Effect of Democratization on Deforestation
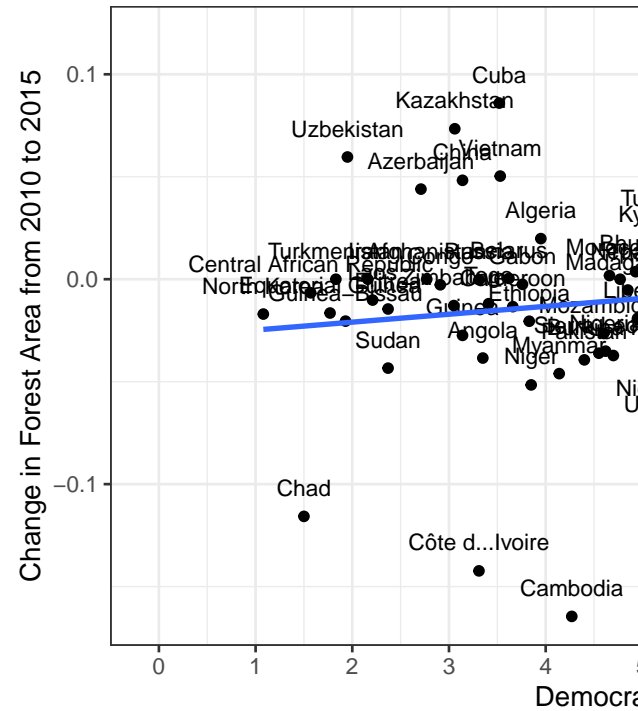
Students: Albert Yao and Takeo Tokunari

Democracization's Effect on Deforestation
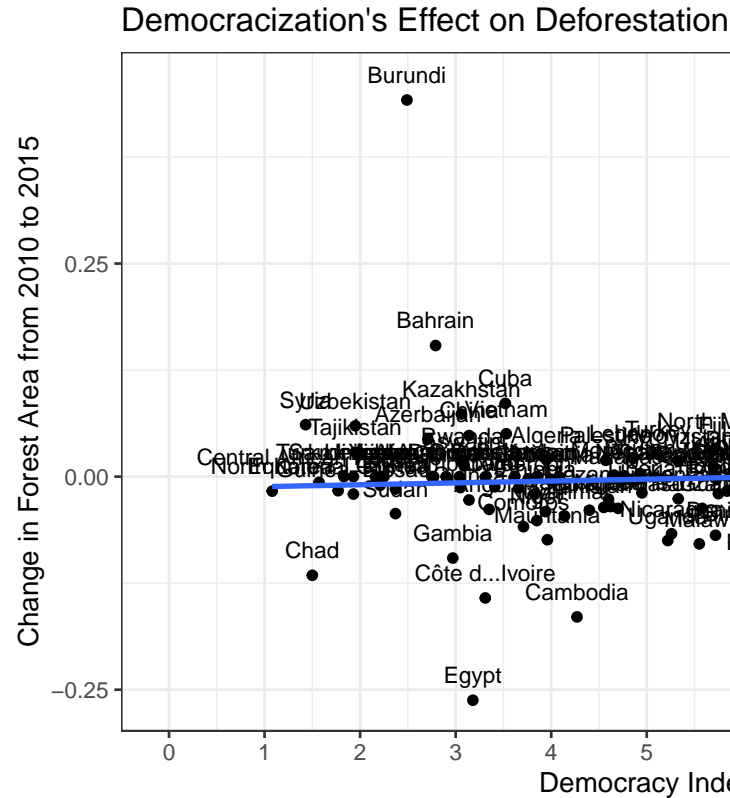
1. Effect of democratization on deforestation (all countries)

	Model 1
(Intercept)	-0.014
	(0.012)
'2015'	0.002
	(0.002)
Num.Obs.	159
R2	0.007
R2 Adj.	0.001

* p < 0.1, ** p < 0.05, *** p < 0.01

Democracization's Effect on Defores...

Countries with forest land over one million h...

Change in Forest Area from 2010 to 2015

0.1

Cuba
Kazakhstan
Uzbekistan
Ch...Vietnam
Azerbaijan
Algeria
Tu...
Ky...
Turkmenistan...Afghanistan...Belarus Mo...Bh...
Central African Republic Ethiopia Madag...
North... Gabon Li...
Guinea–Bissau Cameroon Mozambiqu...
Guinea Eritrea Guinea Congo
0.0
Angola Niger... Nigeria
Sudan Myanmar Pakistan
Niger
Ni...
U...

−0.1
Chad

Côte d...Ivoire

Cambodia

0   1   2   3   4   5

Democra...

2. Effect of democratization on deforestation (countries with forest)

	Model 1
(Intercept)	-0.029***
	(0.010)
'2015'	0.004**
	(0.002)
Num.Obs.	115
R2	0.044
R2 Adj.	0.036

* p < 0.1, ** p < 0.05, *** p < 0.01

Agricultural Land Growth and Deforestation, 2015
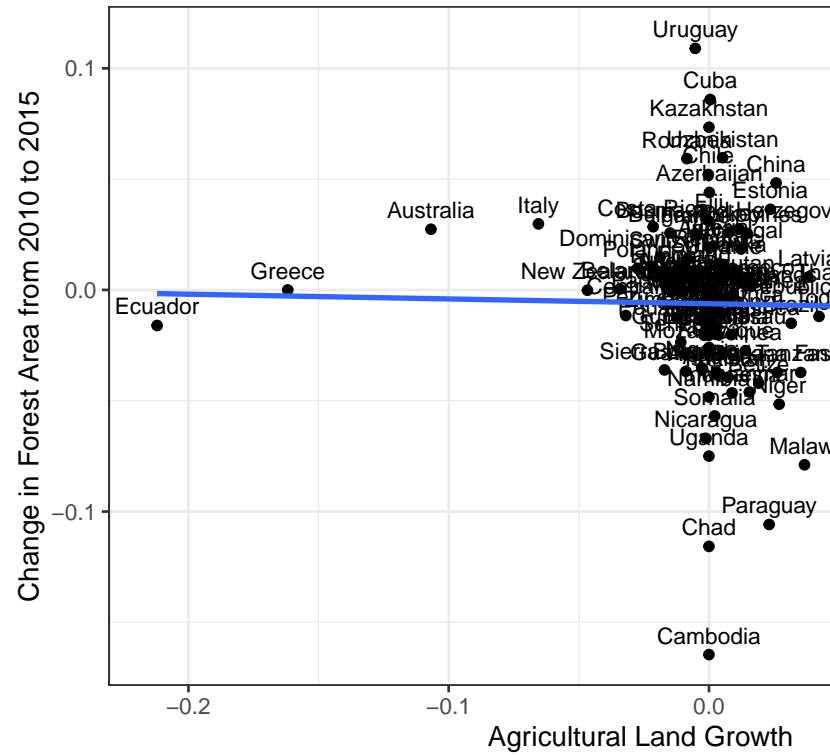
3. Agricultural land growth (countries with forest)

	Model 1
(Intercept)	-0.006*
	(0.004)
agri_change	-0.021
	(0.087)
Num.Obs.	108
R2	0.001
R2 Adj.	-0.009

* p < 0.1, ** p < 0.05, *** p < 0.01

4. GDP per capita growth (countries with forest)

	Model 1
(Intercept)	-0.012***
	(0.004)
GDPcap_2015	0.000***
	(0.000)
Num.Obs.	108
R2	0.064
R2 Adj.	0.056

* p < 0.1, ** p < 0.05, *** p < 0.01

3

GDP Per Capita and Deforestation, 2015
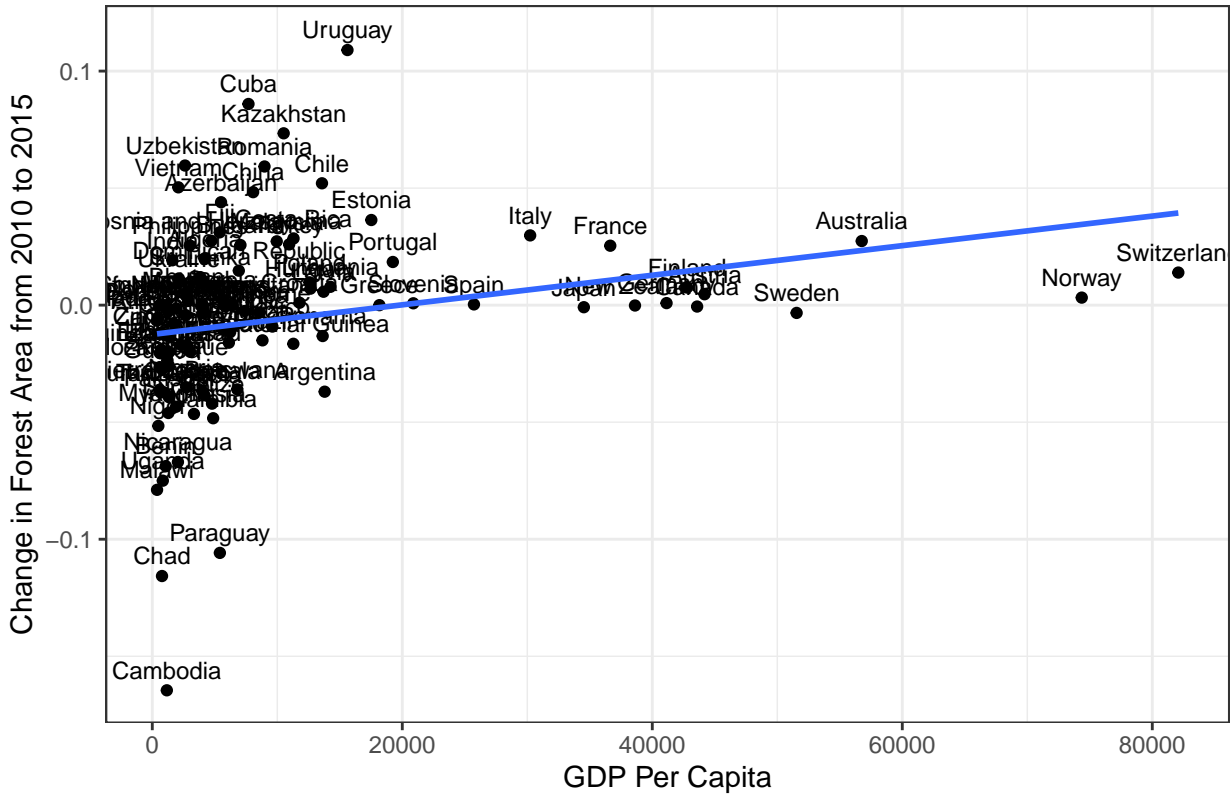
5. GDP per capita (countries with forest and with less than US$20,000 GDP per capita)

```
gdp_less_20000 <- read_csv("WB_GDPperCapita_Cleaned.csv",
    col_types = cols(GDPcap_2015 = col_double())) %>%
    filter(GDPcap_2015 < 20000) %>%
    select(`Country Name`, `Country Code`, `GDPcap_2015`) %>%
    rename("Country" = "Country Name") %>%
    right_join(for_big)
```

```
## Joining, by = "Country"
```

```
gdp_less_20000_lm <- lm(change2015_big ~ GDPcap_2015, data = gdp_less_20000)
modelsummary::modelsummary(gdp_less_20000_lm, gof_omit = "AIC|BIC|Log.Lik.|F", stars = TRUE)
```

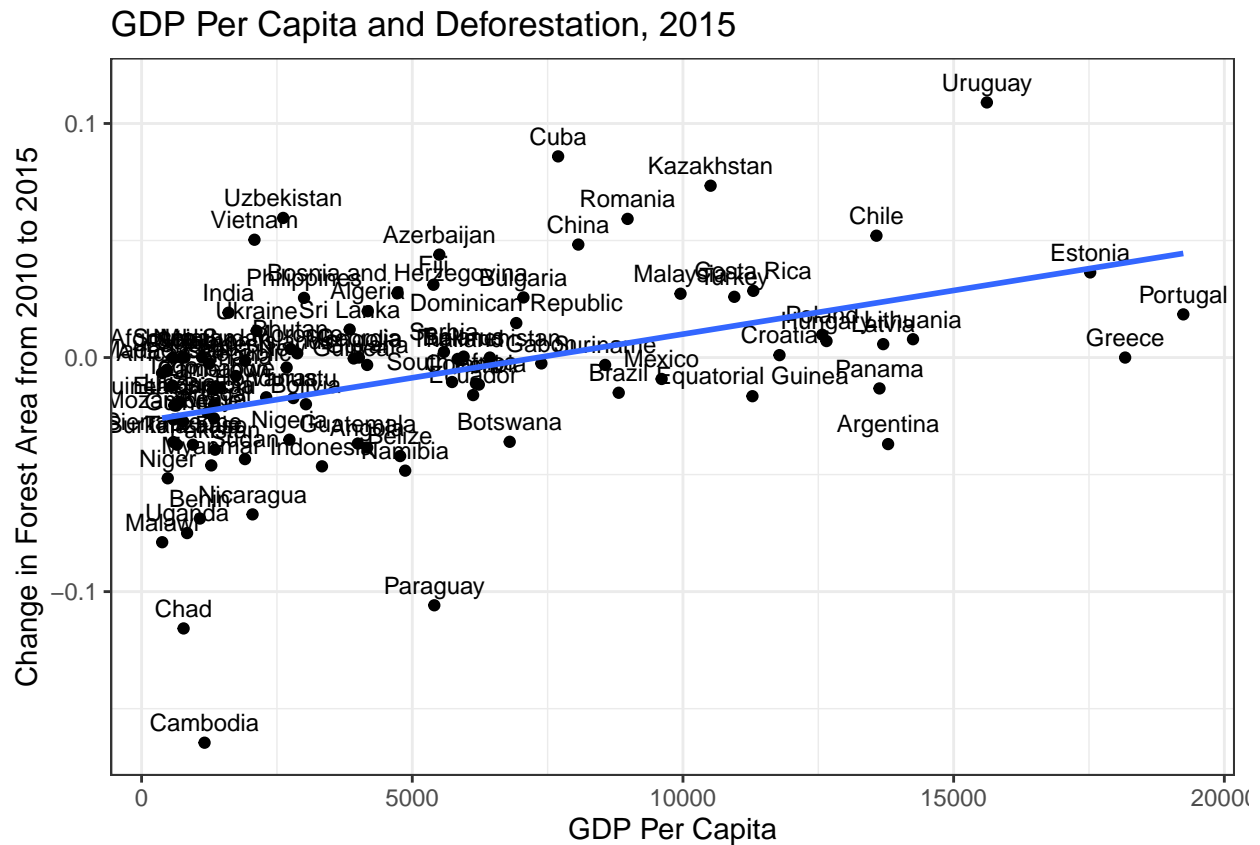|	Model 1
(Intercept)	-0.027***
	(0.006)
GDPcap__2015	0.000***
	(0.000)
Num.Obs.	94
R2	0.195
R2 Adj.	0.186

* p < 0.1, ** p < 0.05, *** p < 0.01

4

```
gdp_less_20000 %>%
  ggplot(aes(x = GDPcap_2015, y = change2015_big, label = Country)) +
  geom_point() +
  geom_text(vjust = 0, nudge_y = 0.005, size = 3) +
  geom_smooth(method = "lm", se = FALSE) +
  labs(
    title = "GDP Per Capita and Deforestation, 2015",
    x = "GDP Per Capita",
    y = "Change in Forest Area from 2010 to 2015"
  ) +
  theme_bw()
```
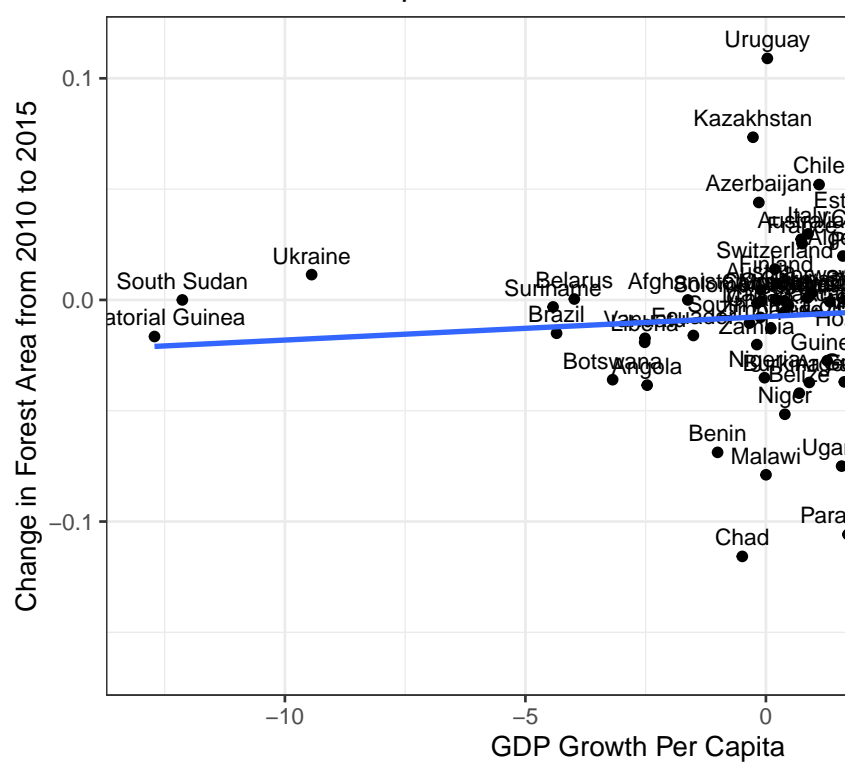
`geom_smooth()` using formula 'y ~ x'

Warning: Removed 30 rows containing non-finite values (stat_smooth).

Warning: Removed 30 rows containing missing values (geom_point).

Warning: Removed 30 rows containing missing values (geom_text).
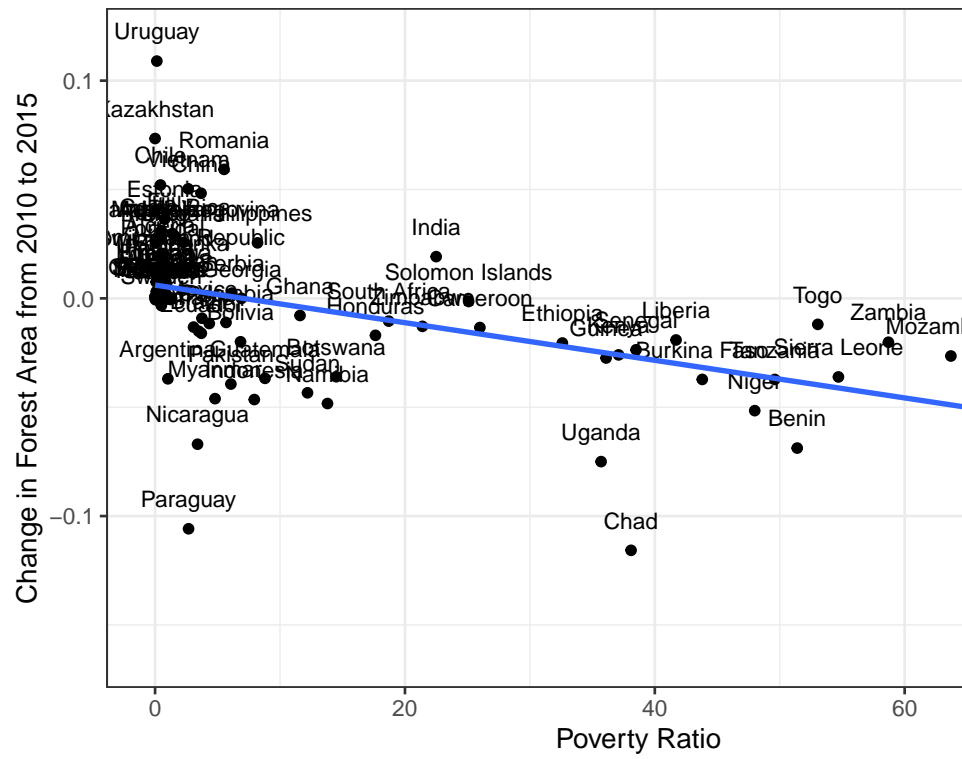
GDP Growth Per Capita and Deforestation, 2015

6. GDP growth per capita (countries with forest)

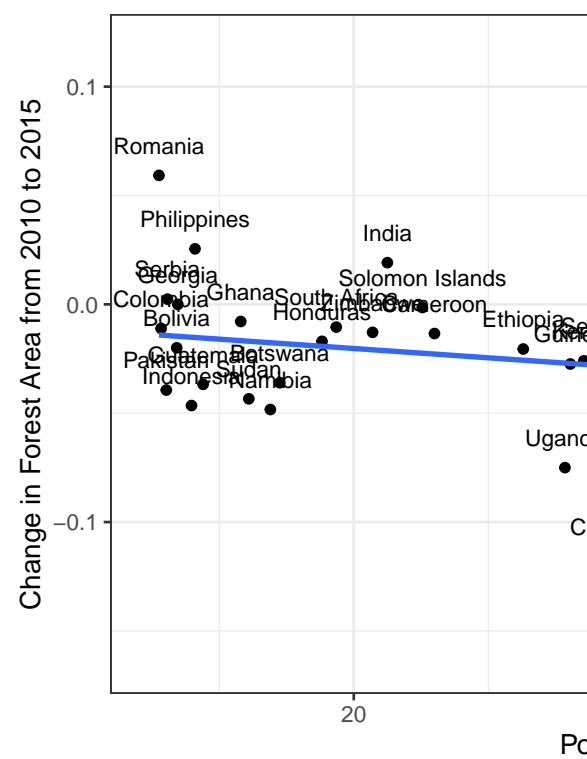|	Model 1
(Intercept)	-0.008*
	(0.004)
GrowthCap__2015	0.001
	(0.001)
Num.Obs.	107
R2	0.009
R2 Adj.	-0.001

* p < 0.1, ** p < 0.05,
*** p < 0.01

Poverty Ratio and Deforestation, 2015

7. Poverty ratio (countries with forest)

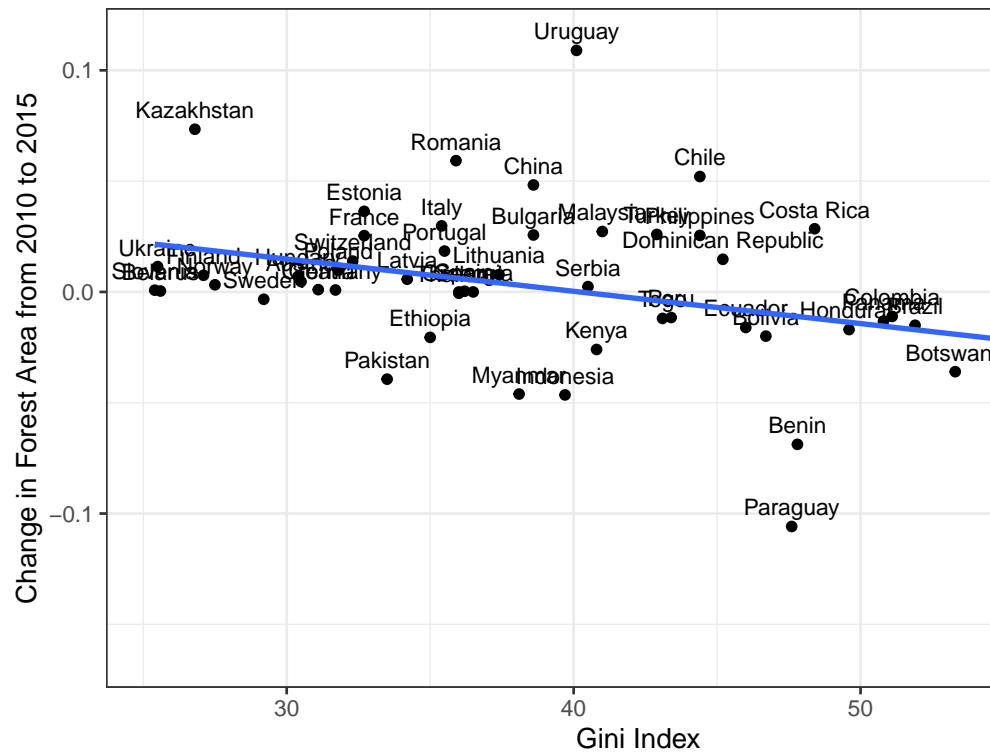|	Model 1
(Intercept)	0.006
	(0.004)
'Average_2011-2015'	-0.001***
	(0.000)
Num.Obs.	85
R2	0.209
R2 Adj.	0.200

* p < 0.1, ** p < 0.05, *** p < 0.01

Poverty Ratio and Deforestation,

8. Poverty ratio (countries with forest and poverty ratio of 5% or higher)

	Model 1
(Intercept)	-0.012
	(0.009)
'Average_2011-2015'	0.000*
	(0.000)
Num.Obs.	35
R2	0.080
R2 Adj.	0.052

* p < 0.1, ** p < 0.05, *** p < 0.01

Gini Index and Deforestation, 2015

9. Gini Index (countries with forest)

	Model 1
(Intercept)	0.059***
	(0.022)
Gini_2015	-0.001**
	(0.001)
Num.Obs.	52
R2	0.125
R2 Adj.	0.108
* p < 0.1, ** p < 0.05, *** p < 0.01	

10. Does Gini Index explain the difference in the effect of democratization on deforestation?

Model 1: average treatment effect of Gini Index as a binary variable

Model 2: multivariable linear regression

	Model 1
(Intercept)	0.246**
	(0.099)
'2015'	-0.028*
	(0.014)
Gini_2015	-0.007**
	(0.003)
'2015' × Gini_2015	0.001**
	(0.000)
Num.Obs.	52
R2	0.215
R2 Adj.	0.166

* p < 0.1, ** p < 0.05, *** p < 0.01

Code

```
knitr::opts_chunk$set(echo = TRUE)
library(tidyverse)
library(readxl)
library(knitr)
library(modelsummary)

di <- read_excel("Democracy-Index-2019.xlsx") %>%
  rename("Country" = '2019') %>%
  rename("2019" = '...4') %>%
  select(c("Country", "2019", "2015", "2010"))

forest <- read_excel("Forest Area.xlsx", sheet = 2) %>%
  select(c("Country and Area", "Forest Area, 2010", "Forest Area, 2015", "Forest Area, 2020")) %>%
  rename("Country" = "Country and Area")

for_change <- forest %>%
  group_by(Country) %>%
  summarize(change2015 = ('Forest Area, 2015' - 'Forest Area, 2010')/'Forest Area, 2010',
            change2020 = ('Forest Area, 2020' - 'Forest Area, 2015')/'Forest Area, 2015')

di_forest <- di %>%
  right_join(for_change)

df2015 <- di_forest %>%
  select(Country, '2015', change2015)
df2015_lm <- lm(change2015 ~ '2015', data = df2015)

df2015 %>%
  ggplot(aes(x = '2015', y = change2015, label = Country)) +
  geom_point() +
  geom_text(vjust = 0, nudge_y = 0.02, size = 3) +
  geom_smooth(method = "lm", se = FALSE) +
  scale_x_continuous(breaks = c(0:10), labels = c(0:10), limits = c(0, 10)) +
  labs(
```

```
    title = "Democracization's Effect on Deforestation, 2015",
    x = "Democracy Index",
    y = "Change in Forest Area from 2010 to 2015"
  ) +
  theme_bw()


modelsummary::modelsummary(df2015_lm, gof_omit = "AIC|BIC|Log.Lik.|F", stars = TRUE)


for_big <- forest %>%
  filter(`Forest Area, 2010` >= 1000) %>%
  group_by(Country) %>%
  summarize(change2015_big = (`Forest Area, 2015` - `Forest Area, 2010`)/`Forest Area, 2010`)
di_forest_big <- di %>%
  right_join(for_big)

df2015_big <- di_forest_big %>%
  select(Country, `2015`, change2015_big)
df2015_big_lm <- lm(change2015_big ~ `2015`, data = df2015_big)

df2015_big %>%
  ggplot(aes(x = `2015`, y = change2015_big, label = Country)) +
  geom_point() +
  geom_text(vjust = 0, nudge_y = 0.01, size = 3) +
  geom_smooth(method = "lm", se = FALSE) +
  scale_x_continuous(breaks = c(0:10), labels = c(0:10), limits = c(0, 10)) +
  labs(
    title = "Democracization's Effect on Deforestation, 2015",
    subtitle = "Countries with forest land over one million hectares",
    x = "Democracy Index",
    y = "Change in Forest Area from 2010 to 2015"
  ) +
  theme_bw()

modelsummary::modelsummary(df2015_big_lm, gof_omit = "AIC|BIC|Log.Lik.|F", stars = TRUE)


agri <- read_csv("WB_Agri_Land_Cleaned.csv") %>%
  group_by(`Country Name`) %>%
  summarize(agri_change = (Agri_2015 - Agri_2011)/Agri_2011) %>%
  rename("Country" = `Country Name`) %>%
  right_join(for_big)
agri_lm <- lm(change2015_big ~ agri_change, data = agri)

agri %>%
  ggplot(aes(x = agri_change, y = change2015_big, label = Country)) +
  geom_point() +
  geom_text(vjust = 0, nudge_y = 0.005, size = 3) +
  geom_smooth(method = "lm", se = FALSE) +
  labs(
    title = "Agricultural Land Growth and Deforestation, 2015",
    x = "Agricultural Land Growth",
```

```
    y = "Change in Forest Area from 2010 to 2015"
  ) +
  theme_bw()

modelsummary::modelsummary(agri_lm, gof_omit = "AIC|BIC|Log.Lik.|F", stars = TRUE)


gdp <- read_csv("WB_GDPperCapita_Cleaned.csv",
    col_types = cols(GDPcap_2015 = col_double())) %>%
#    filter(GDPcap_2015 < 20000) %>%
    select('Country Name', 'Country Code', 'GDPcap_2015') %>%
    rename("Country" = "Country Name") %>%
    right_join(for_big)
gdp_lm <- lm(change2015_big ~ GDPcap_2015, data = gdp)
modelsummary::modelsummary(gdp_lm, gof_omit = "AIC|BIC|Log.Lik.|F", stars = TRUE)

gdp %>%
  ggplot(aes(x = GDPcap_2015, y = change2015_big, label = Country)) +
  geom_point() +
  geom_text(vjust = 0, nudge_y = 0.005, size = 3) +
  geom_smooth(method = "lm", se = FALSE) +
  labs(
    title = "GDP Per Capita and Deforestation, 2015",
    x = "GDP Per Capita",
    y = "Change in Forest Area from 2010 to 2015"
  ) +
  theme_bw()

gdp_less_20000 <- read_csv("WB_GDPperCapita_Cleaned.csv",
    col_types = cols(GDPcap_2015 = col_double())) %>%
    filter(GDPcap_2015 < 20000) %>%
    select('Country Name', 'Country Code', 'GDPcap_2015') %>%
    rename("Country" = "Country Name") %>%
    right_join(for_big)
gdp_less_20000_lm <- lm(change2015_big ~ GDPcap_2015, data = gdp_less_20000)
modelsummary::modelsummary(gdp_less_20000_lm, gof_omit = "AIC|BIC|Log.Lik.|F", stars = TRUE)

gdp_less_20000 %>%
  ggplot(aes(x = GDPcap_2015, y = change2015_big, label = Country)) +
  geom_point() +
  geom_text(vjust = 0, nudge_y = 0.005, size = 3) +
  geom_smooth(method = "lm", se = FALSE) +
  labs(
    title = "GDP Per Capita and Deforestation, 2015",
    x = "GDP Per Capita",
    y = "Change in Forest Area from 2010 to 2015"
  ) +
  theme_bw()


gdp_growth <- read_csv("WB_GDP_Growth_per_Capita_Cleaned.csv") %>%
  select('Country Name', 'Country Code', 'GrowthCap_2015') %>%
```

```r
  rename("Country" = "Country Name") %>%
  right_join(for_big) %>%
  filter(Country != "Sierra Leone")
gdp_growth_lm <- lm(change2015_big ~ GrowthCap_2015, data = gdp_growth)

gdp_growth %>%
  ggplot(aes(x = GrowthCap_2015, y = change2015_big, label = Country)) +
  geom_point() +
  geom_text(vjust = 0, nudge_y = 0.005, size = 3) +
  geom_smooth(method = "lm", se = FALSE) +
  labs(
    title = "GDP Growth Per Capita and Deforestation, 2015",
    x = "GDP Growth Per Capita",
    y = "Change in Forest Area from 2010 to 2015"
  ) +
  theme_bw()

modelsummary::modelsummary(gdp_growth_lm, gof_omit = "AIC|BIC|Log.Lik.|F", stars = TRUE)

pov_ratio <- read_csv("World_Bank_Poor_Ratio_Cleaned.csv") %>%
# filter('Average_2011-2015' > 5) %>%
  rename("Country" = 'Country Name') %>%
  select(Country, 'Average_2011-2015') %>%
  right_join(for_big)

pov_ratio %>%
  ggplot(aes(x = 'Average_2011-2015', y = change2015_big, label = Country)) +
  geom_point() +
  geom_text(vjust = 0, nudge_y = 0.01, size = 3) +
  geom_smooth(method = "lm", se = FALSE) +
  labs(
    title = "Poverty Ratio and Deforestation, 2015",
    x = "Poverty Ratio",
    y = "Change in Forest Area from 2010 to 2015"
  ) +
  theme_bw()

pov_lm <- lm(change2015_big ~ 'Average_2011-2015', data = pov_ratio)
modelsummary::modelsummary(pov_lm, gof_omit = "AIC|BIC|Log.Lik.|F", stars = TRUE)


pov_ratio_5 <- read_csv("World_Bank_Poor_Ratio_Cleaned.csv") %>%
  filter('Average_2011-2015' > 5) %>%
  rename("Country" = 'Country Name') %>%
  select(Country, 'Average_2011-2015') %>%
  right_join(for_big)

pov_ratio_5 %>%
  ggplot(aes(x = 'Average_2011-2015', y = change2015_big, label = Country)) +
  geom_point() +
  geom_text(vjust = 0, nudge_y = 0.01, size = 3) +
  geom_smooth(method = "lm", se = FALSE) +
  labs(
```

```
    title = "Poverty Ratio and Deforestation, 2015",
    x = "Poverty Ratio",
    y = "Change in Forest Area from 2010 to 2015"
  ) +
  theme_bw()

pov_lm_5 <- lm(change2015_big ~ `Average_2011-2015`, data = pov_ratio_5)
modelsummary::modelsummary(pov_lm_5, gof_omit = "AIC|BIC|Log.Lik.|F", stars = TRUE)


gini <- read_csv("WB_Gini_Cleaned.csv") %>%
  select(`Country Name`, `Country Code`, Gini_2015) %>%
  slice(1:169) %>%
  rename("Country" = "Country Name") %>%
  right_join(for_big)

gini_lm <- lm(change2015_big ~ Gini_2015, data = gini)

gini %>%
  ggplot(aes(x = Gini_2015, y = change2015_big, label = Country)) +
  geom_point() +
  geom_text(vjust = 0, nudge_y = 0.005, size = 3) +
  geom_smooth(method = "lm", se = FALSE) +
  labs(
    title = "Gini Index and Deforestation, 2015",
    x = "Gini Index",
    y = "Change in Forest Area from 2010 to 2015"
  ) +
  theme_bw()

modelsummary::modelsummary(gini_lm, gof_omit = "AIC|BIC|Log.Lik.|F", stars = TRUE)


gini_avg <- read_csv("WB_Gini_Cleaned_1.csv") %>%
  select(`Country Name`, `Country Code`, `Gini_2011-2015`) %>%
  slice(1:169) %>%
  filter(!is.na(`Gini_2011-2015`))

gini_avg_best <- gini_avg %>%
  arrange(`Gini_2011-2015`) %>%
  slice(1:30) %>%
  mutate(gap = 1)

gini_avg_worst <- gini_avg %>%
  arrange(desc(`Gini_2011-2015`)) %>%
  slice(1:30) %>%
  mutate(gap = 0)

gini_bw <- gini_avg_best %>%
  rbind(gini_avg_worst) %>%
  rename("Country" = "Country Name") %>%
  right_join(for_big) %>%
  filter(!is.na(change2015_big)) %>%
```

```r
  filter(!is.na(gap)) %>%
  group_by(gap) %>%
  summarize(
    for_mean = mean(change2015_big),
    for_se = sd(change2015_big)/sqrt(n())
  )  %>%
  pivot_wider(names_from = gap, values_from = c(for_mean, for_se)) %>%
  mutate(
    for_diff = for_mean_1 - for_mean_0,
    for_diff_se = sqrt(for_se_1 ^ 2 + for_se_0 ^ 2),
    ci_lower = for_diff - 1.96 * for_diff_se,
    ci_upper = for_diff + 1.96 * for_diff_se
  )
for_diff_z <- (gini_bw$for_diff - 0)/gini_bw$for_diff_se
for_diff_p <- 2 * pnorm(abs(for_diff_z))


all_data <- di_forest %>%
  left_join(gini) %>%
  left_join(gdp_growth) %>%
  left_join(gdp) %>%
  left_join(pov_ratio) %>%
  filter(!is.na(Gini_2015)) %>%
  filter(!is.na(GrowthCap_2015)) %>%
  filter(!is.na(GDPcap_2015)) %>%
  filter(!is.na(`Average_2011-2015`)) %>%
  select(!`2019`)

all_lm <- lm(change2015 ~ `2015` + Gini_2015 + Gini_2015 * `2015`, data = all_data)
modelsummary::modelsummary(all_lm, gof_omit = "AIC|BIC|Log.Lik.|F", stars = TRUE)
```