

# Replicating a Study that Analysed Fossil Fuel Tax Levels in 2003-2015

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## 1) INTRODUCTION

### Outline of Original Paper

- Mahdavi et al (2020) ‘Why Do Governments Tax or Subsidise Fossil Fuels?’
- Measured fossil fuel tax and subsidy levels and change between 2003-2015 and analysed whether either varies under different political and economic settings
- Relationship between fossil fuel tax/subsidies and political and economic factors

### Data: Outcome and Predictor Variables

- Outcome variable: Implicit Fossil fuel tax/subsidy level; measured by comparing a country’s fuel and gas prices against the international supply price of fuel.
- Authors argue that if the local price is above the international supply price, it implies that the country is likely a net taxer of oil and gas and vice-versa for subsidisers.
- In other words, it is the difference between the price of fuel and the price it is to bring the fuel to consumers, implies that a subsidy has been put in place by government
- Economic explanatory variables: GNI per-capita, government debt and fossil fuel wealth.
- Political explanatory variables: Democracy and Government Effectiveness

### Testing Findings of Original Paper

- I analyse explanations for fossil fuel tax/subsidy levels in 2003-2015 via cross-national data
- I Do not analyse reasons for fossil fuel tax/subsidy change from 2003-15 (i.e. across time)
- This tests two out of four major findings of original paper:
  - Finding 1: The relationship between tax/subsidies and economic predictors is by far the strongest.
  - Finding 2: There is a weak relationship between tax/subsidies and political predictors.

### Adding an Interaction Term

- Particularly wishes to expand on original study by focusing on the European Union and whether a member state’s fuel wealth explained its 2003-2015 tax and subsidy levels
- This is achieved by adding an interaction term between the EU countries and fuel wealth indicators

## Method

### 1) Data Collection:

- Collected the Data From the Harvard Database Website
- Load Data into RStudio

### 2) Data Analysis I: Analyse Expanations for Tax and Subsidy Levels

- Run a glm() linear regression to regress tax/subsidy levels on economic and political predictors.
- Linear regression is used as the outcome is continuous

OVERALL, RESULTS FOUND WERE QUITE SIMILAR TO ORIGINAL PAPER

### 3. Data Analysis II: Analyse Whether EU Country's Wealthy From Oil and Gas Tax and Subsidise Less

- Run a glm() linear regression to regress tax/subsidy change on economic and political predictors.
- Linear regression used as outcome variable is continuous

## 2) ANALYSIS PART I: EXPLAINING TAX AND SUBSIDY LEVELS

```
# Libraries
library(dplyr)

##
## Attaching package: 'dplyr'

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

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

library(tidyr)
library(ggplot2)

# Load dataset
dataset <- read.csv('cross_national_ffs_final.csv')
View(dataset)

### 1) RUN REGRESSION MODEL ###
## Try with glm()
lm <- glm(meanbmgap2015adj ~ meanfuelexports+fuel_income_dependence+average_oilgas_exports_pc +
          meangdppc + meangdppcatlas + gdp_ppc_gd + autocracy_polity + meangoveffect +
          avg_gov_debt + meanvat, data = dataset, family=gaussian(link="identity"))

# Summarise the output
summary(lm)
```

```
##
## Call:
## glm(formula = meanbmgap2015adj ~ meanfuelexports + fuel_income_dependence +
##       average_oilgas_exports_pc + meangdppc + meangdppcatlas +
##       gdp_ppc_gd + autocracy_polity + meangoveffect + avg_gov_debt +
##       meanvat, family = gaussian(link = "identity"), data = dataset)
##
## Deviance Residuals:
##      Min       1Q   Median       3Q      Max
## -0.53684  -0.16762   0.01626   0.14600   1.01056
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    -9.903e-03  1.093e-01  -0.091  0.927934
## meanfuelexports  -7.876e-03  1.625e-03  -4.848  3.78e-06 ***
## fuel_income_dependence  4.542e-03  5.524e-03   0.822  0.412541
## average_oilgas_exports_pc -1.005e-05  1.658e-05  -0.606  0.545481
## meangdppc       -3.412e-06  4.279e-06  -0.797  0.426811
## meangdppcatlas   1.416e-05  3.735e-06   3.790  0.000237 ***
## gdp_ppc_gd      -2.215e-14  1.729e-14  -1.281  0.202654
## autocracy_polity -4.778e-02  1.005e-01  -0.475  0.635389
## meangoveffect    1.472e-02  5.477e-02   0.269  0.788549
## avg_gov_debt     1.963e-03  8.185e-04   2.398  0.018003 *
## meanvat          3.187e-02  4.663e-03   6.835  3.64e-10 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for gaussian family taken to be 0.06727797)
##
##      Null deviance: 31.9020  on 130  degrees of freedom
## Residual deviance:  8.0734  on 120  degrees of freedom
## (25 observations deleted due to missingness)
## AIC: 30.714
##
## Number of Fisher Scoring iterations: 2
```

## DATA VISUALISATION AND INTERPRETATION

With the explanatory and outcome variable in place in a summarised regression, the covariates can now be interpreted and visualised using ggplot.

This can test whether findings observed in the original paper are valid.

## ECONOMIC PREDICTORS:

**Fossil Fuel Wealth: Fuel income dependence, meanfuelexports and average oil exports per capita.**

### Fuel income dependence

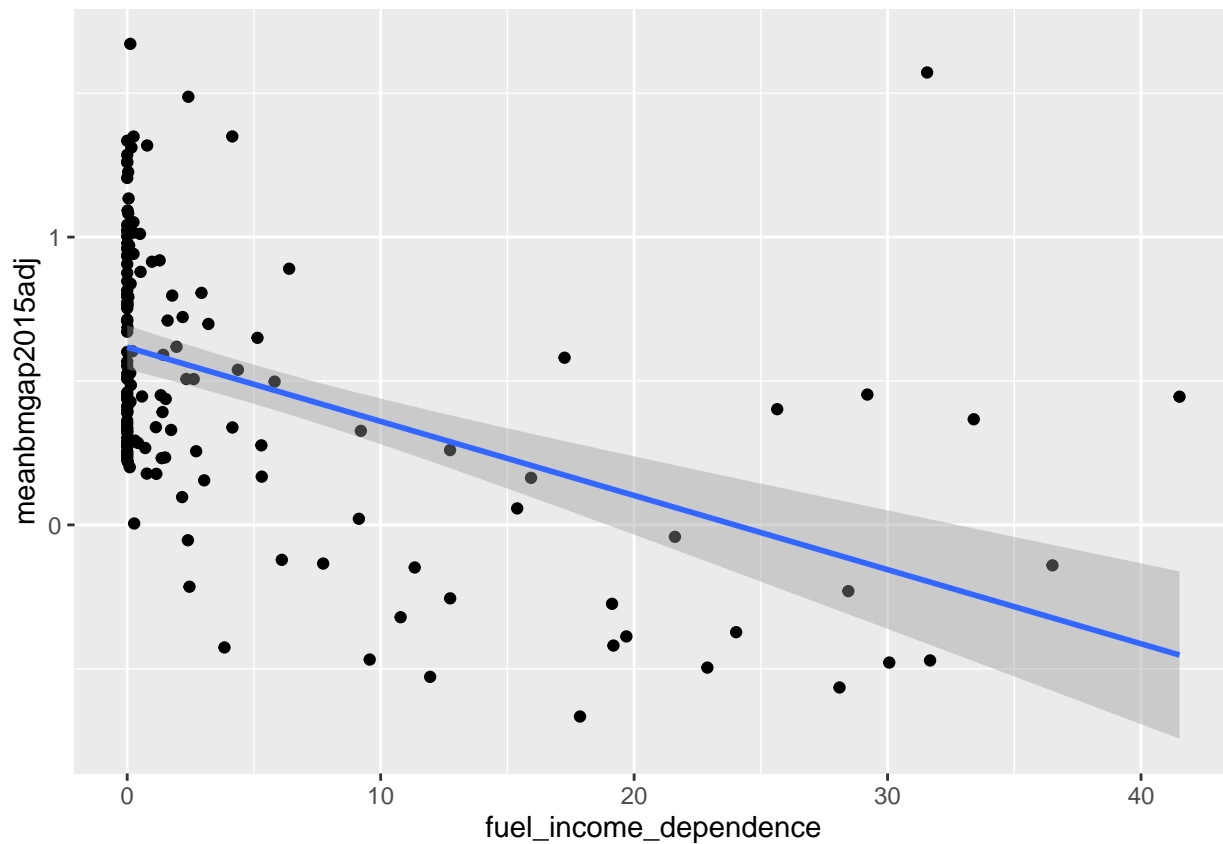
- Strongly negative correlation between fuel income dependence and net implicit gas tax/subs

```
ggplot(dataset, aes(fuel_income_dependence, meanbmgap2015adj)) +
  geom_point() +
```

```
stat_smooth(method = "lm",
            formula = y ~ x,
            geom = "smooth")
```

## Warning: Removed 2 rows containing non-finite values (stat\_smooth).

## Warning: Removed 2 rows containing missing values (geom\_point).

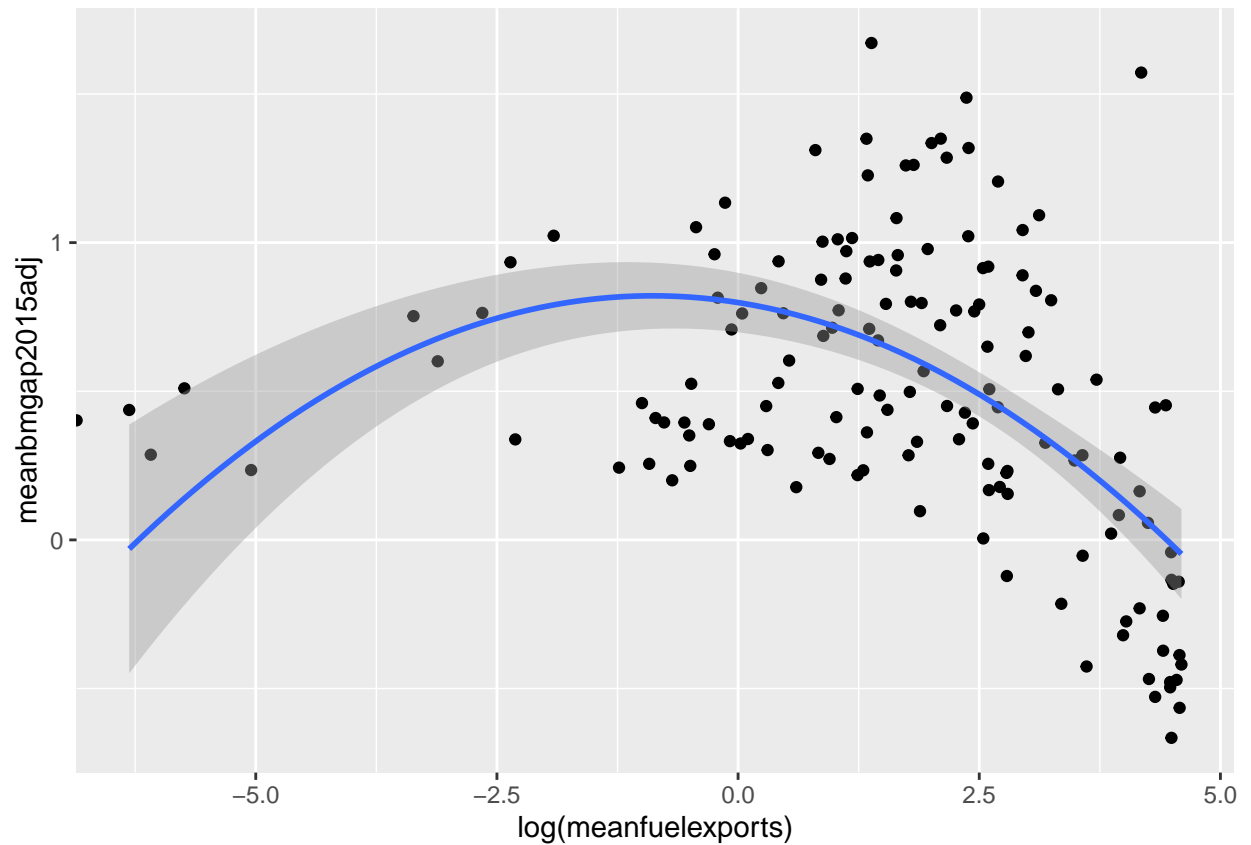


## Average Fuel Exports

```
ggplot(dataset, aes(log(meanfuelexports), meanbmgap2015adj)) +
  geom_point() +
  stat_smooth(method = "lm",
            formula = y ~ x + I(x^2),
            geom = "smooth")
```

## Warning: Removed 9 rows containing non-finite values (stat\_smooth).

## Warning: Removed 8 rows containing missing values (geom\_point).

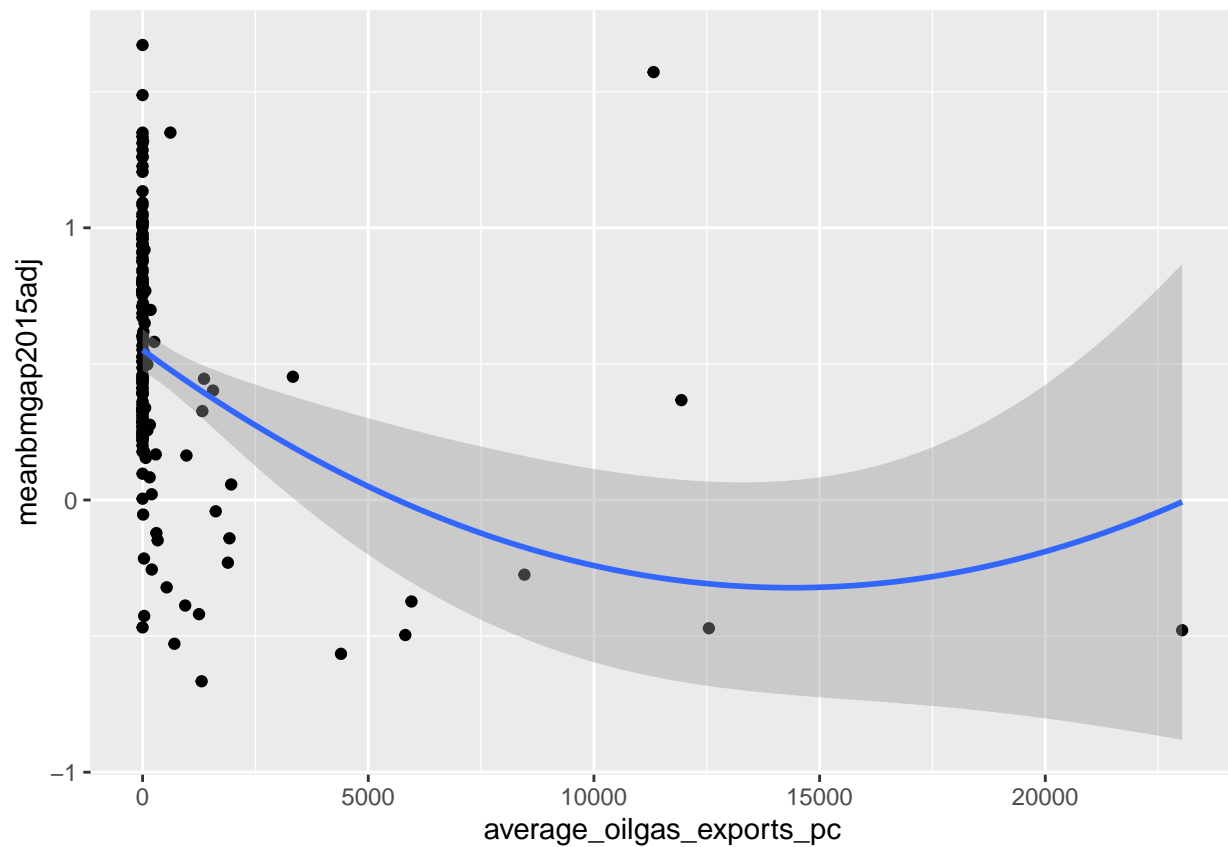


## Average Oil Exports Per Capita

```
ggplot(dataset, aes(average_oilgas_exports_pc, meanbmgap2015adj)) +  
  geom_point() +  
  stat_smooth(method = "lm",  
             formula = y ~ x + I(x^2),  
             geom = "smooth")
```

## Warning: Removed 1 rows containing non-finite values (stat\_smooth).

## Warning: Removed 1 rows containing missing values (geom\_point).

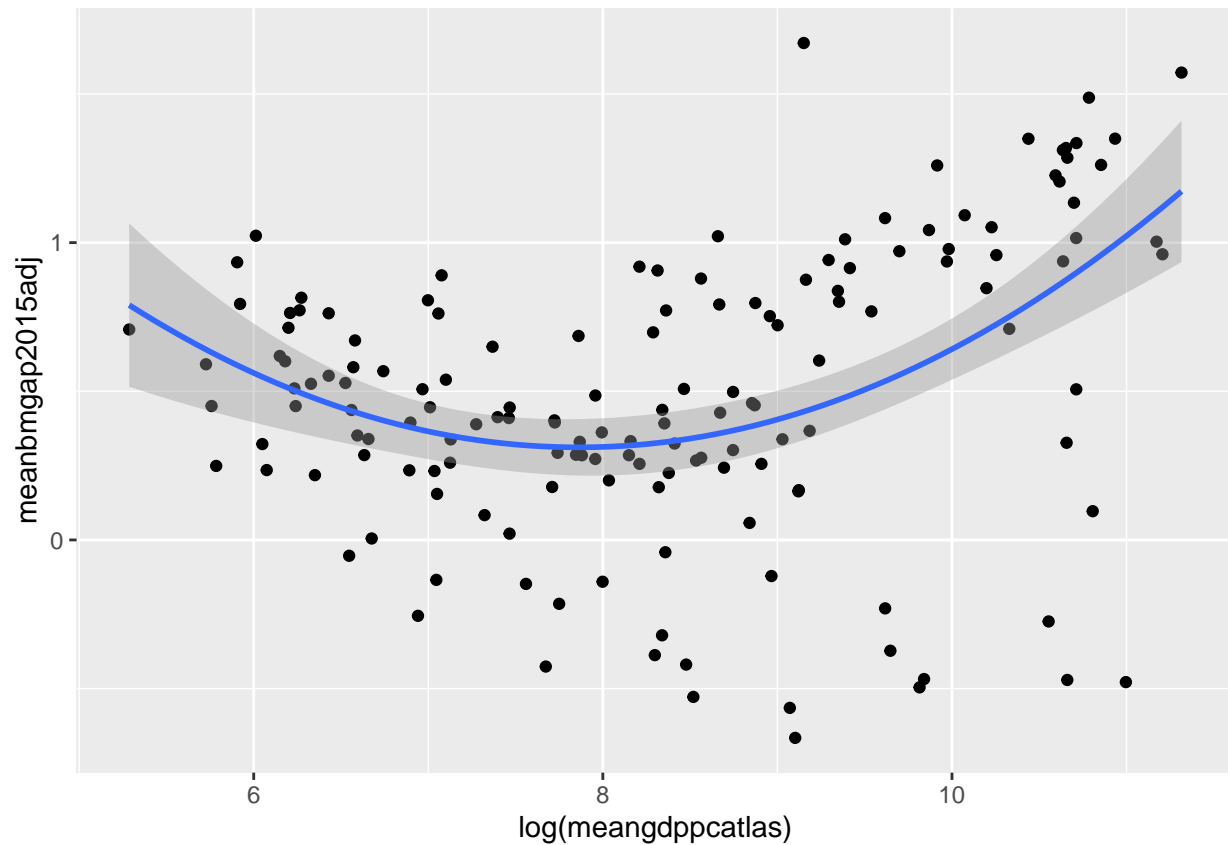


# GNI Per Capita

```
ggplot(dataset, aes(log(meangdppcatlas), meanbmgap2015adj)) +
  geom_point() +
  stat_smooth(method = "lm",
              formula = y ~ x + I(x^2),
              geom = "smooth")
```

## Warning: Removed 1 rows containing non-finite values (stat\_smooth).

## Warning: Removed 1 rows containing missing values (geom\_point).

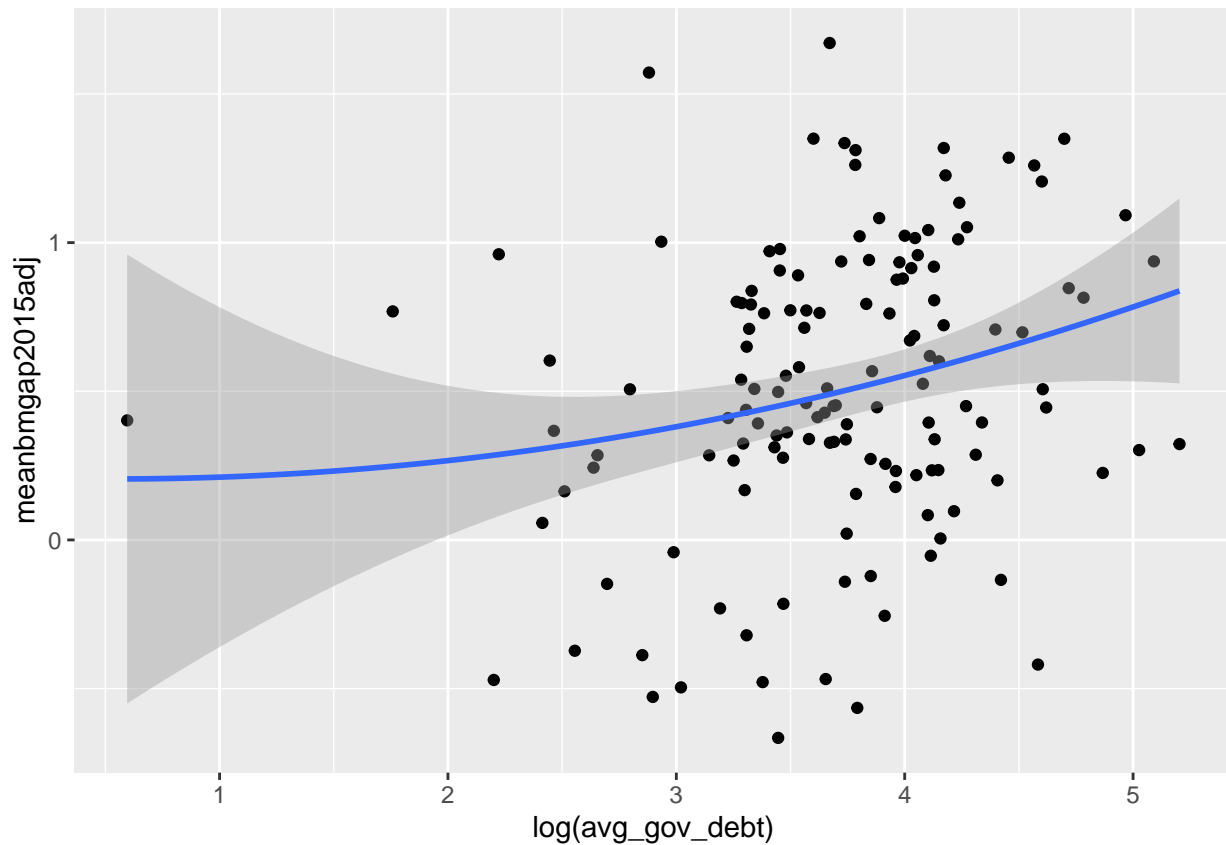


# Average Government Debt

```
ggplot(dataset, aes(log(avg_gov_debt), meanbmgap2015adj)) +
  geom_point() +
  stat_smooth(method = "lm",
             formula = y ~ x + I(x^2),
             geom = "smooth")
```

## Warning: Removed 15 rows containing non-finite values (stat\_smooth).

## Warning: Removed 15 rows containing missing values (geom\_point).



## POLITICAL PREDICTORS

### Democracy

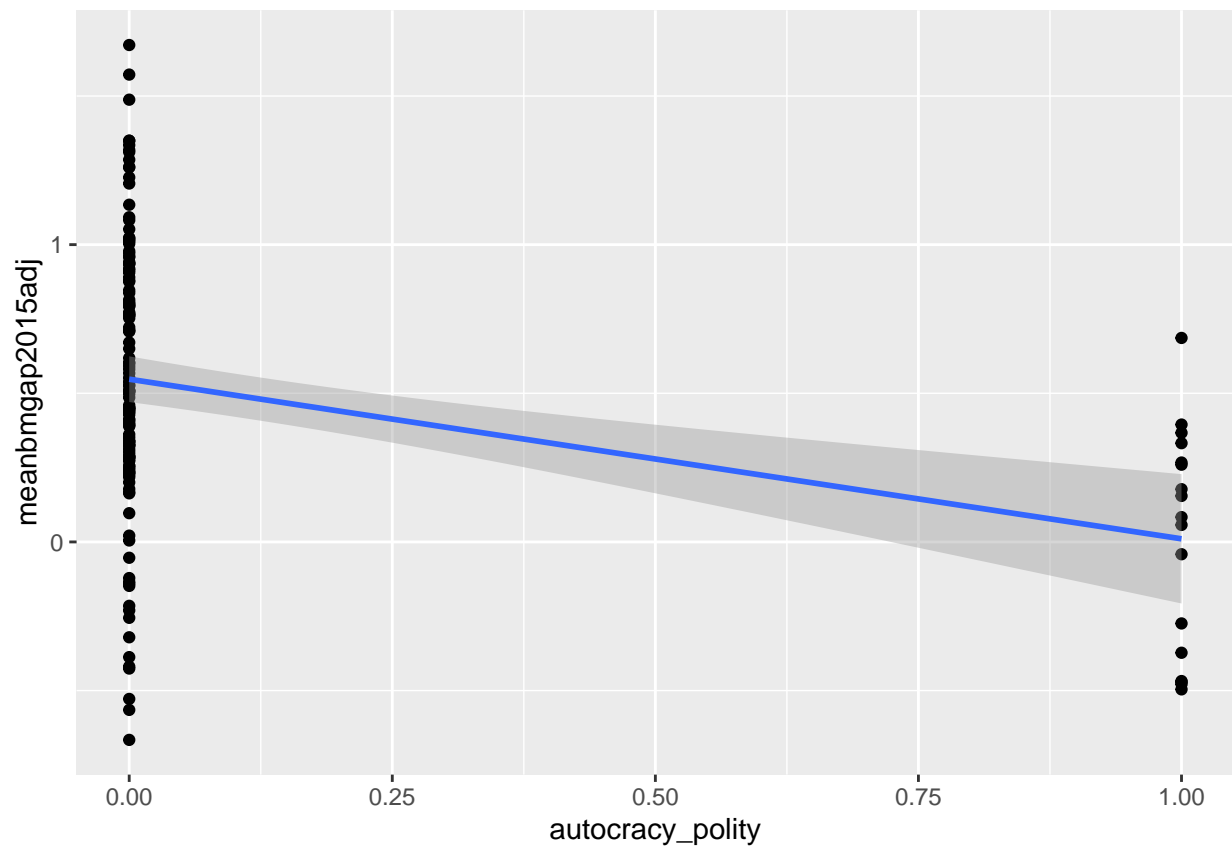
```
ggplot(dataset, mapping = aes(autocracy_polity, meanbmgap2015adj)) +
  geom_point() +
  stat_smooth(method = "lm",
              formula = y ~ x + I(x^2),
              geom = "smooth")
```

```
## Warning: Removed 3 rows containing non-finite values (stat_smooth).
```

```
## Warning in predict.lm(model, newdata = new_data_frame(list(x = xseq)), se.fit =
## se, : prediction from a rank-deficient fit may be misleading
```

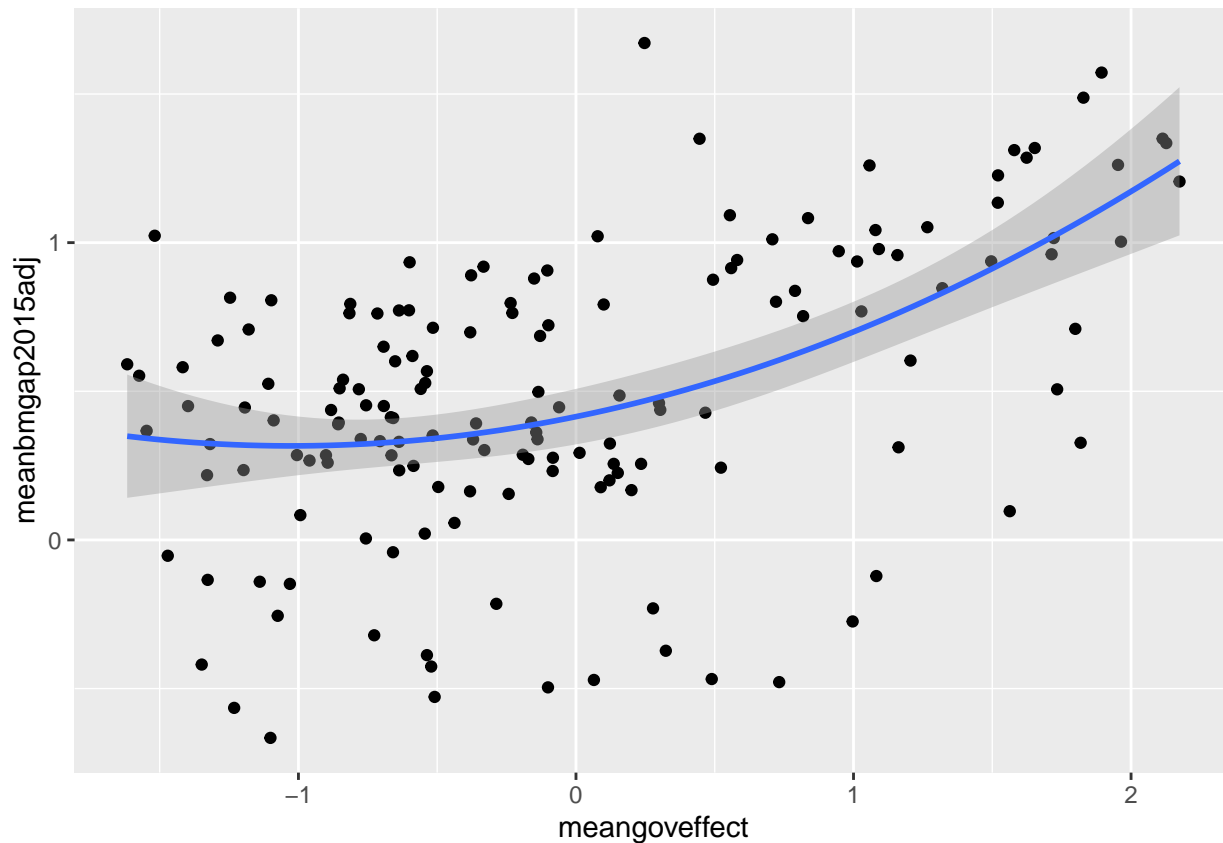
```
## Warning: Removed 3 rows containing missing values (geom_point).
```





## Government Effectiveness

```
ggplot(dataset, mapping=aes(meangoveffect, meanbmgap2015adj)) +
  geom_point() +
  stat_smooth(method = "lm",
             formula = y ~ x + I(x^2),
             geom = "smooth")
```



## INTERACTION ANALYSIS: HOW DOES THE EUROPEAN UNION VARIABLE INTERACT WITH FOSSIL FUEL WEALTH

```
imodel1 <- glm(meanbmgap2015adj ~ fuel_income_dependence*europeanunion, data = dataset, family=gaussian)

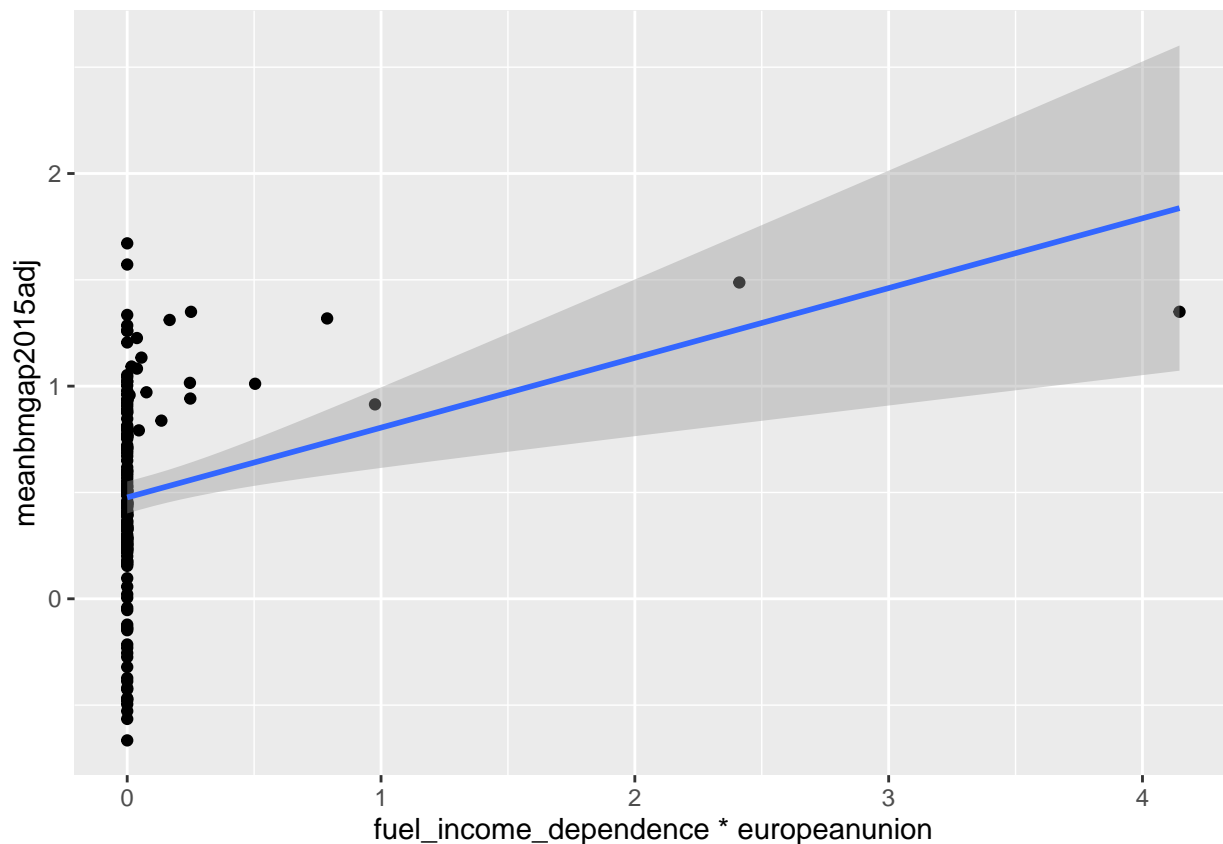
# Summarise the output
summary(imodel1)
```

```
##
## Call:
## glm(formula = meanbmgap2015adj ~ fuel_income_dependence * europeanunion,
##      family = gaussian(link = "identity"), data = dataset)
##
## Deviance Residuals:
##      Min       1Q   Median       3Q      Max
## -0.83354  -0.21881  -0.05585   0.22699   1.72496
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    0.485189   0.037023  13.105 < 2e-16 ***
## fuel_income_dependence -0.020219   0.003366  -6.006 1.38e-08 ***
## europeanunion     0.563381   0.084037   6.704 3.86e-10 ***
## fuel_income_dependence:europeanunion  0.116782   0.078349   1.491  0.138
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
##
## (Dispersion parameter for gaussian family taken to be 0.1302581)
##
## Null deviance: 35.701 on 153 degrees of freedom
## Residual deviance: 19.539 on 150 degrees of freedom
## (2 observations deleted due to missingness)
## AIC: 129.09
##
## Number of Fisher Scoring iterations: 2
ggplot(dataset, mapping=aes(fuel_income_dependence*europeanunion, meanbmgap2015adj)) +
  geom_point() +
  stat_smooth(method = "lm",
              formula = y ~ x,
              geom = "smooth")
```

```
## Warning: Removed 2 rows containing non-finite values (stat_smooth).
```

```
## Warning: Removed 2 rows containing missing values (geom_point).
```



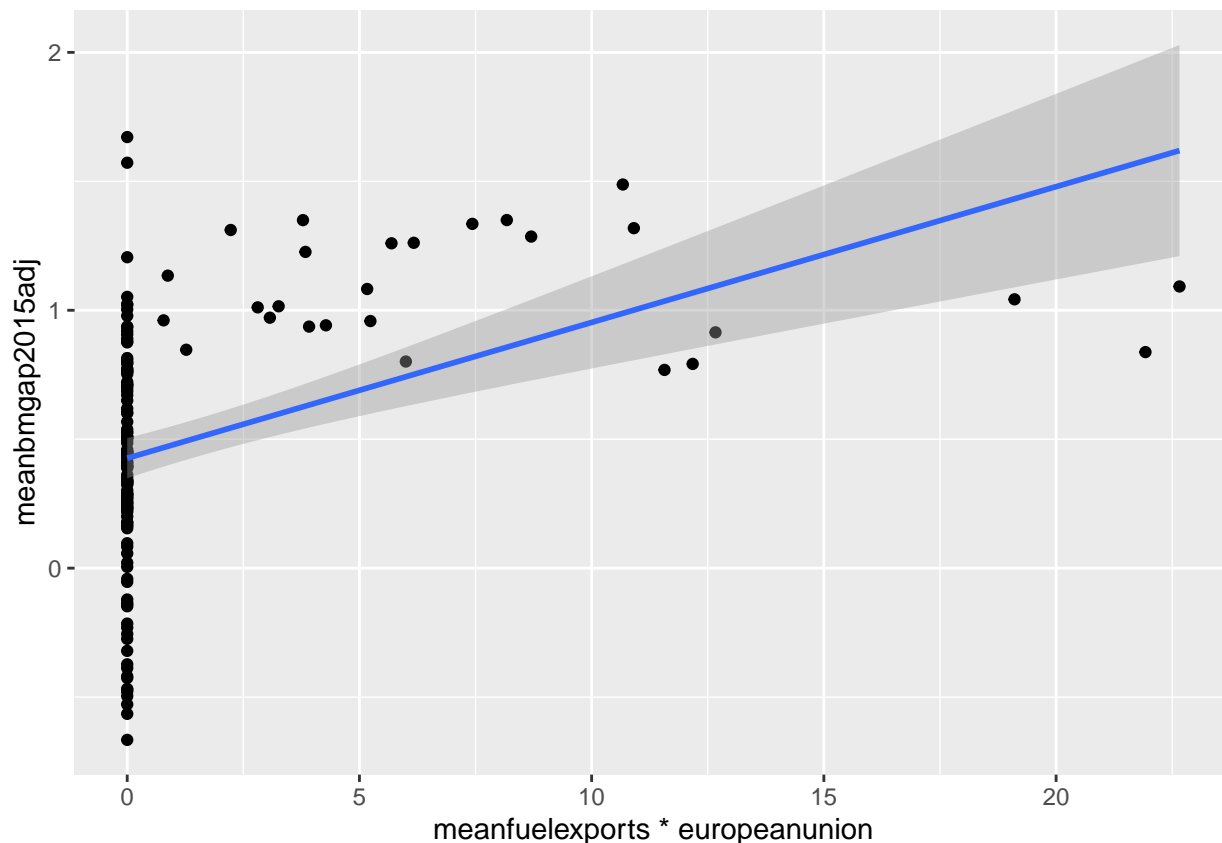
```
# Analyse interaction between avg oil exports per capita and EU members
imodel2 <- glm(meanbmgap2015adj ~ average_oilgas_exports_pc*europeanunion, data = dataset, family=gauss)
summary(imodel2)
```

```
##
## Call:
## glm(formula = meanbmgap2015adj ~ average_oilgas_exports_pc *
##     europeanunion, family = gaussian(link = "identity"), data = dataset)
```

```
##
## Deviance Residuals:
##      Min       1Q   Median       3Q      Max
## -1.02130  -0.17614  -0.01442   0.22382   1.62868
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)      4.093e-01  3.544e-02  11.547 < 2e-16
## average_oilgas_exports_pc -4.115e-05  1.179e-05  -3.490 0.000634
## europeanunion      6.655e-01  8.375e-02   7.946 4.12e-13
## average_oilgas_exports_pc:europeanunion  4.409e-04  6.366e-04   0.693 0.489660
##
## (Intercept)          ***
## average_oilgas_exports_pc      ***
## europeanunion          ***
## average_oilgas_exports_pc:europeanunion
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for gaussian family taken to be 0.1483491)
##
##      Null deviance: 35.507  on 154  degrees of freedom
## Residual deviance: 22.401  on 151  degrees of freedom
## (1 observation deleted due to missingness)
## AIC: 150.05
##
## Number of Fisher Scoring iterations: 2

ggplot(dataset, mapping=aes(meanfuelexportseuropeanunion, meanbmgap2015adj)) +
  geom_point() +
  stat_smooth(method = "lm",
              formula = y ~ x,
              geom = "smooth")

## Warning: Removed 8 rows containing non-finite values (stat_smooth).
## Warning: Removed 8 rows containing missing values (geom_point).
```

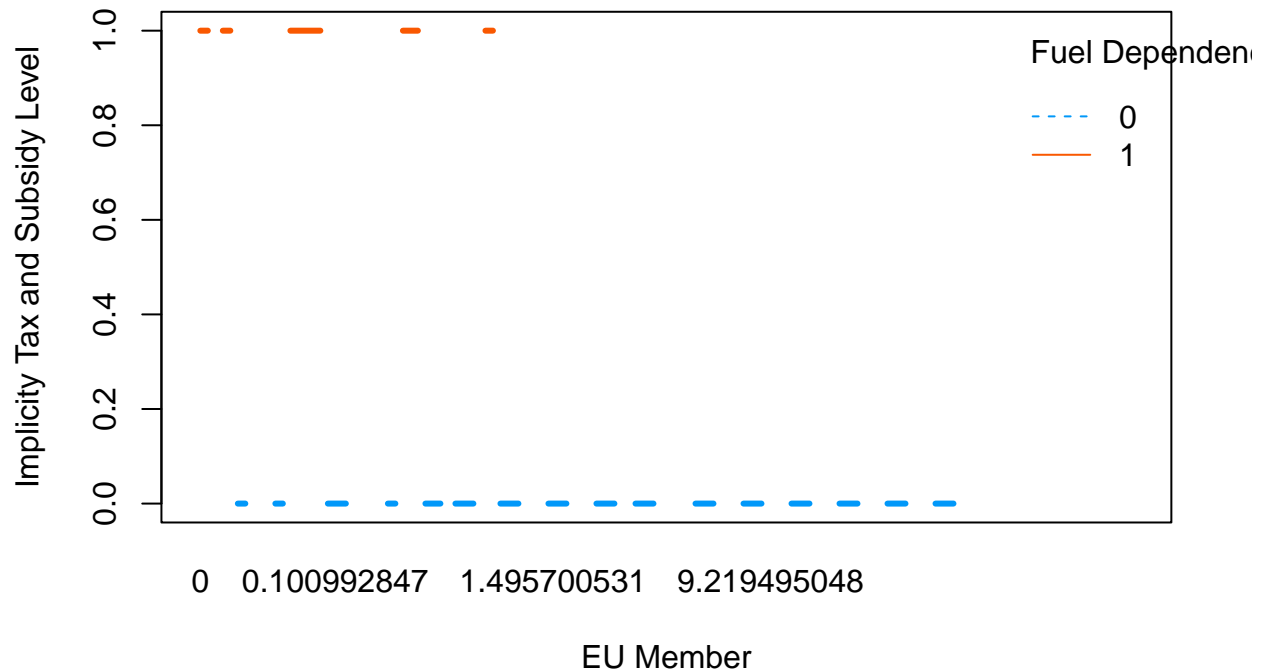


```
interaction.plot(
  x.factor = dataset$fuel_income_dependence,
  trace.factor = dataset$europeanunion,
  response = dataset$europeanunion,
  fun = median,
  ylab = "Implicit Tax and Subsidy Level",
  xlab = "EU Member",
  trace.label = "Fuel Dependence",
  col = c("#0198f9", "#f95801"),
  lyt = 1,
  lwd = 3
)
```

```
## Warning in plot.window(...): "lyt" is not a graphical parameter
## Warning in plot.xy(xy, type, ...): "lyt" is not a graphical parameter
## Warning in axis(side = side, at = at, labels = labels, ...): "lyt" is not a
## graphical parameter

## Warning in axis(side = side, at = at, labels = labels, ...): "lyt" is not a
## graphical parameter

## Warning in box(...): "lyt" is not a graphical parameter
## Warning in title(...): "lyt" is not a graphical parameter
## Warning in axis(1, x, ...): "lyt" is not a graphical parameter
```



#### 4) CONCLUSION

##### Economic Explanations of Fuel Tax and Subsidy Levels

- It Is Not Surprising that Fossil Fuel Wealth Indicators are Overall Negatively Correlated With Fuel and Tax Levels.
- Positive relationship between government debt and taxes not surprising.
- Somewhat positive U shaped relation between GNI per capita and taxes also not too surprising.

##### Political Explanations of Fuel Tax and Subsidy Levels

- Slightly positive relation between government effectiveness and tax and subsidy levels also not too surprising
- Idea that Autocracies tax less than democracies also not surprising
- Overall, finding of original paper that political predictors are not strongly correlated with tax and subsidy levels, relative to economic factors, is shown here also.

**There appears to be no interaction between EU member oil dependency on tax/subsidy levels in 2015**

##### Significance Levels

- Caveat that only GNI per capita, average fuel exports and government debt coefficients p-values were  $<0.05$
- Other variables greater than 0.05

## Room for Further Work

- Analyse the second dataset and look at tax and subsidy changes between 2003-15