

Assignment three

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Chapter 9: Instrumental Variables. Assignment Three: Q 1, 2, 4, and 5.

```
library (tidyverse)
```

```
## Loading tidyverse: ggplot2
## Loading tidyverse: tibble
## Loading tidyverse: tidyr
## Loading tidyverse: readr
## Loading tidyverse: purrr
## Loading tidyverse: dplyr

## Conflicts with tidy packages -----

## filter(): dplyr, stats
## lag():    dplyr, stats
```

```
library (broom)
library(rio)
library (modelr)
```

```
##
## Attaching package: 'modelr'

## The following object is masked from 'package:broom':
##
##   bootstrap
```

```
library (AER)
```

```
## Warning: package 'AER' was built under R version 3.3.3
## Loading required package: car
## Warning: package 'car' was built under R version 3.3.3
##
## Attaching package: 'car'

## The following object is masked from 'package:dplyr':
##
##   recode

## The following object is masked from 'package:purrr':
##
##   some

## Loading required package: lmtest
## Warning: package 'lmtest' was built under R version 3.3.3
## Loading required package: zoo
## Warning: package 'zoo' was built under R version 3.3.3
```

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

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

## Loading required package: sandwich

## Warning: package 'sandwich' was built under R version 3.3.3

## Loading required package: survival

library(car)
library(plm)

## Warning: package 'plm' was built under R version 3.3.3

## Loading required package: Formula

##
## Attaching package: 'plm'

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

rain <- read_csv("RainIV.csv")

## Parsed with column specification:
## cols(
##   .default = col_integer(),
##   country_name = col_character(),
##   country_code = col_character(),
##   GPCP = col_double(),
##   RainfallGrowth = col_double(),
##   LaggedRainfallGrowth = col_double(),
##   pop = col_double(),
##   lpopl1 = col_double(),
##   Mountains = col_double(),
##   lmtnest = col_double(),
##   EthnicFrac = col_double(),
##   ReligiousFrac = col_double(),
##   GDPGrowth = col_double(),
##   LaggedGDPGrowth = col_double(),
##   InitialGDP = col_double()
## )

## See spec(...) for full column specifications.
```

1 a)

```
# 1. a. Estimate a bivariate OLS model with internal conflict and GDP.
```

```
ols <- tidy(lm (InternalConflict ~ LaggedGDPGrowth, data = rain))
ols
```

```
##           term      estimate std.error statistic    p.value
## 1   (Intercept)  0.26737746 0.01631415  16.3892984 9.586655e-52
```

```
## 2 LaggedGDPGrowth -0.08206485 0.22485213 -0.3649725 7.152360e-01
```

When we run a bivariate OLS model we find no significant results (at the alpha equals 0.05) to suggest that growth in GDP would reduce conflict.

b)

```
# b. with controls
```

```
olscontrol <- tidy(lm(InternalConflict ~ LaggedGDPGrowth + InitialGDP + Democracy + Mountains + EthnicFrac))
olscontrol
```

##	term	estimate	std.error	statistic	p.value
## 1	(Intercept)	0.070355529	0.0731012386	0.9624396	3.361449e-01
## 2	LaggedGDPGrowth	-0.108797693	0.2200998529	-0.4943106	6.212343e-01
## 3	InitialGDP	-0.056909063	0.0182258230	-3.1224413	1.863801e-03
## 4	Democracy	0.001224162	0.0028894131	0.4236714	6.719292e-01
## 5	Mountains	0.003865434	0.0009526937	4.0573730	5.493161e-05
## 6	EthnicFrac	0.324793069	0.0918181328	3.5373521	4.295018e-04
## 7	ReligiousFrac	0.010516152	0.0958907296	0.1096681	9.127025e-01

These results also do not establish a causal relationship between economic growth and reduction in civil conflict (the p values are not significant at the 0.05 level).

c)

```
#c. Instrumental variable test for rainfall
```

```
ols2 <- tidy(lm(LaggedGDPGrowth ~ LaggedRainfallGrowth + InitialGDP + Democracy + Mountains + EthnicFrac))
ols2
```

##	term	estimate	std.error	statistic	p.value
## 1	(Intercept)	-0.0058040646	0.0121558449	-0.4774711	0.6331684550
## 2	LaggedRainfallGrowth	0.0439769947	0.0128127339	3.4322881	0.0006319632
## 3	InitialGDP	-0.0008055799	0.0030286889	-0.2659830	0.7903267540
## 4	Democracy	0.0005373436	0.0004797716	1.1199986	0.2630797024
## 5	Mountains	0.0001086811	0.0001582464	0.6867842	0.4924350511
## 6	EthnicFrac	0.0031602813	0.0152584101	0.2071173	0.8359755120
## 7	ReligiousFrac	-0.0017176029	0.0159357476	-0.1077830	0.9141971916

The two conditions for a good instrument: 1. Inclusion condition: the instrument must explain X. 2. Exclusion condition: the instrument must explain x without explaining y.

We can only test for the first condition using a linear regression, like done in part c. Here we find the instrument explains x at an alpha of 0.05. But we cannot explain the exclusion condition. The only way to do this is through theory and justification. Rainfall can explain GDP growth but not conflict according to the authors of the study.

d. Why use rainfall as an instrument?

If we use rainfall as an instrument for GDP growth we can make a connection between the two, since rainfall would definitely effect agrarian societies. Larger amounts would signal more harvest and better export. However, rainfall would be a hard factor in thinking about conflict, other authors (Acemoglu and Robinson)

do mention possible flooding of roads as a factor but dismiss this in their paper as unlikely. Therefore, rainfall can explain conflict but only through economic growth.

e)

```
# e. Real Instrument test with ivreg

instrument <- ivreg(InternalConflict ~ LaggedGDPGrowth + InitialGDP + Democracy + Mountains + EthnicFrac + ReligiousFrac | LaggedRainfallGrowth + InitialGDP + Democracy + Mountains + EthnicFrac + ReligiousFrac, data = rain)

summary(instrument)

##
## Call:
## ivreg(formula = InternalConflict ~ LaggedGDPGrowth + InitialGDP + Democracy + Mountains + EthnicFrac + ReligiousFrac | LaggedRainfallGrowth + InitialGDP + Democracy + Mountains + EthnicFrac + ReligiousFrac, data = rain)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -1.1693 -0.3106 -0.1897  0.4203  2.0093
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    0.062506   0.077268   0.809 0.418802
## LaggedGDPGrowth -2.063153   1.845106  -1.118 0.263857
## InitialGDP      -0.058080   0.019209  -3.024 0.002584 **
## Democracy        0.002361   0.003221   0.733 0.463785
## Mountains        0.004069   0.001020   3.988 7.34e-05 ***
## EthnicFrac       0.328851   0.096686   3.401 0.000707 ***
## ReligiousFrac    0.004724   0.101042   0.047 0.962721
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.456 on 736 degrees of freedom
## Multiple R-Squared:  -0.05059,    Adjusted R-squared:  -0.05916
## Wald test:  6.133 on 6 and 736 DF,   p-value: 2.748e-06
```

From this 2SLS we can see that there is not a significant result (at the alpha equals 0.05 level) for GDP growth even with the instrumental variable. We cannot reject the null hypothesis.

f)

```
#f. Dummy variables

reg3 <- ivreg(InternalConflict ~ LaggedGDPGrowth + InitialGDP + Democracy + Mountains + EthnicFrac + ReligiousFrac + factor(country_name) | LaggedRainfallGrowth + InitialGDP + Democracy + Mountains + EthnicFrac + ReligiousFrac + factor(country_name), data = rain)

summary(reg3)

##
## Call:
```

```

## ivreg(formula = InternalConflict ~ LaggedGDPGrowth + InitialGDP +
##      Democracy + Mountains + EthnicFrac + ReligiousFrac + factor(country_name) |
##      LaggedRainfallGrowth + InitialGDP + Democracy + Mountains +
##      EthnicFrac + ReligiousFrac + factor(country_name), data = rain)
##
## Residuals:
##      Min        1Q      Median        3Q        Max
## -1.60872 -0.18282 -0.01501  0.13649  1.92662
##
## Coefficients:
##                                     Estimate Std. Error
## (Intercept)                        0.459156    1.863122
## LaggedGDPGrowth                    -2.853380    1.535631
## InitialGDP                         -0.476826    0.792632
## Democracy                          0.001065    0.003276
## Mountains                          0.092267    0.020715
## EthnicFrac                        -0.177308    0.960665
## ReligiousFrac                      0.122734    1.081919
## factor(country_name)Benin          0.102932    0.151373
## factor(country_name)Botswana       0.459522    0.379597
## factor(country_name)Burkina Faso   0.001897    0.456368
## factor(country_name)Burundi       -6.759628    1.224003
## factor(country_name)Cameroon      -1.449536    0.539017
## factor(country_name)Central African Republic -0.527030    0.202258
## factor(country_name)Chad          -0.049368    0.121434
## factor(country_name)Congo          0.594180    0.520803
## factor(country_name)Djibouti       0.108725    0.362860
## factor(country_name)Ethiopia      -5.942561    1.157047
## factor(country_name)Gabon          1.894540    2.969182
## factor(country_name)Gambia         0.146595    0.339041
## factor(country_name)Ghana          0.160302    0.216191
## factor(country_name)Guinea         -0.165534    0.412092
## factor(country_name)Guinea-Bissau -0.012907    0.290915
## factor(country_name)Ivory Coast     0.570719    1.158194
## factor(country_name)Kenya          -2.322296    0.572570
## factor(country_name)Lesotho        -7.505690    1.488785
## factor(country_name)Liberia         0.260105    0.270259
## factor(country_name)Madagascar    -3.146483    0.563717
## factor(country_name)Malawi         -0.962630    0.304634
## factor(country_name)Mali           -0.011005    0.632748
## factor(country_name)Mauritania      0.051883    0.865955
## factor(country_name)Mozambique      0.502944    0.170638
## factor(country_name)Namibia         0.191278    1.379937
## factor(country_name)Niger           0.029188    0.386649
## factor(country_name)Nigeria        0.016553    0.535843
## factor(country_name)Rwanda         -6.447391    1.211757
## factor(country_name)Senegal         0.581121    0.314757
## factor(country_name)Sierra Leone   0.384331    0.279397
## factor(country_name)Somalia        -0.202700    0.986690
## factor(country_name)South Africa    1.195777    2.036813
## factor(country_name)Sudan           0.352135    0.189502
## factor(country_name)Swaziland      -0.336431    1.607692
## factor(country_name)Tanzania, United Republic of -2.107378    0.320915
## factor(country_name)Togo           0.014390    0.326231

```

```

##                                     t value Pr(>|t|)
## (Intercept)                        0.246  0.80541
## LaggedGDPGrowth                   -1.858  0.06357 .
## InitialGDP                        -0.602  0.54765
## Democracy                          0.325  0.74518
## Mountains                         4.454 9.81e-06 ***
## EthnicFrac                       -0.185  0.85362
## ReligiousFrac                     0.113  0.90971
## factor(country_name)Benin          0.680  0.49674
## factor(country_name)Botswana       1.211  0.22648
## factor(country_name)Burkina Faso   0.004  0.99668
## factor(country_name)Burundi       -5.523 4.71e-08 ***
## factor(country_name)Cameroon      -2.689  0.00733 **
## factor(country_name)Central African Republic -2.606  0.00936 **
## factor(country_name)Chad          -0.407  0.68447
## factor(country_name)Congo          1.141  0.25430
## factor(country_name)Djibouti       0.300  0.76455
## factor(country_name)Ethiopia      -5.136 3.64e-07 ***
## factor(country_name)Gabon          0.638  0.52364
## factor(country_name)Gambia         0.432  0.66560
## factor(country_name)Ghana          0.741  0.45865
## factor(country_name)Guinea        -0.402  0.68803
## factor(country_name)Guinea-Bissau -0.044  0.96463
## factor(country_name)Ivory Coast    0.493  0.62233
## factor(country_name)Kenya         -4.056 5.56e-05 ***
## factor(country_name)Lesotho       -5.041 5.89e-07 ***
## factor(country_name)Liberia        0.962  0.33617
## factor(country_name)Madagascar   -5.582 3.41e-08 ***
## factor(country_name)Malawi        -3.160  0.00165 **
## factor(country_name)Mali          -0.017  0.98613
## factor(country_name)Mauritania     0.060  0.95224
## factor(country_name)Mozambique     2.947  0.00331 **
## factor(country_name)Namibia        0.139  0.88980
## factor(country_name)Niger          0.075  0.93985
## factor(country_name)Nigeria       0.031  0.97536
## factor(country_name)Rwanda        -5.321 1.39e-07 ***
## factor(country_name)Senegal        1.846  0.06528 .
## factor(country_name)Sierra Leone  1.376  0.16939
## factor(country_name)Somalia       -0.205  0.83729
## factor(country_name)South Africa   0.587  0.55734
## factor(country_name)Sudan          1.858  0.06356 .
## factor(country_name)Swaziland     -0.209  0.83430
## factor(country_name)Tanzania, United Republic of -6.567 1.00e-10 ***
## factor(country_name)Togo          0.044  0.96483
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.3709 on 700 degrees of freedom
## Multiple R-Squared: 0.3391, Adjusted R-squared: 0.2995
## Wald test: 13.55 on 42 and 700 DF, p-value: < 2.2e-16

```

In this 2SLS regression with dummy variables we find an effect at the 0.1 confidence level, but not at 0.05. Including the country fixed effects decreases the p value of the GDP growth (0.26 to 0.06). This shows us that when we control for confounders through dummies we can improve the certainty of our statistic.

G)

```
# g) funky
```

```
firststage <- ivreg (InternalConflict ~ LaggedRainfallGrowth + InitialGDP + Democracy + Mountains + EthnicFrac + ReligiousFrac + country_name, data = rain)
```

```
rstage <- resid(firststage) #saving residuals
```

```
tidy(lm (InternalConflict ~ LaggedGDPGrowth + InitialGDP +Democracy + Mountains +EthnicFrac + ReligiousFrac + country_name + rstage, data = rain))
```

##		term	estimate	std.error
## 1		(Intercept)	2.5100367169	0.1042045386
## 2		LaggedGDPGrowth	-0.0448711969	0.0134271274
## 3		InitialGDP	-1.3878591337	0.0432091287
## 4		Democracy	0.0005370009	0.0002275299
## 5		Mountains	0.0722343450	0.0012296864
## 6		EthnicFrac	-1.0446318870	0.0583997984
## 7		ReligiousFrac	-0.7703105924	0.0674526241
## 8		country_nameBenin	-0.0397979871	0.0090694625
## 9		country_nameBotswana	0.8083551149	0.0229445633
## 10		country_nameBurkina Faso	-0.5533437117	0.0239060606
## 11		country_nameBurundi	-6.3312432241	0.0837921361
## 12		country_nameCameroon	-0.8201056831	0.0290812835
## 13		country_nameCentral African Republic	-0.4828668709	0.0140032689
## 14		country_nameChad	-0.0867613748	0.0083481133
## 15		country_nameCongo	1.1308025413	0.0301112974
## 16		country_nameDjibouti	0.2489343578	0.0247386024
## 17		country_nameEthiopia	-5.1686189349	0.0751775981
## 18		country_nameGabon	5.2775400486	0.1627502703
## 19		country_nameGambia	-0.1288913787	0.0212195752
## 20		country_nameGhana	0.1923917761	0.0150251388
## 21		country_nameGuinea	-0.5897153514	0.0238368241
## 22		country_nameGuinea-Bissau	-0.3714800694	0.0150833515
## 23		country_nameIvory Coast	1.8844278355	0.0636592242
## 24		country_nameKenya	-1.6487935387	0.0307391100
## 25		country_nameLesotho	-6.5516196660	0.0973322344
## 26		country_nameLiberia	0.4902084075	0.0167137094
## 27		country_nameMadagascar	-3.0058016830	0.0389436737
## 28		country_nameMalawi	-1.2538922557	0.0181606071
## 29		country_nameMali	-0.7150231616	0.0351766039
## 30		country_nameMauritania	-0.8640094123	0.0494527070
## 31		country_nameMozambique	0.6079564786	0.0112152664
## 32		country_nameNamibia	1.7855881729	0.0749755050
## 33		country_nameNiger	-0.3535873457	0.0227419181
## 34		country_nameNigeria	0.6052400022	0.0300022391
## 35		country_nameRwanda	-5.8170461181	0.0810568576
## 36		country_nameSenegal	0.3585837090	0.0202683789
## 37		country_nameSierra Leone	0.7127181342	0.0150080157
## 38		country_nameSomalia	-1.0200417689	0.0614604581
## 39		country_nameSouth Africa	3.5294182108	0.1112571794
## 40		country_nameSudan	0.2025473989	0.0119404844
## 41		country_nameSwaziland	1.6117885311	0.0844737754

```

## 42 country_nameTanzania, United Republic of -1.8764457845 0.0206007422
## 43 country_nameTogo -0.3634022924 0.0176981357
## 44 rstage 0.9998999744 0.0031496528
## statistic p.value
## 1 24.087595 8.294953e-94
## 2 -3.341831 8.765760e-04
## 3 -32.119582 9.562442e-140
## 4 2.360133 1.854217e-02
## 5 58.742087 1.478668e-272
## 6 -17.887594 3.331869e-59
## 7 -11.420024 8.159210e-28
## 8 -4.388131 1.319790e-05
## 9 35.230791 4.149018e-157
## 10 -23.146587 1.977724e-88
## 11 -75.558919 0.000000e+00
## 12 -28.200464 1.986835e-117
## 13 -34.482439 5.735377e-153
## 14 -10.392932 1.265749e-23
## 15 37.554096 8.401258e-170
## 16 10.062588 2.458075e-22
## 17 -68.752116 2.868067e-313
## 18 32.427228 1.767047e-141
## 19 -6.074173 2.046181e-09
## 20 12.804659 7.140546e-34
## 21 -24.739678 1.516728e-97
## 22 -24.628483 6.589023e-97
## 23 29.601803 1.887661e-125
## 24 -53.638298 5.703255e-250
## 25 -67.311921 1.101777e-307
## 26 29.329719 6.770461e-124
## 27 -77.183311 0.000000e+00
## 28 -69.044622 2.157579e-314
## 29 -20.326668 1.588550e-72
## 30 -17.471428 5.465887e-57
## 31 54.207939 1.478543e-252
## 32 23.815620 2.987671e-92
## 33 -15.547824 4.906970e-47
## 34 20.173161 1.132190e-71
## 35 -71.765009 0.000000e+00
## 36 17.691780 3.692423e-58
## 37 47.489165 5.793526e-221
## 38 -16.596716 2.115921e-52
## 39 31.723060 1.657171e-137
## 40 16.963081 2.603940e-54
## 41 19.080342 1.185673e-65
## 42 -91.086320 0.000000e+00
## 43 -20.533366 1.121987e-73
## 44 317.463554 0.000000e+00

```

Here we can see the coefficient is much lower than the previous 2SLS regression (from -2.8 to -0.045) but it is now significant at the alpha equals 0.05 level. Endogeneity is addressed in this calculation by using the first stage in the two stage regression, removing the chance of correlation with the error term.

Question 2:

```
tv <- import ("news_study_MAB.dta")
```

a) Bivariate OLS

```
reg1 <- tidy(lm (InformationLevel ~ WatchProgram, data = tv))
```

```
reg1
```

```
##           term estimate std.error statistic      p.value
## 1 (Intercept) 3.1567568 0.04270106 73.926887 5.884937e-270
## 2 WatchProgram 0.2963682 0.08422643  3.518708 4.735592e-04
```

The results can be biased because there may be a selection problem, those who were likely to watch the tv program might have had previous higher levels of information. There could be a problem with causality in this situation.

b) With controls

```
reg2 <- tidy(lm (InformationLevel ~ WatchProgram + PoliticalInterest + ReadNews + Education, data = tv))
```

```
reg2
```

```
##           term      estimate std.error  statistic      p.value
## 1 (Intercept) 1.6942655996 0.16400904 10.33031811 9.323271e-23
## 2 WatchProgram 0.2329058838 0.07695731  3.02642967 2.605338e-03
## 3 PoliticalInterest 0.2650756301 0.04600878  5.76141449 1.478782e-08
## 4 ReadNews 0.1087892561 0.01827182  5.95393810 5.008485e-09
## 5 Education 0.0008843813 0.01242477  0.07117888 9.432846e-01
```

The results do not appear to be as different from each other. The coefficients are relatively the same, only reducing slightly in the controlled regression. The estimate for watching the program is still significant. But there is a problem with endogeneity because multiple variables could be correlated with the error term. The causal direction is still uncertain.

c) Instrument test

```
reg3 <- lm (WatchProgram ~ TreatmentGroup + PoliticalInterest + ReadNews + Education, data = tv)
```

```
tidy(reg3)
```

```
##           term      estimate std.error  statistic      p.value
## 1 (Intercept) -0.144715179 0.085775678 -1.6871354 9.220479e-02
## 2 TreatmentGroup 0.406446411 0.034296486 11.8509638 1.045858e-28
## 3 PoliticalInterest 0.036886861 0.023493045  1.5701183 1.170240e-01
## 4 ReadNews 0.015588089 0.009254475  1.6843841 9.273530e-02
## 5 Education -0.002065028 0.006345252 -0.3254446 7.449816e-01
```

```
nobs (reg3)
```

```
## [1] 502
```

In this case the assignment to watch the program should be random. Using this as an instrument is useful since it does create a difference in the treatment variable (watching the program), but it does not effect the dependent variable (information levels).

We can test the instrument using an OLS regression with the treatment group and the explanatory variable, and the test confirms that it is a good instrument.

d) 2SLS model

```
ivreg_tv <- ivreg (InformationLevel ~ WatchProgram + PoliticalInterest + ReadNews + Education | TreatmentGroup + PoliticalInterest + ReadNews + Education, data = tv)
```

```
summary(ivreg_tv)
```

```
##
## Call:
## ivreg(formula = InformationLevel ~ WatchProgram + PoliticalInterest +
##       ReadNews + Education | TreatmentGroup + PoliticalInterest +
##       ReadNews + Education, data = tv)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -2.5086 -0.5071  0.2001  0.4929  1.9362
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    1.6887506   0.1646510   10.257 < 2e-16 ***
## WatchProgram    0.2913412   0.1613956    1.805  0.0717 .
## PoliticalInterest 0.2640640   0.0461014    5.728 1.78e-08 ***
## ReadNews        0.1078766   0.0184163    5.858 8.64e-09 ***
## Education       0.0007689   0.0124353    0.062  0.9507
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.7426 on 488 degrees of freedom
## Multiple R-Squared:  0.2043, Adjusted R-squared:  0.1978
## Wald test:      30 on 4 and 488 DF, p-value: < 2.2e-16
```

```
nobs (ivreg_tv)
```

```
## [1] 493
```

From looking at the observations (nobs) we can see that there are 9 more observations in part c. This is because there are some missing variables from information level. Therefore, we have a different result from the first stage of the 2SLS, due to the missing variables.

- e) The results of the 2SLS suggest that watching the program and information levels are not correlated at the alpha equals 0.05 level. The results are less significant than part b. We can't be certain that we have defeated endogeneity but using assignment to group as an instrument helps to reduce the endogeneity issue in this experiment. We can see the difference in the number of groups who watched the program and those who did not as the result of the assignment, therefore it is a useful IV.

Question 4:

```
inmates <- import ("inmates.dta")
```

A) OLS/Linear Model

```
reg_in <- tidy (lm(prison ~ educ + age + AfAm + factor(state) + factor(year), data = inmates))
```

```
reg_in
```

##	term	estimate	std.error	statistic	p.value
## 1	(Intercept)	2.911017e-02	4.082012e-04	71.31330309	0.000000e+00
## 2	educ	-1.198227e-03	1.391285e-05	-86.12375996	0.000000e+00
## 3	age	-3.748158e-04	3.654210e-06	-102.57097019	0.000000e+00
## 4	AfAm	2.117762e-02	1.413494e-04	149.82461390	0.000000e+00
## 5	factor(state)2	-9.472433e-05	1.069555e-03	-0.08856425	9.294282e-01
## 6	factor(state)4	5.170998e-03	5.231901e-04	9.88359148	4.907607e-23
## 7	factor(state)5	2.555370e-04	5.359734e-04	0.47677172	6.335247e-01
## 8	factor(state)6	5.465906e-03	3.485131e-04	15.68350388	1.969600e-55
## 9	factor(state)8	3.030158e-03	4.899818e-04	6.18422549	6.241476e-10
## 10	factor(state)9	2.187014e-03	4.841199e-04	4.51750390	6.257485e-06
## 11	factor(state)10	2.771091e-03	8.725128e-04	3.17598844	1.493282e-03
## 12	factor(state)11	-8.194725e-03	7.984155e-04	-10.26373489	1.027381e-24
## 13	factor(state)12	5.989221e-03	3.916785e-04	15.29116713	8.790159e-53
## 14	factor(state)13	3.752581e-03	4.175951e-04	8.98617221	2.561092e-19
## 15	factor(state)15	-2.340230e-03	1.070713e-03	-2.18567505	2.883945e-02
## 16	factor(state)16	3.254323e-03	7.456558e-04	4.36437703	1.274891e-05
## 17	factor(state)17	1.135495e-03	3.711432e-04	3.05945341	2.217429e-03
## 18	factor(state)18	2.720454e-03	4.162350e-04	6.53585993	6.325345e-11
## 19	factor(state)19	1.950507e-03	4.875034e-04	4.00101298	6.307315e-05
## 20	factor(state)20	6.224430e-03	5.136310e-04	12.11848436	8.443144e-34
## 21	factor(state)21	2.256223e-03	4.595330e-04	4.90981764	9.116510e-07
## 22	factor(state)22	2.317930e-03	4.458728e-04	5.19863601	2.007671e-07
## 23	factor(state)23	1.530918e-03	6.823467e-04	2.24360727	2.485774e-02
## 24	factor(state)24	2.363109e-03	4.388537e-04	5.38472976	7.255808e-08
## 25	factor(state)25	1.820838e-03	4.175363e-04	4.36090846	1.295271e-05
## 26	factor(state)26	2.500146e-03	3.804544e-04	6.57147224	4.982691e-11
## 27	factor(state)27	2.169128e-03	4.475376e-04	4.84680622	1.254701e-06
## 28	factor(state)28	-3.263172e-03	5.184077e-04	-6.29460654	3.082157e-10
## 29	factor(state)29	2.373224e-03	4.275987e-04	5.55011909	2.854950e-08
## 30	factor(state)30	2.801168e-03	7.727596e-04	3.62488892	2.890896e-04
## 31	factor(state)31	2.386516e-03	5.944719e-04	4.01451529	5.956928e-05
## 32	factor(state)32	4.963035e-03	7.941429e-04	6.24954840	4.116868e-10
## 33	factor(state)33	6.260272e-04	7.442533e-04	0.84114805	4.002651e-01
## 34	factor(state)34	1.325544e-03	3.995486e-04	3.31760403	9.079400e-04
## 35	factor(state)35	2.606832e-03	6.553712e-04	3.97764165	6.960352e-05
## 36	factor(state)36	2.715425e-03	3.573534e-04	7.59871210	2.991638e-14
## 37	factor(state)37	2.443545e-03	4.082960e-04	5.98473773	2.167591e-09
## 38	factor(state)38	2.541534e-04	8.308884e-04	0.30588154	7.596949e-01
## 39	factor(state)39	2.455550e-03	3.713369e-04	6.61272957	3.773496e-11
## 40	factor(state)40	4.481614e-03	4.853333e-04	9.23409578	2.606109e-20
## 41	factor(state)41	4.276777e-03	5.094514e-04	8.39486793	4.665832e-17
## 42	factor(state)42	1.495267e-03	3.673122e-04	4.07083353	4.684621e-05
## 43	factor(state)44	3.330304e-04	7.269775e-04	0.45810279	6.468786e-01
## 44	factor(state)45	1.988727e-04	4.770117e-04	0.41691374	6.767415e-01
## 45	factor(state)46	2.514182e-03	8.216288e-04	3.05999727	2.213406e-03
## 46	factor(state)47	1.663289e-03	4.339458e-04	3.83294151	1.266222e-04
## 47	factor(state)48	4.748619e-03	3.634679e-04	13.06475565	5.245940e-39
## 48	factor(state)49	2.726360e-03	6.448055e-04	4.22819002	2.355846e-05

```
## 49 factor(state)50 1.518474e-03 9.561976e-04 1.58803402 1.122787e-01
## 50 factor(state)51 3.330358e-03 4.153312e-04 8.01856057 1.070231e-15
## 51 factor(state)53 4.277593e-03 4.473036e-04 9.56306387 1.143888e-21
## 52 factor(state)54 5.624378e-04 5.512585e-04 1.02027961 3.075959e-01
## 53 factor(state)55 1.940161e-03 4.327306e-04 4.48353058 7.342033e-06
## 54 factor(state)56 1.915642e-03 9.618774e-04 1.99156529 4.641885e-02
## 55 factor(year)70 -3.271980e-04 1.633371e-04 -2.00320697 4.515515e-02
## 56 factor(year)80 1.561171e-03 1.476457e-04 10.57376602 3.946817e-26
```

From this OLS we can see that education attainment is highly significant in whether or not an individual will go to prison. The coefficient, however, is small but when the difference is between no education and a full 12 years of education, the difference is substantive and the chances of going to prison are much more likely when one has no education (30% probability).

B) No, we cannot prove a causal relationship between education levels and crime. There can be multiple confounding factors at play which can effect the likelihood of crime. This is a difficult relationship to estimate due to the large amount of factors, such as economic conditions, family background, geography and historical discrimination. As a result these confounders could bias the regression.

C) test

```
test <- lm ( educ ~ age + AfAm + state + year + ca9 +ca10 +ca11, data = inmates)

linearHypothesis(test, c("ca9", "ca10", "ca11"))

## Linear hypothesis test
##
## Hypothesis:
## ca9 = 0
## ca10 = 0
## ca11 = 0
##
## Model 1: restricted model
## Model 2: educ ~ age + AfAm + state + year + ca9 + ca10 + ca11
##
##      Res.Df      RSS Df Sum of Sq      F      Pr(>F)
## 1 3610662 34559655
## 2 3610659 34464227  3      95428 3332.5 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Since there are multiple IVs we use an f test to discover their strength. The test demonstrates that they are strong instruments.

D) 2sls

```
ivreg_in <- ivreg (prison ~ educ + age + AfAm + factor(state) + factor(year) | ca9 + ca10 + ca11 + age +
                  AfAm + factor (state) + factor (year), data = inmates)

## Error: cannot allocate vector of size 1.5 Gb

ivreg_in

## Error in eval(expr, envir, enclos): object 'ivreg_in' not found
```

I am unable to carry out this 2SLS due to the error: cannot allocate vector of size 1.5 GB, even though I have sufficient space on my computer for R to run this. Therefore, I also cannot finish part e.

Question 5:

```
income <- read_csv ("democracy_income.csv")
```

```
## Parsed with column specification:
## cols(
##   CountryCode = col_integer(),
##   democracy_fh = col_double(),
##   log_gdp = col_double(),
##   year = col_integer(),
##   worldincome = col_double(),
##   YearOrder = col_integer()
## )
```

```
income <- income %>%
  group_by (CountryCode) %>%
  select (CountryCode, year, democracy_fh, log_gdp, worldincome, YearOrder)
```

a) Pooled Regression

```
pincome <- pdata.frame(income)

pincome$lag_gdp <- lag(pincome$log_gdp, k = 1)

regplm <- tidy(plm(democracy_fh ~ lag_gdp, data = pincome, model = "pooling"))

regplm
```

```
##           term      estimate  std.error statistic      p.value
## 1 (Intercept) -1.3372658 0.073522000 -18.18865 3.094652e-63
## 2      lag_gdp  0.2337698 0.008984252  26.01995 7.472710e-112
```

From this pooled regression we can see that the lagged GDP is highly significant. But, bias still remains a concern because we cannot be certain that democracy is not influenced by other factors apart from GDP. Alternative theories point to institutional mechanisms, self expression values (Inglehart and Wetzel) or colonial history.

b)

```
regplm2 <- tidy(plm(democracy_fh ~ lag_gdp + year + CountryCode, data = pincome, model = "pooling"))

regplm2
```

```
##           term      estimate  std.error statistic      p.value
## 1 (Intercept) -0.193512460 0.21733121 -0.8904035 3.735263e-01
## 2      lag_gdp  0.038408436 0.02899967  1.3244437 1.857472e-01
## 3    year1965  0.006163702 0.03606057  0.1709264 8.643264e-01
## 4    year1970 -0.120493663 0.03620568 -3.3280321 9.160006e-04
## 5    year1975 -0.139872667 0.03699592 -3.7807596 1.683989e-04
## 6    year1980 -0.089822072 0.03799717 -2.3639150 1.832935e-02
## 7    year1985 -0.077313968 0.03892343 -1.9863094 4.735172e-02
## 8    year1990 -0.033422339 0.03922256 -0.8521202 3.944113e-01
## 9    year1995  0.021434278 0.04030639  0.5317836 5.950287e-01
## 10   year2000  0.041941455 0.04095516  1.0240822 3.061168e-01
## 11 CountryCode6 0.554905159 0.12093186  4.5885769 5.205932e-06
## 12 CountryCode8 0.378525927 0.15289470  2.4757295 1.350963e-02
## 13 CountryCode9 0.867225099 0.12878129  6.7340922 3.218476e-11
## 14 CountryCode10 0.869033575 0.12552622  6.9231239 9.291354e-12
## 15 CountryCode14 0.043970988 0.11706171  0.3756223 7.073008e-01
```

## 16	CountryCode16	0.235315751	0.11235299	2.0944325	3.654652e-02
## 17	CountryCode17	0.246659655	0.11374776	2.1684792	3.042658e-02
## 18	CountryCode18	0.483460784	0.12451885	3.8826313	1.121628e-04
## 19	CountryCode24	0.853674312	0.14638751	5.8316061	8.065076e-09
## 20	CountryCode25	0.485660611	0.11075876	4.3848506	1.321349e-05
## 21	CountryCode26	0.566909129	0.11364901	4.9882450	7.529182e-07
## 22	CountryCode27	0.886095165	0.12911682	6.8627399	1.386162e-11
## 23	CountryCode30	0.790128616	0.12008742	6.5796121	8.692856e-11
## 24	CountryCode31	0.185913032	0.11184504	1.6622376	9.687056e-02
## 25	CountryCode32	0.865713850	0.12938637	6.6909200	4.256978e-11
## 26	CountryCode33	0.856988395	0.13301754	6.4426723	2.063155e-10
## 27	CountryCode34	0.555610262	0.11489429	4.8358388	1.600151e-06
## 28	CountryCode35	0.049302680	0.10980109	0.4490181	6.535444e-01
## 29	CountryCode36	0.144661348	0.11220132	1.2893016	1.976789e-01
## 30	CountryCode37	0.125525909	0.11199602	1.1208069	2.627182e-01
## 31	CountryCode38	0.172306016	0.11199788	1.5384757	1.243416e-01
## 32	CountryCode39	0.634632630	0.11253452	5.6394487	2.392747e-08
## 33	CountryCode40	0.260631535	0.12395532	2.1026248	3.582139e-02
## 34	CountryCode41	0.458398468	0.12402875	3.6959050	2.345695e-04
## 35	CountryCode42	0.894086969	0.11392615	7.8479519	1.408776e-14
## 36	CountryCode43	-0.151644299	0.14727418	-1.0296734	3.034854e-01
## 37	CountryCode44	0.762482403	0.11963827	6.3732316	3.179047e-10
## 38	CountryCode47	0.804697111	0.15825936	5.0846730	4.624176e-07
## 39	CountryCode51	0.794942030	0.13460253	5.9058475	5.253847e-09
## 40	CountryCode52	0.865298667	0.12955387	6.6790648	4.595535e-11
## 41	CountryCode53	0.579673563	0.11029783	5.2555301	1.911024e-07
## 42	CountryCode54	0.119901439	0.11804092	1.0157616	3.100607e-01
## 43	CountryCode55	0.518316869	0.11126507	4.6583970	3.751439e-06
## 44	CountryCode56	0.230833722	0.10998083	2.0988541	3.615361e-02
## 45	CountryCode58	0.521504496	0.12155549	4.2902586	2.010991e-05
## 46	CountryCode60	0.244106665	0.21852753	1.1170522	2.643191e-01
## 47	CountryCode61	0.125239015	0.11770201	1.0640346	2.876453e-01
## 48	CountryCode63	0.794020654	0.12587493	6.3080128	4.753996e-10
## 49	CountryCode64	0.473293582	0.12169156	3.8892885	1.091881e-04
## 50	CountryCode65	0.852526241	0.12629639	6.7502026	2.898402e-11
## 51	CountryCode66	0.188969601	0.11968658	1.5788704	1.147749e-01
## 52	CountryCode67	0.870486595	0.12664778	6.8732873	1.292885e-11
## 53	CountryCode70	0.315803773	0.11223996	2.8136482	5.022654e-03
## 54	CountryCode71	0.050400449	0.11266810	0.4473356	6.547581e-01
## 55	CountryCode72	0.549627554	0.11515706	4.7728515	2.172159e-06
## 56	CountryCode73	0.308820940	0.12789516	2.4146413	1.598194e-02
## 57	CountryCode74	-0.026718435	0.11880681	-0.2248898	8.221245e-01
## 58	CountryCode75	0.711053674	0.12015806	5.9176529	4.905606e-09
## 59	CountryCode76	0.803348014	0.13338162	6.0229290	2.647385e-09
## 60	CountryCode77	0.495102553	0.11156254	4.4378926	1.040480e-05
## 61	CountryCode78	0.495398217	0.11910152	4.1594616	3.547531e-05
## 62	CountryCode79	0.486805342	0.10975722	4.4352921	1.052803e-05
## 63	CountryCode81	0.195596789	0.11959362	1.6355119	1.023489e-01
## 64	CountryCode82	0.478613135	0.12654252	3.7822318	1.674239e-04
## 65	CountryCode83	0.240959898	0.11181555	2.1549765	3.147186e-02
## 66	CountryCode84	0.782702178	0.10964525	7.1384961	2.177569e-12
## 67	CountryCode85	0.880440811	0.12081951	7.2872402	7.822353e-13
## 68	CountryCode86	0.195032842	0.11279487	1.7290933	8.419166e-02
## 69	CountryCode88	0.871405786	0.12714577	6.8535962	1.472345e-11

## 70	CountryCode89	0.784370839	0.12195513	6.4316346	2.210516e-10
## 71	CountryCode90	0.870297708	0.12506150	6.9589577	7.317639e-12
## 72	CountryCode91	0.816102316	0.11710778	6.9688136	6.851211e-12
## 73	CountryCode92	0.243060348	0.11103038	2.1891338	2.888549e-02
## 74	CountryCode93	0.841877305	0.12395942	6.7915557	2.212924e-11
## 75	CountryCode95	0.195788887	0.11538494	1.6968322	9.013097e-02
## 76	CountryCode99	0.837676841	0.14936489	5.6082581	2.846191e-08
## 77	CountryCode101	0.481507717	0.11289838	4.2649657	2.246960e-05
## 78	CountryCode107	0.882489266	0.13395430	6.5879876	8.241110e-11
## 79	CountryCode109	0.686214509	0.10960339	6.2608877	6.344199e-10
## 80	CountryCode110	0.328318973	0.11910009	2.7566644	5.977069e-03
## 81	CountryCode114	0.335609836	0.11268760	2.9782322	2.989827e-03
## 82	CountryCode116	0.495225522	0.11234626	4.4080287	1.190693e-05
## 83	CountryCode118	0.502400653	0.11649356	4.3126905	1.821667e-05
## 84	CountryCode120	0.259148196	0.11320885	2.2891161	2.234144e-02
## 85	CountryCode125	0.288011649	0.12491553	2.3056513	2.139400e-02
## 86	CountryCode126	0.118244513	0.11180201	1.0576242	2.905572e-01
## 87	CountryCode127	0.791357630	0.12475966	6.3430572	3.831285e-10
## 88	CountryCode128	0.267568389	0.11864281	2.2552432	2.439700e-02
## 89	CountryCode129	0.522758147	0.11530807	4.5335783	6.718544e-06
## 90	CountryCode130	0.674215535	0.16574903	4.0676892	5.235336e-05
## 91	CountryCode131	0.177991565	0.11207197	1.5881898	1.126523e-01
## 92	CountryCode132	0.285963476	0.11233918	2.5455364	1.110412e-02
## 93	CountryCode133	0.415416504	0.11141064	3.7286970	2.065288e-04
## 94	CountryCode134	0.870866230	0.12735363	6.8381733	1.629773e-11
## 95	CountryCode135	0.871645104	0.12705389	6.8604364	1.407395e-11
## 96	CountryCode136	0.454148252	0.11284032	4.0246982	6.266145e-05
## 97	CountryCode137	0.870259750	0.12758843	6.8208360	1.826504e-11
## 98	CountryCode140	0.309009270	0.12405817	2.4908418	1.295288e-02
## 99	CountryCode141	0.455231877	0.16547232	2.7511060	6.078423e-03
## 100	CountryCode142	0.421670759	0.11307636	3.7290797	2.062210e-04
## 101	CountryCode144	0.495108485	0.11348923	4.3626033	1.459570e-05
## 102	CountryCode145	0.587183329	0.11058763	5.3096656	1.436723e-07
## 103	CountryCode147	0.743934951	0.12505492	5.9488660	4.089742e-09
## 104	CountryCode148	0.616224712	0.13684817	4.5029809	7.733939e-06
## 105	CountryCode150	0.599698014	0.11802801	5.0809805	4.712012e-07
## 106	CountryCode151	0.350517329	0.11228619	3.1216424	1.865397e-03
## 107	CountryCode153	0.152845151	0.11292345	1.3535289	1.762824e-01
## 108	CountryCode155	0.060013028	0.11605259	0.5171193	6.052208e-01
## 109	CountryCode160	0.420689919	0.11479672	3.6646510	2.645942e-04
## 110	CountryCode162	0.278669381	0.12580010	2.2151762	2.703875e-02
## 111	CountryCode165	0.262437561	0.11507261	2.2806257	2.284197e-02
## 112	CountryCode166	0.597354584	0.11291306	5.2903939	1.590758e-07
## 113	CountryCode168	0.450316663	0.12453348	3.6160290	3.185686e-04
## 114	CountryCode172	0.849171630	0.12859656	6.6033775	7.470216e-11
## 115	CountryCode174	0.275727322	0.13844960	1.9915358	4.677351e-02
## 116	CountryCode175	0.050918727	0.11258279	0.4522781	6.511955e-01
## 117	CountryCode176	0.115975173	0.11219683	1.0336760	3.016109e-01
## 118	CountryCode177	0.132190157	0.11214359	1.1787580	2.388573e-01
## 119	CountryCode178	0.496574363	0.11011274	4.5096904	7.499421e-06
## 120	CountryCode182	0.809944436	0.12360027	6.5529342	1.029955e-10
## 121	CountryCode183	0.147961202	0.11733361	1.2610300	2.076785e-01
## 122	CountryCode184	0.532063858	0.11314268	4.7025918	3.042002e-06
## 123	CountryCode187	0.246501040	0.11918350	2.0682481	3.894877e-02

```
## 124 CountryCode188 0.193912704 0.11822854 1.6401514 1.013805e-01
## 125 CountryCode191 0.676540988 0.11797822 5.7344566 1.403123e-08
## 126 CountryCode192 0.845393650 0.13180640 6.4139042 2.469056e-10
## 127 CountryCode195 0.756268526 0.13413464 5.6381297 2.410411e-08
## 128 CountryCode196 0.719650183 0.12001869 5.9961510 3.099845e-09
## 129 CountryCode197 -0.114932843 0.16450698 -0.6986503 4.849808e-01
## 130 CountryCode208 0.518376369 0.11787867 4.3975417 1.248200e-05
## 131 CountryCode209 0.078366058 0.11393125 0.6878364 4.917622e-01
## 132 CountryCode210 0.336158421 0.11520840 2.9178292 3.626999e-03
## 133 CountryCode211 0.261178390 0.11528561 2.2654900 2.375851e-02
```

Here we included country and year fixed effects, there still is a significant result for the lagged GDP ($\alpha = 0.05$). But this significance has reduced once the controls are added.

c) Instrument test

```
test1 <- tidy(plm(lag_gdp ~ worldincome, data = pincome, model = "pooling"))
```

```
test1
```

```
##          term estimate std.error statistic    p.value
## 1 (Intercept) 7.8359751 0.056223749 139.371265 0.000000e+00
## 2 worldincome 0.0243718 0.003900008   6.249167 6.349186e-10
```

The instrument test shows that world income is a strong instrument for log gdp. 1. Inclusion condition: The test determines this, that world income is correlated with log gdp at the $\alpha = 0.05$ level. 2. Exclusion condition: The IV should not be correlated with y, only through x. This can only be justified through theory, and here trading partner income is correlated with the GDP of a country, but should not be correlated with the level of democracy.

d)

```
tidy(plm(democracy_fh ~ lag_gdp + year + CountryCode | lag(worldincome, k = 1) + year + CountryCode, data = pincome, model = "pooling"))
```

```
##          term estimate std.error statistic    p.value
## 1 (Intercept) 1.51163356 0.79580909 1.89949271 5.787170e-02
## 2 lag_gdp -0.21298773 0.11645759 -1.82888656 6.780174e-02
## 3 year1965 0.05206503 0.04299022 1.21109020 2.262310e-01
## 4 year1970 -0.03297144 0.05450022 -0.60497808 5.453711e-01
## 5 year1975 -0.01995469 0.06616449 -0.30159210 7.630441e-01
## 6 year1980 0.05824546 0.07725812 0.75390734 4.511344e-01
## 7 year1985 0.09094348 0.08558194 1.06264799 2.882735e-01
## 8 year1990 0.14196499 0.08854339 1.60333801 1.092685e-01
## 9 year1995 0.21405518 0.09593169 2.23132911 2.594536e-02
## 10 year2000 0.24458584 0.10026514 2.43939054 1.493594e-02
## 11 CountryCode6 1.00096838 0.23630403 4.23593443 2.550341e-05
## 12 CountryCode8 0.84313365 0.26233613 3.21394409 1.363588e-03
## 13 CountryCode9 1.45567649 0.29571932 4.92249377 1.044924e-06
## 14 CountryCode10 1.40201234 0.27221367 5.15041124 3.301284e-07
## 15 CountryCode14 -0.15531084 0.15158527 -1.02457740 3.058832e-01
## 16 CountryCode16 0.13874667 0.12536137 1.10677372 2.687361e-01
## 17 CountryCode17 0.06493209 0.14422626 0.45020989 6.526853e-01
## 18 CountryCode18 0.37353757 0.13938749 2.67985009 7.522265e-03
## 19 CountryCode24 1.11731434 0.19342554 5.77645702 1.105491e-08
## 20 CountryCode25 0.63345107 0.13352308 4.74413169 2.494072e-06
## 21 CountryCode26 0.83258600 0.16819099 4.95024130 9.103698e-07
## 22 CountryCode27 1.32751981 0.23929458 5.54763853 3.978371e-08
```


## 23	CountryCode30	0.95061195	0.14482337	6.56394008	9.604236e-11
## 24	CountryCode31	0.21361414	0.11780884	1.81322673	7.018457e-02
## 25	CountryCode32	1.46405687	0.29994851	4.88102732	1.282345e-06
## 26	CountryCode33	1.51244247	0.32455397	4.66006454	3.722001e-06
## 27	CountryCode34	0.85887905	0.18132265	4.73674445	2.584018e-06
## 28	CountryCode35	-0.02795387	0.12009188	-0.23277069	8.160011e-01
## 29	CountryCode36	0.22691808	0.12315127	1.84259633	6.577075e-02
## 30	CountryCode37	0.18303317	0.12009969	1.52401039	1.279151e-01
## 31	CountryCode38	0.11452728	0.12012765	0.95337985	3.406957e-01
## 32	CountryCode39	0.86187749	0.15563721	5.53773424	4.200856e-08
## 33	CountryCode40	0.30013348	0.13103723	2.29044425	2.226401e-02
## 34	CountryCode41	0.51251659	0.13215294	3.87820786	1.141816e-04
## 35	CountryCode42	1.16853903	0.17118800	6.82605703	1.764929e-11
## 36	CountryCode43	0.14680783	0.20399152	0.71967614	4.719419e-01
## 37	CountryCode44	1.13172325	0.20729639	5.45944503	6.439511e-08
## 38	CountryCode47	1.38890943	0.30941842	4.48877428	8.253909e-06
## 39	CountryCode51	1.04589924	0.18020758	5.80385817	9.454814e-09
## 40	CountryCode52	1.46635920	0.30111220	4.86981001	1.355023e-06
## 41	CountryCode53	0.69877367	0.12722116	5.49258994	5.377644e-08
## 42	CountryCode54	0.35867747	0.16337300	2.19545132	2.842778e-02
## 43	CountryCode55	0.69235675	0.14014734	4.94020628	9.569797e-07
## 44	CountryCode56	0.32537092	0.12271564	2.65142174	8.179523e-03
## 45	CountryCode58	0.98012938	0.24140905	4.06003579	5.406207e-05
## 46	CountryCode60	-0.08758192	0.27276312	-0.32109152	7.482278e-01
## 47	CountryCode61	-0.09114320	0.15673094	-0.58152653	5.610552e-01
## 48	CountryCode63	1.33314442	0.27479819	4.85135809	1.483287e-06
## 49	CountryCode64	0.70760503	0.16501085	4.28823323	2.028980e-05
## 50	CountryCode65	1.39900728	0.27789932	5.03422355	5.973640e-07
## 51	CountryCode66	0.55938520	0.20774565	2.69264452	7.242257e-03
## 52	CountryCode67	1.42304522	0.28046642	5.07385236	4.886157e-07
## 53	CountryCode70	0.22967655	0.12371779	1.85645530	6.376898e-02
## 54	CountryCode71	0.17145498	0.12984207	1.32048871	1.870627e-01
## 55	CountryCode72	0.46916283	0.12587796	3.72712438	2.077982e-04
## 56	CountryCode73	0.03290708	0.18213358	0.18067552	8.566696e-01
## 57	CountryCode74	0.02585678	0.12664961	0.20416000	8.382822e-01
## 58	CountryCode75	1.14111477	0.22984998	4.96460676	8.474393e-07
## 59	CountryCode76	0.99928523	0.16491906	6.05924629	2.135323e-09
## 60	CountryCode77	0.68290870	0.14391049	4.74537136	2.479276e-06
## 61	CountryCode78	0.58502727	0.13103766	4.46457354	9.217637e-06
## 62	CountryCode79	0.55922562	0.11944338	4.68193074	3.355931e-06
## 63	CountryCode81	0.06574841	0.13807659	0.47617347	6.340854e-01
## 64	CountryCode82	0.85992126	0.21598170	3.98145435	7.495377e-05
## 65	CountryCode83	0.25744526	0.11735661	2.19370060	2.855399e-02
## 66	CountryCode84	0.72440602	0.11777319	6.15085667	1.235477e-09
## 67	CountryCode85	1.32421015	0.23537538	5.62595002	2.579638e-08
## 68	CountryCode86	0.43177928	0.15864744	2.72162771	6.642319e-03
## 69	CountryCode88	1.43249317	0.28407681	5.04262615	5.725117e-07
## 70	CountryCode89	1.25090071	0.24463796	5.11327320	3.995429e-07
## 71	CountryCode90	1.39500230	0.26874201	5.19086052	2.678056e-07
## 72	CountryCode91	1.01740808	0.15215807	6.68652048	4.379664e-11
## 73	CountryCode92	0.40544626	0.13711279	2.95702733	3.200821e-03
## 74	CountryCode93	1.34654604	0.26037740	5.17151647	2.960399e-07
## 75	CountryCode95	0.09369721	0.12919950	0.72521346	4.685406e-01
## 76	CountryCode99	1.20602571	0.22718756	5.30850248	1.445595e-07

## 77	CountryCode101	0.72193353	0.15983045	4.51687094	7.255990e-06
## 78	CountryCode107	1.10586515	0.17224195	6.42041692	2.370823e-10
## 79	CountryCode109	0.73825997	0.11714314	6.30220383	4.926630e-10
## 80	CountryCode110	0.23883363	0.13101658	1.82292675	6.870062e-02
## 81	CountryCode114	0.45802092	0.13011471	3.52013181	4.565839e-04
## 82	CountryCode116	0.39924694	0.12526401	3.18724377	1.494136e-03
## 83	CountryCode118	0.84849518	0.19709302	4.30504944	1.884161e-05
## 84	CountryCode120	0.10476778	0.13721789	0.76351399	4.453899e-01
## 85	CountryCode125	0.14830160	0.14499844	1.02278064	3.067315e-01
## 86	CountryCode126	0.11159474	0.11714838	0.95259312	3.410940e-01
## 87	CountryCode127	1.12561160	0.19855141	5.66911906	2.027061e-08
## 88	CountryCode128	0.00733843	0.17025894	0.04310158	9.656317e-01
## 89	CountryCode129	0.76746909	0.16298744	4.70876229	2.953856e-06
## 90	CountryCode130	0.87211290	0.19487446	4.47525492	8.779696e-06
## 91	CountryCode131	0.11027126	0.12123692	0.90955180	3.633424e-01
## 92	CountryCode132	0.19060929	0.12516164	1.52290509	1.281914e-01
## 93	CountryCode133	0.59631933	0.14200006	4.19943007	2.987430e-05
## 94	CountryCode134	1.43548519	0.28557444	5.02665857	6.206278e-07
## 95	CountryCode135	1.43116607	0.28341304	5.04975382	5.522158e-07
## 96	CountryCode136	0.32158539	0.13223200	2.43197859	1.524267e-02
## 97	CountryCode137	1.43884833	0.28725962	5.00887773	6.788036e-07
## 98	CountryCode140	0.25004054	0.13259756	1.88570993	5.970879e-02
## 99	CountryCode141	0.36477030	0.17798782	2.04941160	4.075889e-02
## 100	CountryCode142	0.66830213	0.16184677	4.12922746	4.036162e-05
## 101	CountryCode144	0.75560177	0.16644193	4.53973217	6.530370e-06
## 102	CountryCode145	0.72500707	0.13121563	5.52531046	4.497076e-08
## 103	CountryCode147	0.89272145	0.14692335	6.07610351	1.931825e-09
## 104	CountryCode148	0.94605760	0.20568273	4.59959665	4.944966e-06
## 105	CountryCode150	0.98287576	0.21130333	4.65149209	3.875735e-06
## 106	CountryCode151	0.56833525	0.15271736	3.72148423	2.124115e-04
## 107	CountryCode153	0.29062489	0.13337149	2.17906314	2.962827e-02
## 108	CountryCode155	-0.08842797	0.13850770	-0.63843359	5.233806e-01
## 109	CountryCode160	0.40495885	0.12045314	3.36196167	8.119560e-04
## 110	CountryCode162	0.72498632	0.23917107	3.03124592	2.516759e-03
## 111	CountryCode165	0.19163192	0.12462628	1.53765252	1.245428e-01
## 112	CountryCode166	0.83829803	0.15999764	5.23943996	2.079107e-07
## 113	CountryCode168	0.33915497	0.13959810	2.42950998	1.534606e-02
## 114	CountryCode172	1.43457910	0.29442000	4.87255987	1.336847e-06
## 115	CountryCode174	0.65245154	0.22229530	2.93506679	3.433589e-03
## 116	CountryCode175	0.16585369	0.12864313	1.28925414	1.976954e-01
## 117	CountryCode176	0.03418063	0.12308519	0.27769892	7.813177e-01
## 118	CountryCode177	0.05607920	0.12230034	0.45853675	6.466958e-01
## 119	CountryCode178	0.60202105	0.12460864	4.83129453	1.636016e-06
## 120	CountryCode182	1.20739698	0.21989773	5.49072051	5.432716e-08
## 121	CountryCode183	0.35891794	0.15493835	2.31652091	2.079046e-02
## 122	CountryCode184	0.78097061	0.16259256	4.80323709	1.875211e-06
## 123	CountryCode187	-0.03167731	0.17624373	-0.17973580	8.574071e-01
## 124	CountryCode188	-0.05174011	0.16554642	-0.31254141	7.547134e-01
## 125	CountryCode191	1.05856475	0.21085446	5.02035739	6.406708e-07
## 126	CountryCode192	1.48219548	0.31648509	4.68330268	3.334156e-06
## 127	CountryCode195	0.98763444	0.17449068	5.66009847	2.132065e-08
## 128	CountryCode196	1.14677668	0.22867270	5.01492615	6.584469e-07
## 129	CountryCode197	-0.20624076	0.17709015	-1.16460889	2.445366e-01
## 130	CountryCode208	0.89808369	0.20995464	4.27751295	2.126780e-05

```
## 131 CountryCode209 -0.11180330 0.14654326 -0.76293715 4.457336e-01
## 132 CountryCode210 0.25034890 0.12663322 1.97696077 4.840102e-02
## 133 CountryCode211 0.35445591 0.12776140 2.77435838 5.664510e-03
```

With the use of world income as an instrument we find that the coefficient becomes negative. Therefore, there is a negative relationship between GDP and democracy in this model. This has the opposite outcome from the OLS model and the panel data which demonstrate a positive relationship between democracy and GDP. Also the significance of the result disappears, thus we cannot reject the null hypothesis.