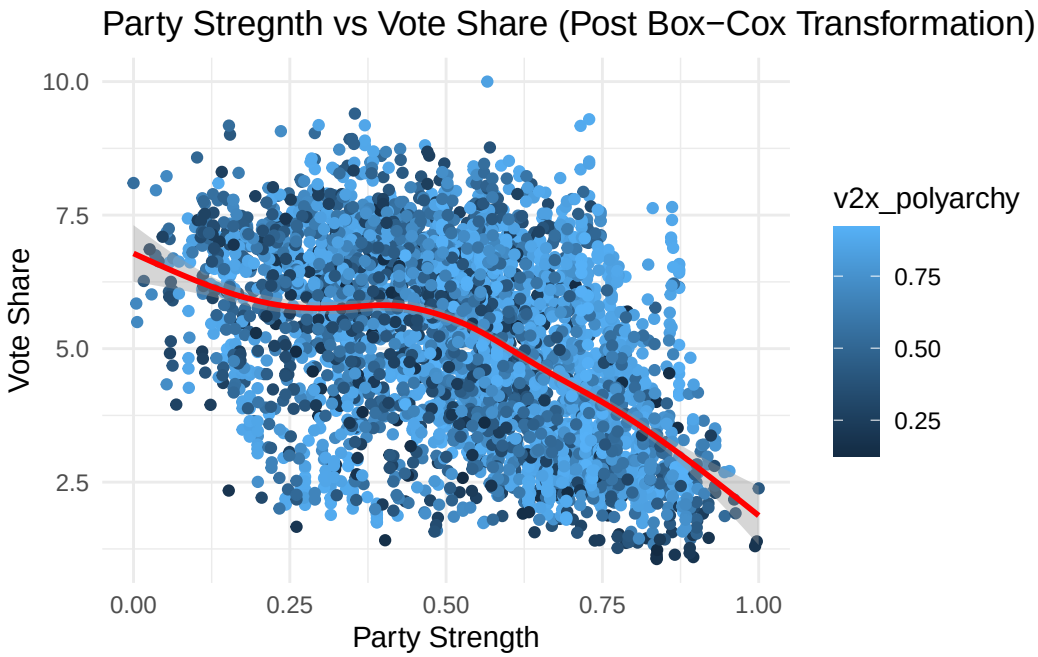

```
#### for Question 2

ggplot(data = dat, aes(x = psla, y = reg_vs)) +
  geom_point(aes(color = v2x_polyarchy)) +
  geom_smooth(color = "red") +
  labs(title = "Party Stregnth vs Vote Share (Pre Box-Cox Transformation)", x = "Party Str
  theme_minimal()
```

```
`geom_smooth()` using method = 'gam' and formula = 'y ~ s(x, bs = "cs")'
```

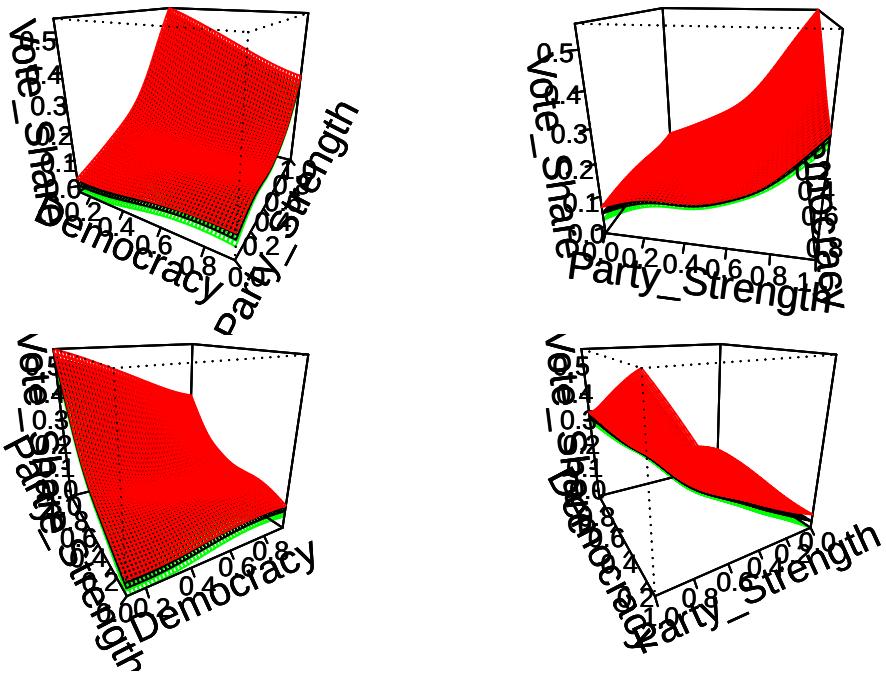



```
ggplot(data = dat_new, aes(x = psla, y = reg_vs)) +
  geom_point(aes(color = v2x_polyarchy)) +
  geom_smooth(color = "red") +
  labs(title = "Party Stregnth vs Vote Share (Post Box-Cox Transformation)", x = "Party St
  theme_minimal()
```

```
`geom_smooth()` using method = 'gam' and formula = 'y ~ s(x, bs = "cs")'
```




```
dat_interflex <- dat %>%
  rename(Democracy = v2x_polyarchy, Vote_Share = reg_vs, Party_Strength = psla)

interflex(estimator = "gam", Y = "Vote_Share", X = "Party_Strength", D = "Democracy", data
```




```
Family: gaussian
Link function: identity

Formula:
Vote_Share ~ s(Democracy, Party_Strength, k = 10)

Estimated degrees of freedom:
8.83  total = 9.83

GCV score: 0.008689635
```

Regression models

```
summary(m3) #### OLS
```

```
Call:
lm(formula = f2)

Residuals:
```

```
    Min      1Q  Median      3Q     Max
-4.4470 -1.1404  0.0217  1.1804  4.9130

Coefficients:
                 Estimate Std. Error t value Pr(>|t|)
(Intercept)       6.87189    0.14306  48.036  < 2e-16 ***
psla             -4.27579    0.13241 -32.292  < 2e-16 ***
elect_system1    -0.39810    0.07956  -5.003 5.86e-07 ***
elect_system2    -0.58638    0.07041  -8.328  < 2e-16 ***
elect_system3    -1.10528    0.27151  -4.071 4.77e-05 ***
v2pariglef       -0.14492    0.01683  -8.613  < 2e-16 ***
v2x_polyarchy     0.65962    0.14883   4.432 9.58e-06 ***
v2xpa_antiplural  0.32292    0.11077   2.915  0.00357 **
v2papariah        0.04857    0.01859   2.613  0.00900 **
v2paelcont1       0.14113    0.07382   1.912  0.05596 .
v2paelcont2       0.22338    0.10421   2.144  0.03212 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 1.543 on 4169 degrees of freedom
Multiple R-squared:  0.2401,    Adjusted R-squared:  0.2383
F-statistic: 131.8 on 10 and 4169 DF,  p-value: < 2.2e-16
```

```r
#### Good F stat and r squared value is about what is industry standard for poli sci. Most

#### partial F test here

#### How important is the effect of party strength

m3 <- lm(reg_vs ~ psla + elect_system + v2pariglef + v2x_polyarchy + v2xpa_antiplural + v2

m4 <- lm(reg_vs ~ elect_system + v2pariglef + v2x_polyarchy + v2xpa_antiplural + v2paparia

anova(m4, m3) #### Party strength is really important
```

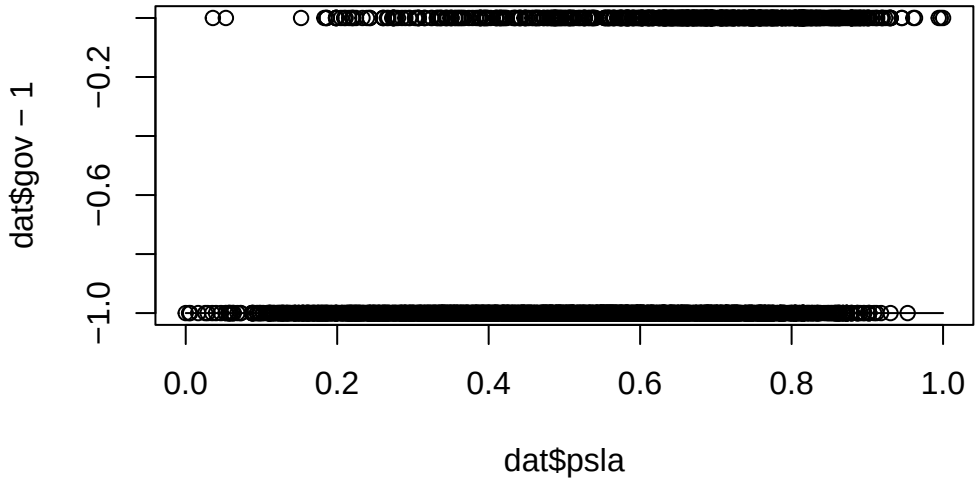
```
Analysis of Variance Table

Model 1: reg_vs ~ elect_system + v2pariglef + v2x_polyarchy + v2xpa_antiplural +
    v2papariah + v2paelcont
Model 2: reg_vs ~ psla + elect_system + v2pariglef + v2x_polyarchy + v2xpa_antiplural +
    v2papariah + v2paelcont
```

```
  Res.Df     RSS Df Sum of Sq      F    Pr(>F)
1   4170 12400.7
2   4169  9919.6  1    2481.1 1042.8 < 2.2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

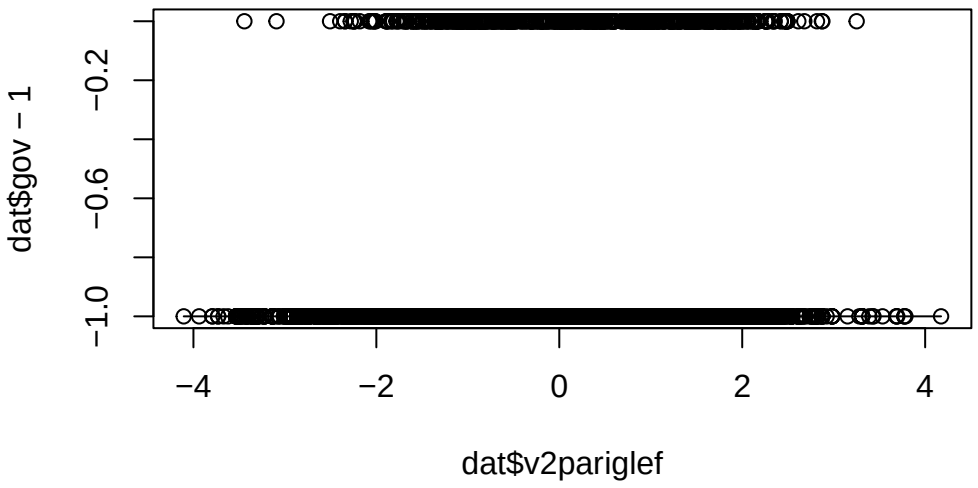
Logit model. Mostly a robustness check, so we did not go too crazy here.

```
robust <- glm(gov ~ psla + elect_system + v2pariglef + v2x_polyarchy + v2xpa_antiplural +
```

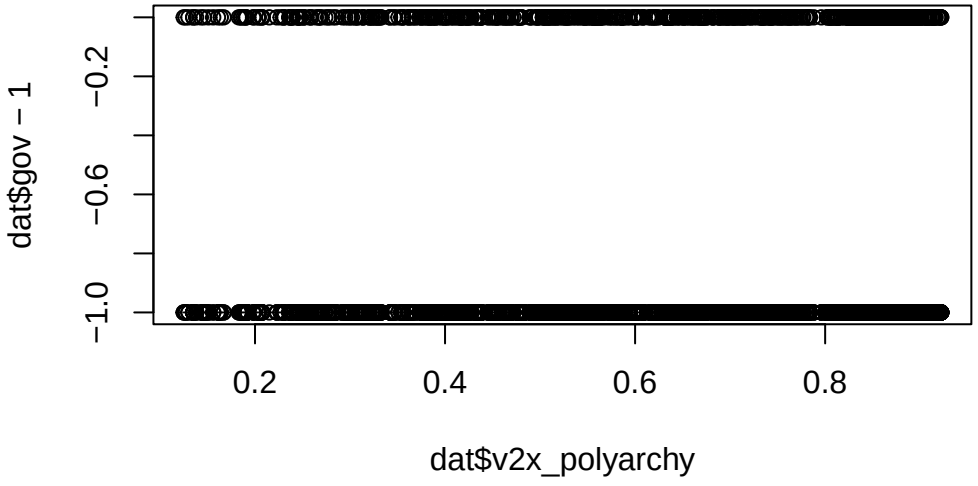
```
scatter.smooth(x = dat$psla, y = dat$gov - 1)
```



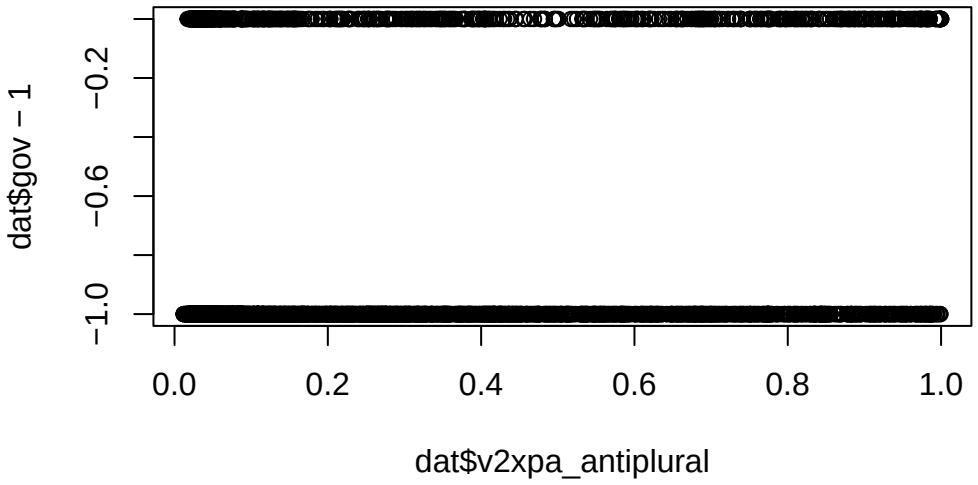

```
scatter.smooth(x = dat$v2pariglef, y = dat$gov - 1)
```



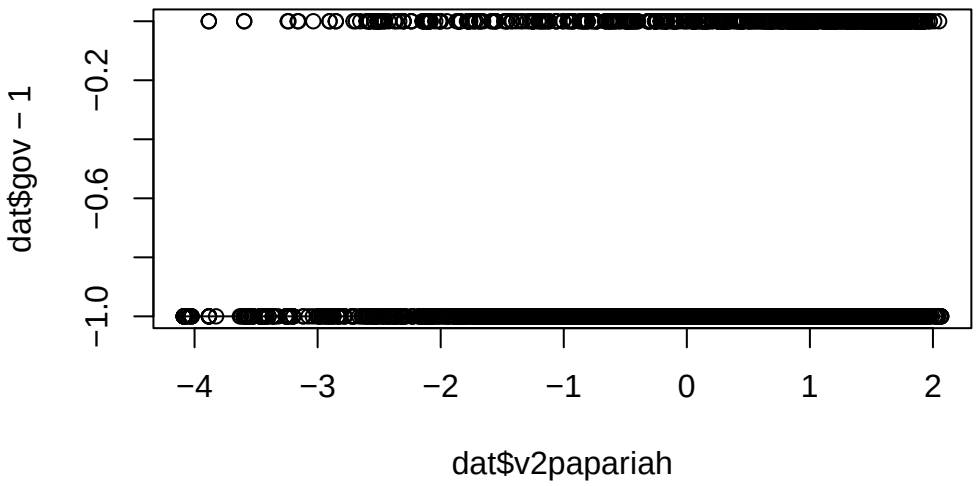

```
scatter.smooth(x = dat$v2x_polyarchy, y = dat$gov - 1)
```



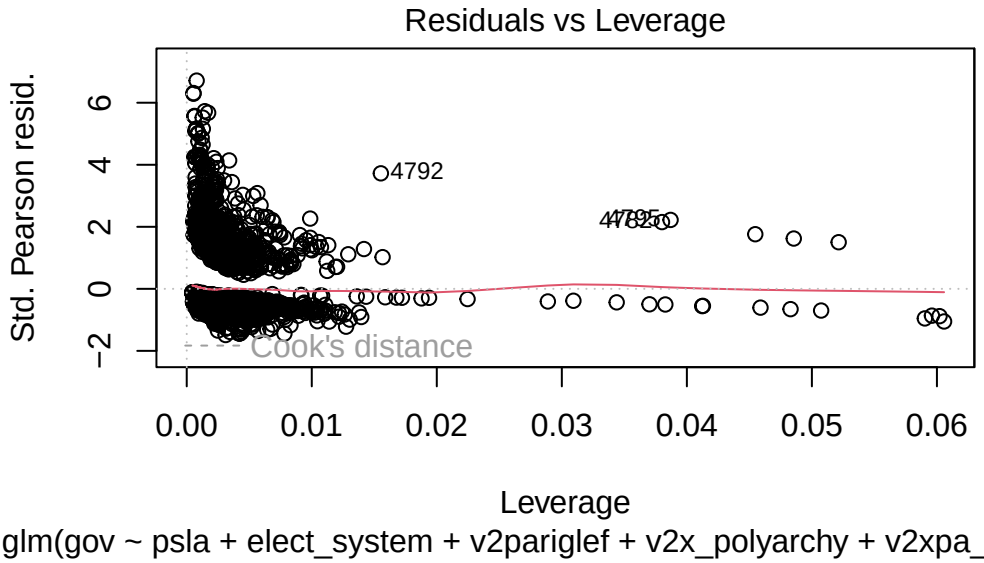
```r
scatter.smooth(x = dat$v2xpa_antiplural, y = dat$gov - 1)
```




```r
scatter.smooth(x = dat$v2papariah, y = dat$gov - 1)
```




```
plot(robust, which = 5, cook.levels = .5)
```



```r
vif(robust)
```

```
                    GVIF Df GVIF^(1/(2*Df))
psla            1.211162  1        1.100528
elect_system    1.100599  3        1.016104
v2pariglef      1.052634  1        1.025980
v2x_polyarchy   2.011111  1        1.418136
v2xpa_antiplural 2.066863  1        1.437659
v2papariah      1.191706  1        1.091653
v2paelcont      1.157573  2        1.037259
```

```r
summary(robust)
```

```
Call:
glm(formula = gov ~ psla + elect_system + v2pariglef + v2x_polyarchy +
    v2xpa_antiplural + v2papariah + v2paelcont, family = binomial(link = "logit"),
    data = dat_new)

Coefficients:
                 Estimate Std. Error z value Pr(>|z|)
(Intercept)      -4.30413    0.28253 -15.234  < 2e-16 ***
psla              5.07036    0.27394  18.509  < 2e-16 ***
elect_system1    -0.14543    0.13275  -1.096 0.273263
elect_system2     0.15582    0.12720   1.225 0.220562
elect_system3     0.37756    0.48677   0.776 0.437966
v2pariglef        0.20123    0.02996   6.716 1.87e-11 ***
v2x_polyarchy    -0.53430    0.27120  -1.970 0.048829 *
v2xpa_antiplural  0.77461    0.19129   4.049 5.13e-05 ***
v2papariah        0.12071    0.03429   3.520 0.000431 ***
v2paelcont1       0.20006    0.14613   1.369 0.170983
v2paelcont2      -0.23430    0.19653  -1.192 0.233195
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 4175.0  on 4179  degrees of freedom
Residual deviance: 3635.6  on 4169  degrees of freedom
AIC: 3657.6
```

```
Number of Fisher Scoring iterations: 5
```

Model selection and assumption check for interaction model

```
attach(dat_center)
```

```
The following objects are masked from dat_new (pos = 3):

    COW, COWcode.x, elect_system, exe_elect, gov, leg_elect, piendla,
    psla, reg_vs, v2elcomvot, v2elparlel, v2eltrnout, v2eltype_0,
    v2eltype_6, v2elvaptrn, v2paelcont, v2pagovsup, v2papariah,
    v2pariglef, v2paseatshare, v2pavote, v2x_polyarchy,
    v2xpa_antiplural

The following objects are masked from dat (pos = 4):

    COW, COWcode.x, elect_system, exe_elect, gov, leg_elect, piendla,
    psla, reg_vs, v2elcomvot, v2elparlel, v2eltrnout, v2eltype_0,
    v2eltype_6, v2elvaptrn, v2paelcont, v2pagovsup, v2papariah,
    v2pariglef, v2paseatshare, v2pavote, v2x_polyarchy,
    v2xpa_antiplural

The following objects are masked from dat_center (pos = 5):

    COW, COWcode.x, elect_system, exe_elect, gov, leg_elect, piendla,
    psla, reg_vs, v2elcomvot, v2elparlel, v2eltrnout, v2eltype_0,
    v2eltype_6, v2elvaptrn, v2paelcont, v2pagovsup, v2papariah,
    v2pariglef, v2paseatshare, v2pavote, v2x_polyarchy,
    v2xpa_antiplural

The following objects are masked from dat_new (pos = 6):

    COW, COWcode.x, elect_system, exe_elect, gov, leg_elect, piendla,
    psla, reg_vs, v2elcomvot, v2elparlel, v2eltrnout, v2eltype_0,
    v2eltype_6, v2elvaptrn, v2paelcont, v2pagovsup, v2papariah,
    v2pariglef, v2paseatshare, v2pavote, v2x_polyarchy,
    v2xpa_antiplural
```

```
The following objects are masked from dat (pos = 7):

    COW, COWcode.x, elect_system, exe_elect, gov, leg_elect, piendla,
    psla, reg_vs, v2elcomvot, v2elparlel, v2eltrnout, v2eltype_0,
    v2eltype_6, v2elvaptrn, v2paelcont, v2pagovsup, v2papariah,
    v2pariglef, v2paseatshare, v2pavote, v2x_polyarchy,
    v2xpa_antiplural
```

```r
base_model <- lm(reg_vs ~ psla*v2x_polyarchy)
full_model <- lm(reg_vs ~ elect_system + v2pariglef + v2papariah + exe_elect + v2paelcont

forward <- step(base_model,
                direction = "forward",
                k = 2,
                scope = list(lower = base_model, upper = full_model))
```

```
Start:  AIC=3785.96
reg_vs ~ psla * v2x_polyarchy

                  Df Sum of Sq   RSS    AIC
+ elect_system     3   231.152 10089 3697.3
+ v2pariglef       1   162.537 10158 3721.6
+ v2paelcont       2    20.017 10300 3781.8
+ exe_elect        1    10.017 10310 3783.9
<none>                         10320 3786.0
+ v2xpa_antiplural 1     3.646 10317 3786.5
+ v2papariah       1     0.577 10320 3787.7

Step:  AIC=3697.28
reg_vs ~ psla + v2x_polyarchy + elect_system + psla:v2x_polyarchy

                  Df Sum of Sq     RSS    AIC
+ v2pariglef       1   151.032  9938.3 3636.2
+ v2paelcont       2    13.069 10076.3 3695.9
+ v2xpa_antiplural 1     7.819 10081.5 3696.0
<none>                         10089.3 3697.3
+ v2papariah       1     1.869 10087.5 3698.5
+ exe_elect        1     0.571 10088.8 3699.0

Step:  AIC=3636.23
reg_vs ~ psla + v2x_polyarchy + elect_system + v2pariglef + psla:v2x_polyarchy
```

```
                   Df Sum of Sq    RSS    AIC
+ v2xpa_antiplural  1   19.3215 9919.0 3630.1
+ v2paelcont        2   14.8828 9923.4 3634.0
+ v2papariah        1    7.5694 9930.7 3635.0
<none>                          9938.3 3636.2
+ exe_elect         1    1.6232 9936.7 3637.5

Step:  AIC=3630.1
reg_vs ~ psla + v2x_polyarchy + elect_system + v2pariglef + v2xpa_antiplural +
    psla:v2x_polyarchy

             Df Sum of Sq    RSS    AIC
+ v2papariah  1   14.7577 9904.2 3625.9
+ v2paelcont  2   16.1174 9902.9 3627.3
<none>                    9919.0 3630.1
+ exe_elect   1    0.8634 9918.1 3631.7

Step:  AIC=3625.87
reg_vs ~ psla + v2x_polyarchy + elect_system + v2pariglef + v2xpa_antiplural +
    v2papariah + psla:v2x_polyarchy

             Df Sum of Sq    RSS    AIC
+ v2paelcont  2   16.4699 9887.7 3622.9
<none>                    9904.2 3625.9
+ exe_elect   1    1.0269 9903.2 3627.4

Step:  AIC=3622.92
reg_vs ~ psla + v2x_polyarchy + elect_system + v2pariglef + v2xpa_antiplural +
    v2papariah + v2paelcont + psla:v2x_polyarchy

            Df Sum of Sq    RSS    AIC
<none>                   9887.7 3622.9
+ exe_elect  1   0.74024 9887.0 3624.6
```

```r
back <- step(full_model,
             direction = "backward",
             k = 2,
             scope = list(lower = base_model, upper = full_model))
```

```
Start:  AIC=3624.6
```

```
reg_vs ~ elect_system + v2pariglef + v2papariah + exe_elect +
    v2paelcont + v2xpa_antiplural + psla * v2x_polyarchy

                   Df Sum of Sq     RSS    AIC
- exe_elect         1     0.740  9887.7 3622.9
<none>                          9887.0 3624.6
- v2paelcont        2    16.183  9903.2 3627.4
- v2papariah        1    15.246  9902.2 3629.0
- v2xpa_antiplural  1    27.219  9914.2 3634.1
- v2pariglef        1   176.493 10063.5 3696.6
- elect_system      3   215.908 10102.9 3708.9

Step:  AIC=3622.92
reg_vs ~ elect_system + v2pariglef + v2papariah + v2paelcont +
    v2xpa_antiplural + psla + v2x_polyarchy + psla:v2x_polyarchy

                   Df Sum of Sq     RSS    AIC
<none>                          9887.7 3622.9
- v2paelcont        2    16.470  9904.2 3625.9
- v2papariah        1    15.110  9902.9 3627.3
- v2xpa_antiplural  1    28.036  9915.8 3632.8
- v2pariglef        1   175.924 10063.7 3694.6
- elect_system      3   223.792 10111.5 3710.5
```

```r
both <- step(base_model,
             direction = "both",
             k = 2,
             scope = list(lower = base_model, upper = full_model))
```

```
Start:  AIC=3785.96
reg_vs ~ psla * v2x_polyarchy

                   Df Sum of Sq   RSS    AIC
+ elect_system      3   231.152 10089 3697.3
+ v2pariglef        1   162.537 10158 3721.6
+ v2paelcont        2    20.017 10300 3781.8
+ exe_elect         1    10.017 10310 3783.9
<none>                         10320 3786.0
+ v2xpa_antiplural  1     3.646 10317 3786.5
+ v2papariah        1     0.577 10320 3787.7
```

```
Step:  AIC=3697.28
reg_vs ~ psla + v2x_polyarchy + elect_system + psla:v2x_polyarchy

                   Df Sum of Sq     RSS    AIC
+ v2pariglef        1   151.032  9938.3 3636.2
+ v2paelcont        2    13.069 10076.3 3695.9
+ v2xpa_antiplural  1     7.819 10081.5 3696.0
<none>                          10089.3 3697.3
+ v2papariah        1     1.869 10087.5 3698.5
+ exe_elect         1     0.571 10088.8 3699.0
- elect_system      3   231.152 10320.5 3786.0

Step:  AIC=3636.23
reg_vs ~ psla + v2x_polyarchy + elect_system + v2pariglef + psla:v2x_polyarchy

                   Df Sum of Sq     RSS    AIC
+ v2xpa_antiplural  1    19.321  9919.0 3630.1
+ v2paelcont        2    14.883  9923.4 3634.0
+ v2papariah        1     7.569  9930.7 3635.0
<none>                          9938.3 3636.2
+ exe_elect         1     1.623  9936.7 3637.5
- v2pariglef        1   151.032 10089.3 3697.3
- elect_system      3   219.648 10157.9 3721.6

Step:  AIC=3630.1
reg_vs ~ psla + v2x_polyarchy + elect_system + v2pariglef + v2xpa_antiplural +
    psla:v2x_polyarchy

                   Df Sum of Sq     RSS    AIC
+ v2papariah        1    14.758  9904.2 3625.9
+ v2paelcont        2    16.117  9902.9 3627.3
<none>                          9919.0 3630.1
+ exe_elect         1     0.863  9918.1 3631.7
- v2xpa_antiplural  1    19.321  9938.3 3636.2
- v2pariglef        1   162.535 10081.5 3696.0
- elect_system      3   225.853 10144.8 3718.2

Step:  AIC=3625.87
reg_vs ~ psla + v2x_polyarchy + elect_system + v2pariglef + v2xpa_antiplural +
    v2papariah + psla:v2x_polyarchy

                   Df Sum of Sq     RSS    AIC
+ v2paelcont        2    16.470  9887.7 3622.9
```

```
<none>                           9904.2 3625.9
+ exe_elect         1     1.027  9903.2 3627.4
- v2papariah        1    14.758  9919.0 3630.1
- v2xpa_antiplural  1    26.510  9930.7 3635.0
- v2pariglef        1   173.321 10077.5 3696.4
- elect_system      3   231.168 10135.4 3716.3

Step:  AIC=3622.92
reg_vs ~ psla + v2x_polyarchy + elect_system + v2pariglef + v2xpa_antiplural +
    v2papariah + v2paelcont + psla:v2x_polyarchy

                  Df Sum of Sq     RSS    AIC
<none>                          9887.7 3622.9
+ exe_elect        1     0.740  9887.0 3624.6
- v2paelcont       2    16.470  9904.2 3625.9
- v2papariah       1    15.110  9902.9 3627.3
- v2xpa_antiplural 1    28.036  9915.8 3632.8
- v2pariglef       1   175.924 10063.7 3694.6
- elect_system     3   223.792 10111.5 3710.5
```

```
forward
```

```
Call:
lm(formula = reg_vs ~ psla + v2x_polyarchy + elect_system + v2pariglef +
    v2xpa_antiplural + v2papariah + v2paelcont + psla:v2x_polyarchy)

Coefficients:
       (Intercept)                psla       v2x_polyarchy       elect_system1
            5.1401             -1.6846              0.3223             -0.3820
     elect_system2       elect_system3          v2pariglef    v2xpa_antiplural
           -0.5723             -1.1252             -0.4216              0.2261
        v2papariah         v2paelcont1         v2paelcont2  psla:v2x_polyarchy
            0.1290              0.1289              0.2245              0.3526
```

```
back
```

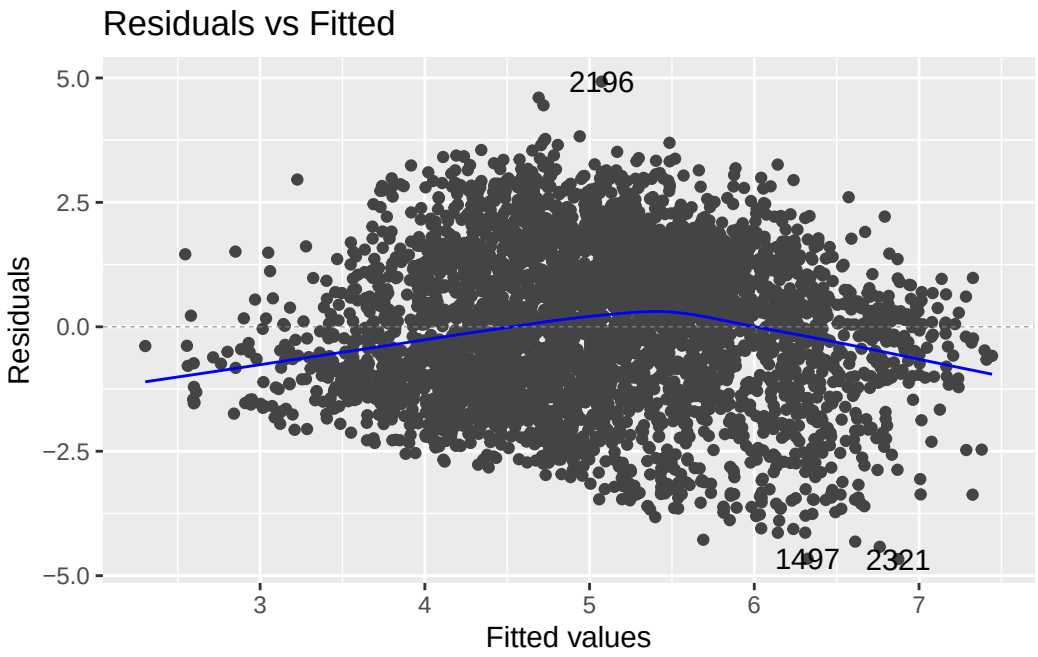
```
Call:
lm(formula = reg_vs ~ elect_system + v2pariglef + v2papariah +
```

```
    v2paelcont + v2xpa_antiplural + psla + v2x_polyarchy + psla:v2x_polyarchy)

Coefficients:
       (Intercept)       elect_system1       elect_system2       elect_system3
            5.1401             -0.3820             -0.5723             -1.1252
        v2pariglef          v2papariah         v2paelcont1         v2paelcont2
           -0.4216              0.1290              0.1289              0.2245
  v2xpa_antiplural                psla       v2x_polyarchy  psla:v2x_polyarchy
            0.2261             -1.6846              0.3223              0.3526
```

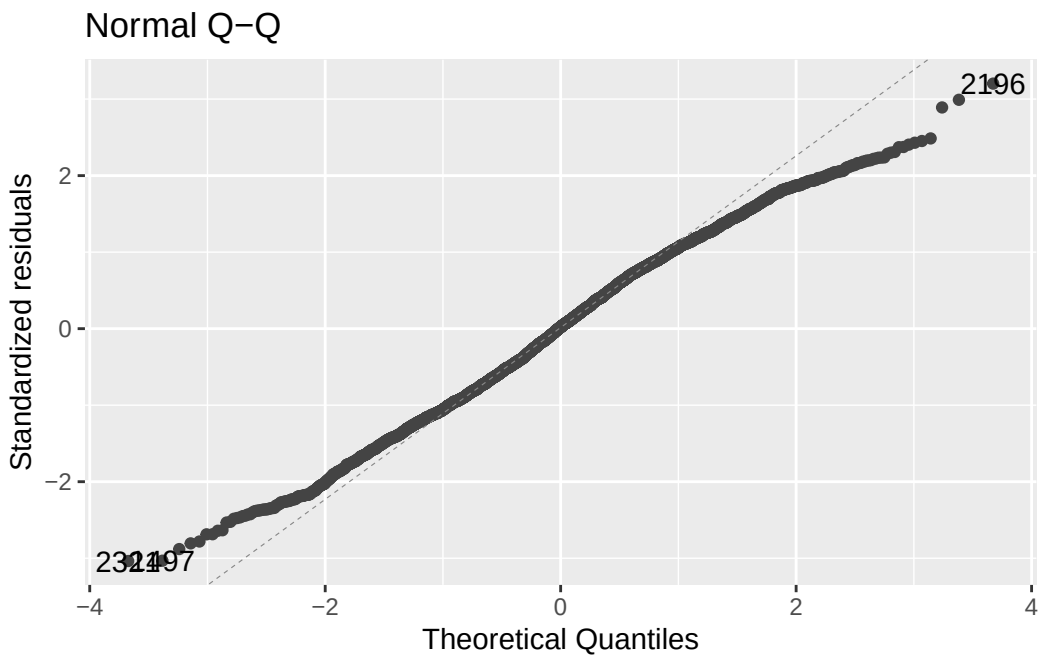
```
both
```

```
Call:
lm(formula = reg_vs ~ psla + v2x_polyarchy + elect_system + v2pariglef +
    v2xpa_antiplural + v2papariah + v2paelcont + psla:v2x_polyarchy)

Coefficients:
       (Intercept)                psla       v2x_polyarchy       elect_system1
            5.1401             -1.6846              0.3223             -0.3820
     elect_system2       elect_system3          v2pariglef    v2xpa_antiplural
           -0.5723             -1.1252             -0.4216              0.2261
        v2papariah         v2paelcont1         v2paelcont2  psla:v2x_polyarchy
            0.1290              0.1289              0.2245              0.3526
```

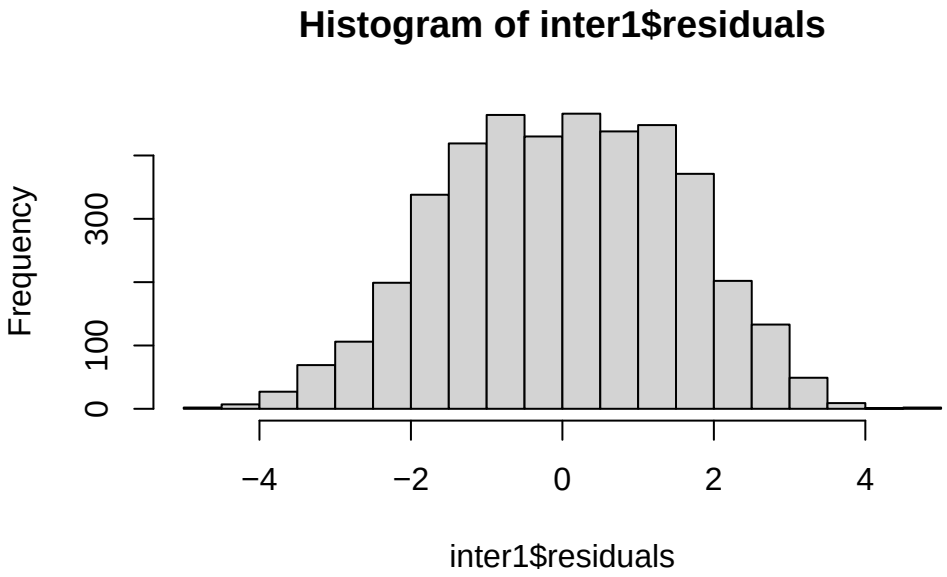
```
#### all the models give the same formula here, so we are going to go with:

f3 <- reg_vs ~ psla + v2x_polyarchy + elect_system + v2pariglef +
  v2xpa_antiplural + v2papariah + v2paelcont + psla:v2x_polyarchy


#### check assumptions

inter1 <- lm(f3)

autoplot(inter1, which = 1, nrow = 1, ncol = 1)
```



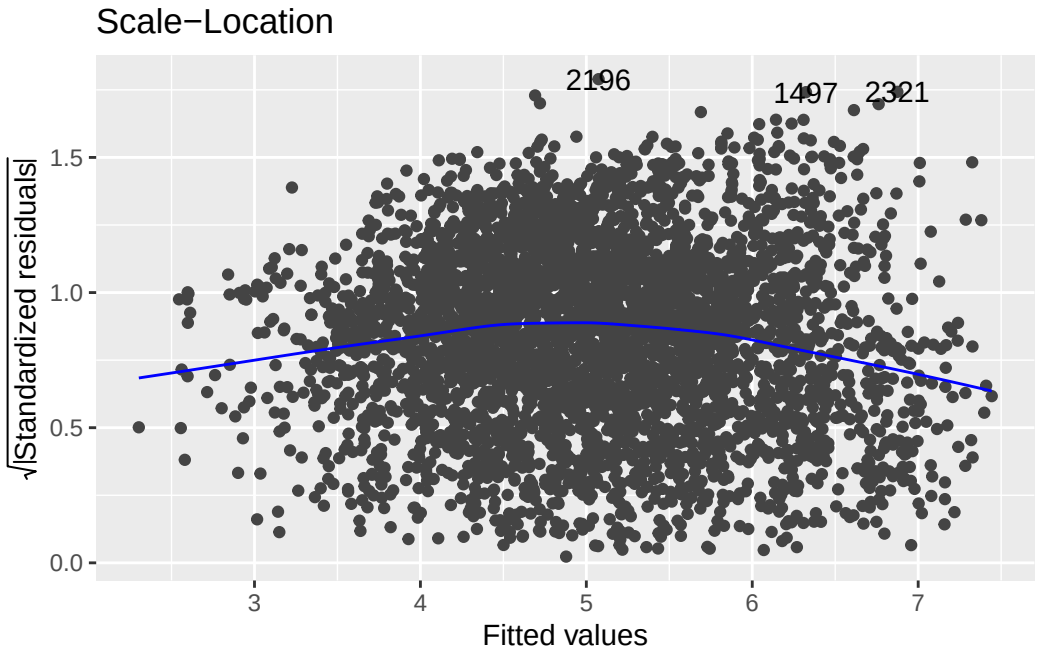

```
#### linearity looks good

autoplot(inter1, which = 2, nrow = 1, ncol = 1)
```



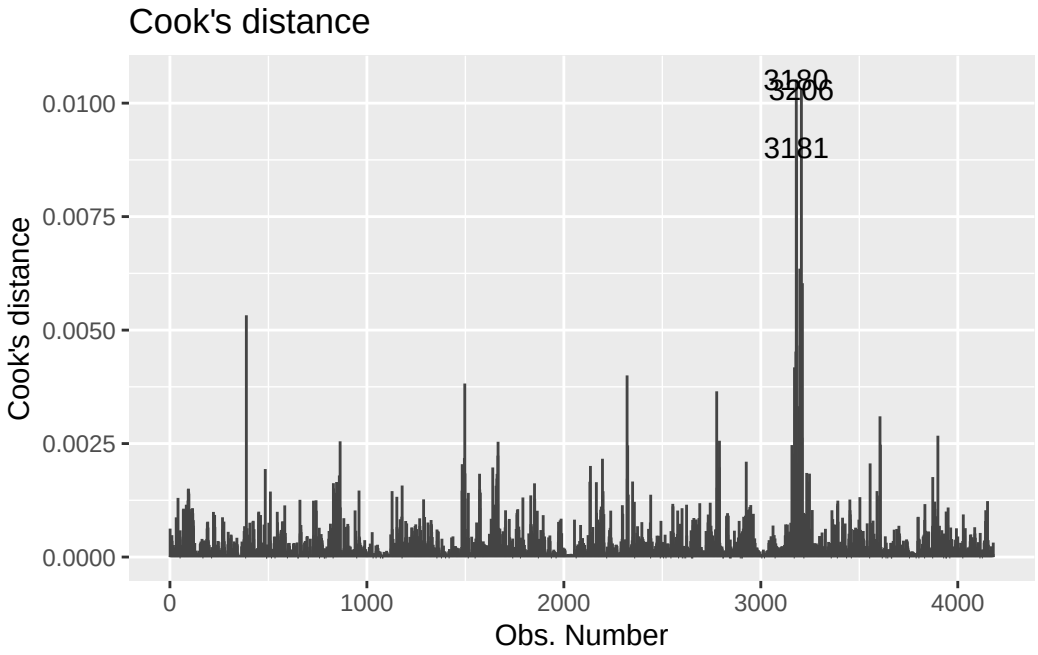

```
hist(inter1$residuals)
```



```
#### looks pretty normal

autoplot(inter1, which = 3, nrow = 1, ncol = 1)
```




```
#### constant variance looks good

autoplot(inter1, which = 4, nrow = 1, ncol = 1)
```




```
#### no serious outliers.

car::vif(inter1, type = "predictor")
```

```
GVIFs computed for predictors

                    GVIF Df GVIF^(1/(2*Df)) Interacts With
psla            2.187939  3        1.139390  v2x_polyarchy
v2x_polyarchy   2.187939  3        1.139390           psla
elect_system    1.103624  3        1.016569             --
v2pariglef      1.055331  1        1.027293             --
v2xpa_antiplural 1.905785  1        1.380502             --
v2papariah      1.151168  1        1.072925             --
v2paelcont      1.177381  2        1.041668             --
                                                                                  Other Predictors
psla                        elect_system, v2pariglef, v2xpa_antiplural, v2papariah, v2paelcont
v2x_polyarchy               elect_system, v2pariglef, v2xpa_antiplural, v2papariah, v2paelcont
elect_system          psla, v2x_polyarchy, v2pariglef, v2xpa_antiplural, v2papariah, v2paelcont
v2pariglef         psla, v2x_polyarchy, elect_system, v2xpa_antiplural, v2papariah, v2paelcont
v2xpa_antiplural      psla, v2x_polyarchy, elect_system, v2pariglef, v2papariah, v2paelcont
v2papariah         psla, v2x_polyarchy, elect_system, v2pariglef, v2xpa_antiplural, v2paelcont
v2paelcont         psla, v2x_polyarchy, elect_system, v2pariglef, v2xpa_antiplural, v2papariah
```

```
#### no multicolinearity

#### meets assumptions
```

Look at results

```
summary(inter1)
```

```
Call:
lm(formula = f3)

Residuals:
    Min      1Q  Median      3Q     Max
-4.6653 -1.1422  0.0331  1.1859  4.9262

Coefficients:
                   Estimate Std. Error t value Pr(>|t|)
(Intercept)         5.14008    0.03123 164.568  < 2e-16 ***
psla               -1.68465    0.05244 -32.126  < 2e-16 ***
v2x_polyarchy       0.32225    0.06497   4.960 7.33e-07 ***
elect_system1      -0.38201    0.07957  -4.801 1.63e-06 ***
elect_system2      -0.57230    0.07041  -8.128 5.71e-16 ***
elect_system3      -1.12520    0.27116  -4.150 3.40e-05 ***
v2pariglef         -0.42155    0.04895  -8.611  < 2e-16 ***
v2xpa_antiplural    0.22615    0.06578   3.438 0.000592 ***
v2papariah          0.12903    0.05113   2.524 0.011647 *
v2paelcont1         0.12894    0.07378   1.748 0.080605 .
v2paelcont2         0.22454    0.10405   2.158 0.030983 *
psla:v2x_polyarchy  0.35257    0.09622   3.664 0.000251 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 1.54 on 4168 degrees of freedom
Multiple R-squared:  0.2426,    Adjusted R-squared:  0.2406
F-statistic: 121.4 on 11 and 4168 DF,  p-value: < 2.2e-16
```

```
#### F stat is not too much larger, and the adjusted r-squared is not that much better, so

anova(m3, inter1)
```

```
Analysis of Variance Table

Model 1: reg_vs ~ psla + elect_system + v2pariglef + v2x_polyarchy + v2xpa_antiplural +
    v2papariah + v2paelcont
Model 2: reg_vs ~ psla + v2x_polyarchy + elect_system + v2pariglef + v2xpa_antiplural +
    v2papariah + v2paelcont + psla:v2x_polyarchy
  Res.Df    RSS Df Sum of Sq      F   Pr(>F)
1   4169 9919.6
2   4168 9887.7  1    31.855 13.428 0.000251 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
#### yeah, looks like it is.
```