Effect of Democratization on Deforestation

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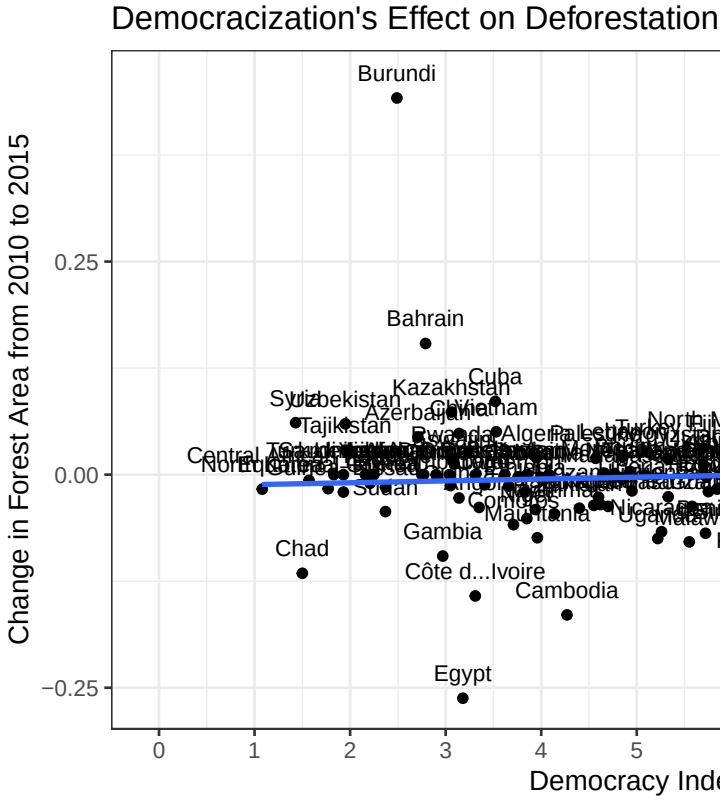
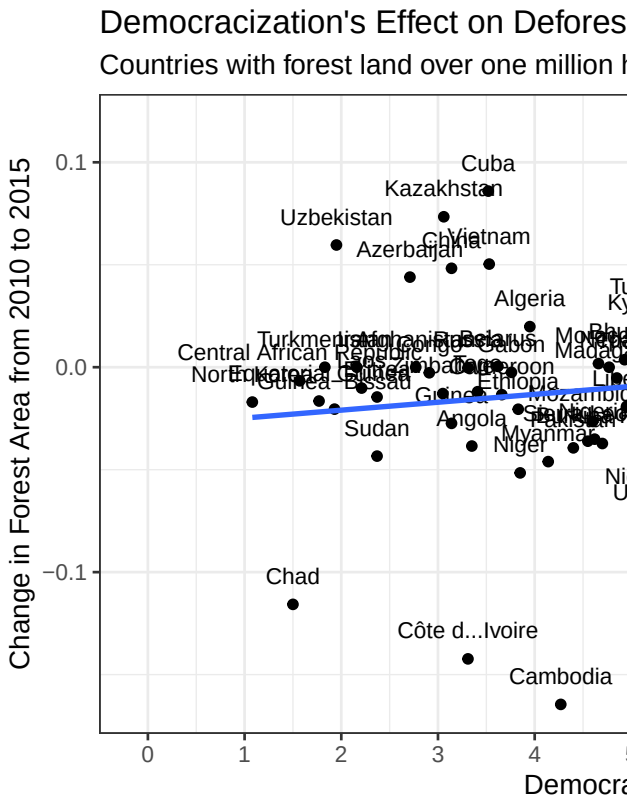


1. Effect of democratization on deforestation (all countries)

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

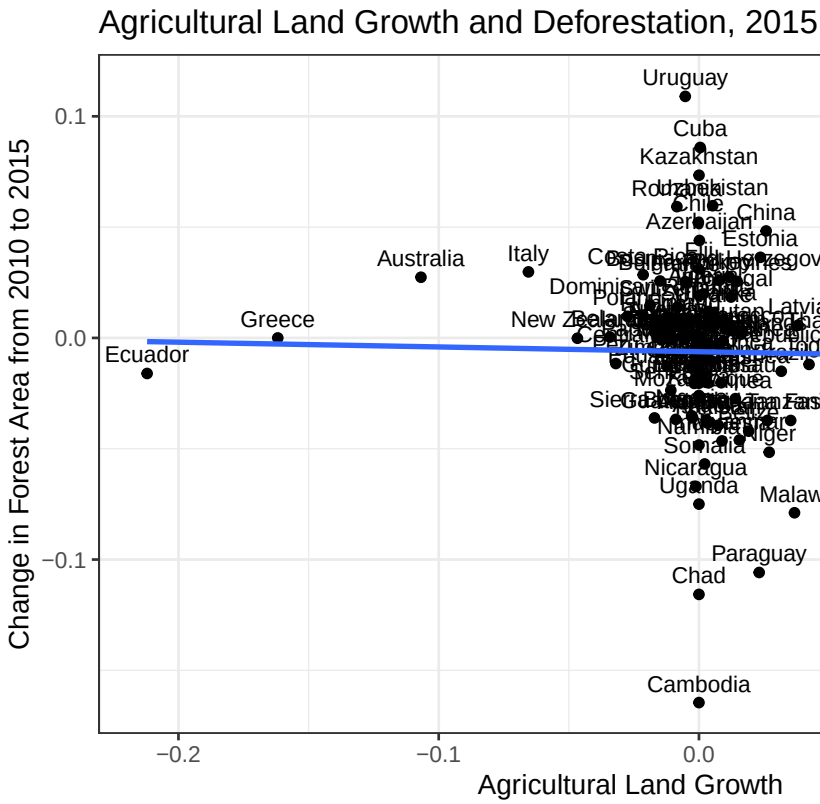
* p < 0.1, ** p < 0.05, *** p < 0.01



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

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

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



3. Agricultural land growth (countries with forest)

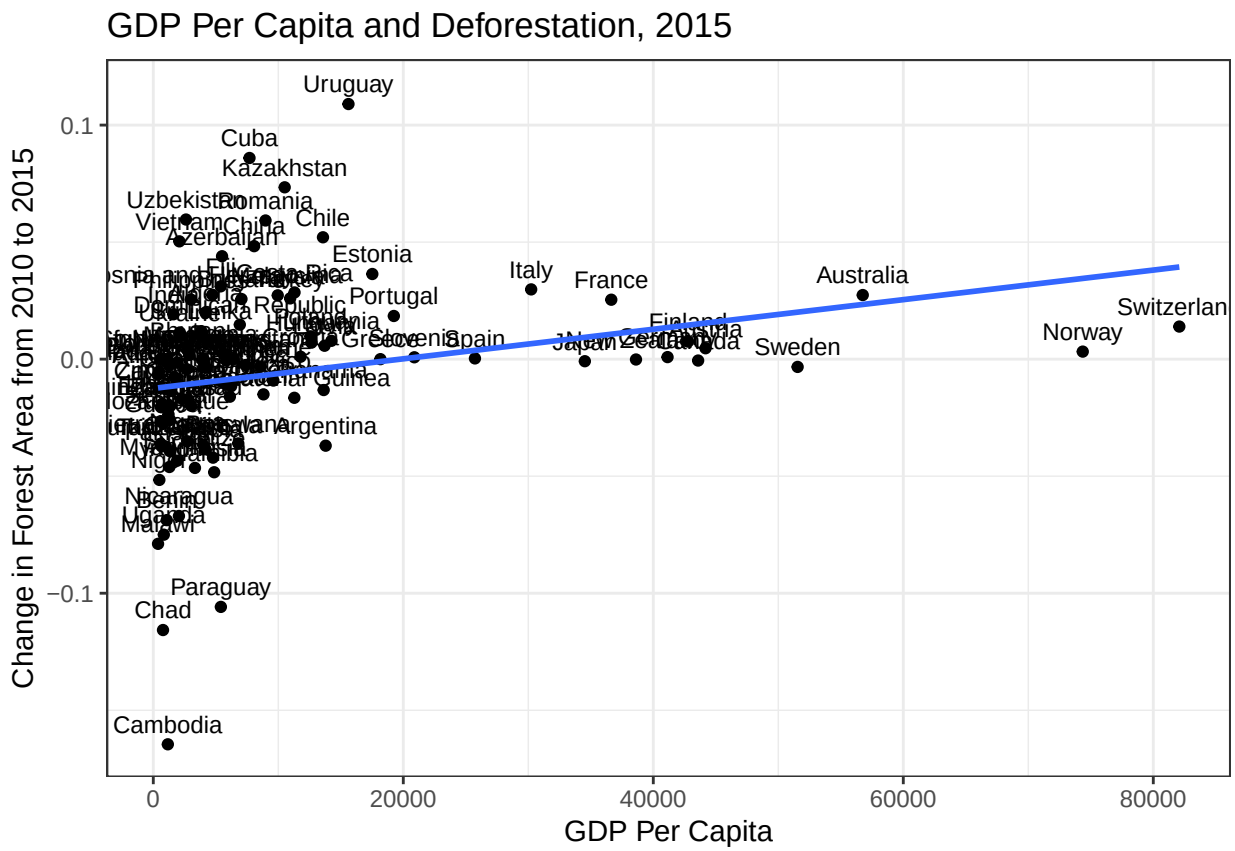
	Model 1
Intercept	-0.006*
	(0.004)
Change in agricultural land	-0.021
	(0.087)
Num.Obs.	108
R2	0.001
R2 Adj.	-0.009

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

4. GDP per capita growth (countries with forest)

	Model 1
Intercept	-0.012***
	(0.004)
GDP per capita in 2015	0.000***
	(0.000)
Num.Obs.	108
R2	0.064
R2 Adj.	0.056

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



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)
coefs <- c(
  "(Intercept)" = "Intercept",
  "GDPcap_2015" = "GDP per capita in 2015"
)
modelsummary::modelsummary(gdp_less_20000_lm, coef_map = coefs, gof_omit = "AIC|BIC|Log.Lik.|F", stars =
```

	Model 1
Intercept	-0.027***
	(0.006)
GDP per capita in 2015	0.000***
	(0.000)
Num.Obs.	94
R2	0.195
R2 Adj.	0.186

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

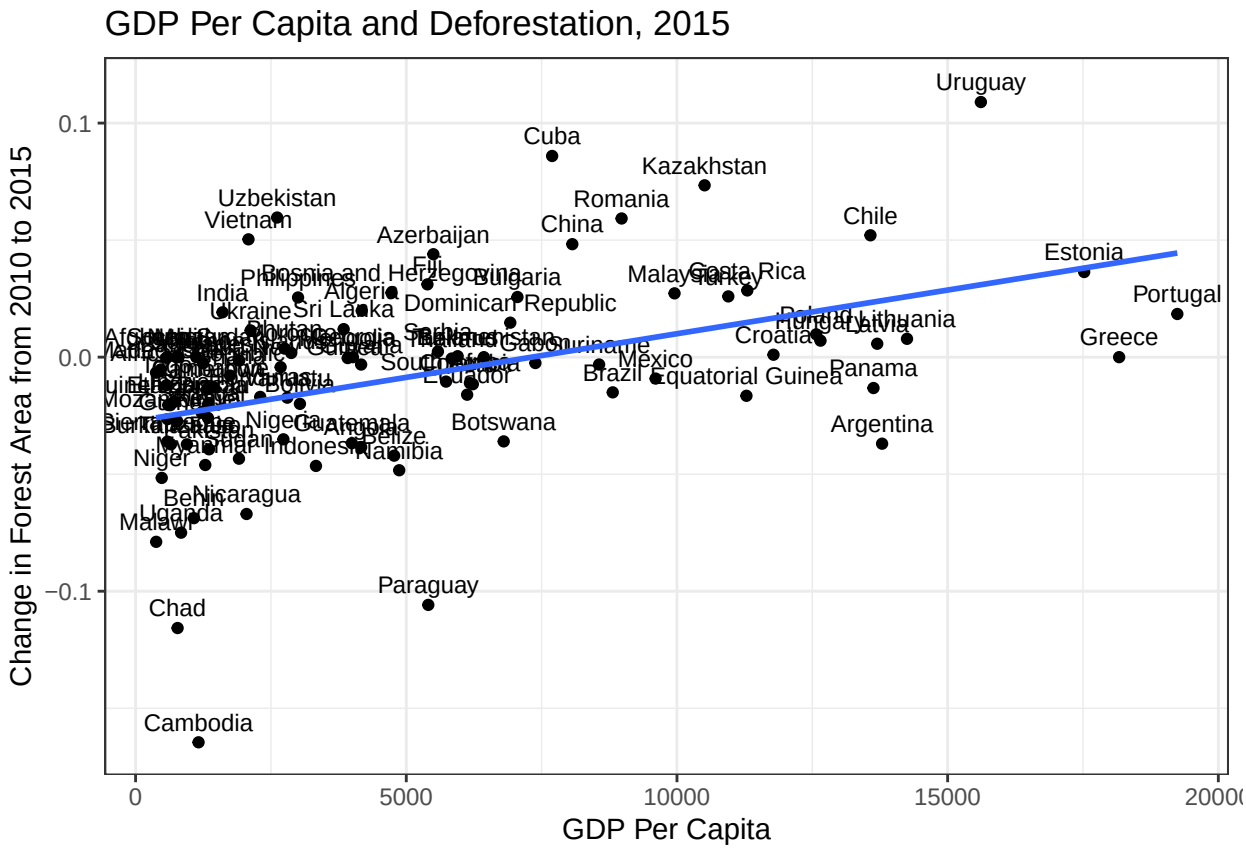
```
gdp_less_20000 %>%
  ggplot(aes(x = GDPcap_2015, y = change2015_big, label = Country)) +
  geom_point() +
  geom_text(vjust = 0, nudge_y = 0.005, size = 3) +
  geom_smooth(method = "lm", se = FALSE) +
  labs(
    title = "GDP Per Capita and Deforestation, 2015",
    x = "GDP Per Capita",
    y =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

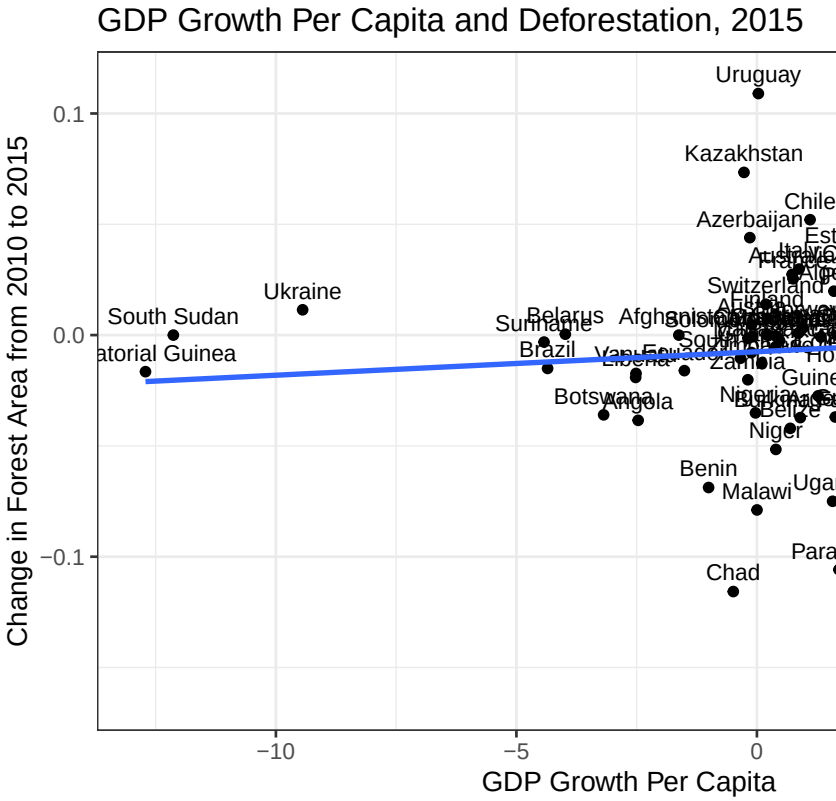
```
## `geom_smooth()` using formula 'y ~ x'
```

```
## 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).
```

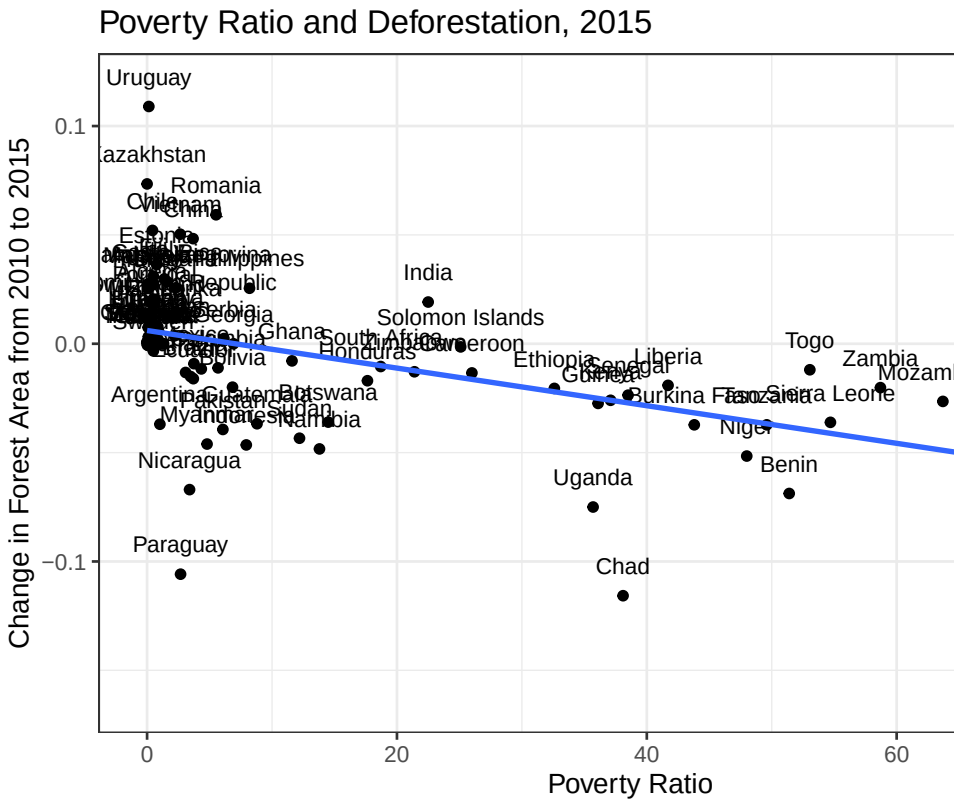




6. GDP growth per capita (countries with forest)

	Model 1
Intercept	-0.008*
	(0.004)
GDP growth per capita in 2015	0.001
	(0.001)
Num.Obs.	107
R2	0.009
R2 Adj.	-0.001

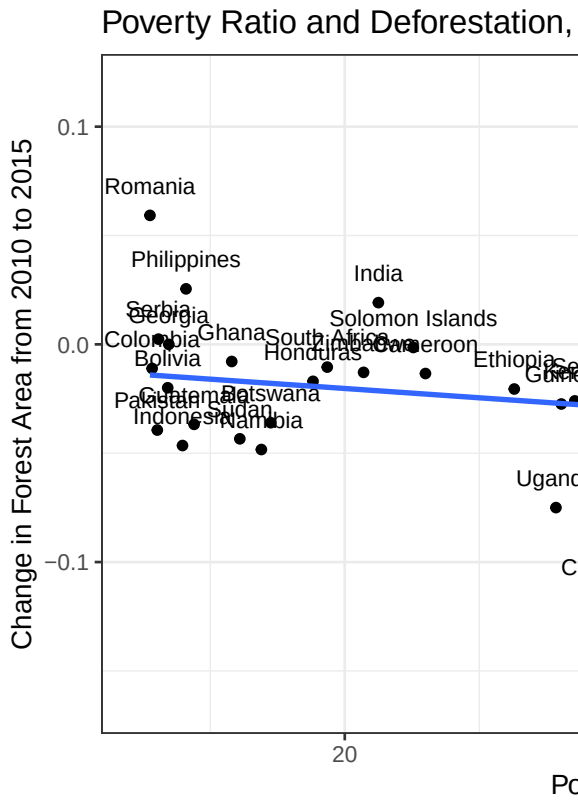
* p < 0.1, ** p < 0.05, *** p < 0.01



7. Poverty ratio (countries with forest)

	Model 1
Intercept	0.006
	(0.004)
Poverty ratio (2011-2015 average)	-0.001***
	(0.000)
Num.Obs.	85
R2	0.209
R2 Adj.	0.200

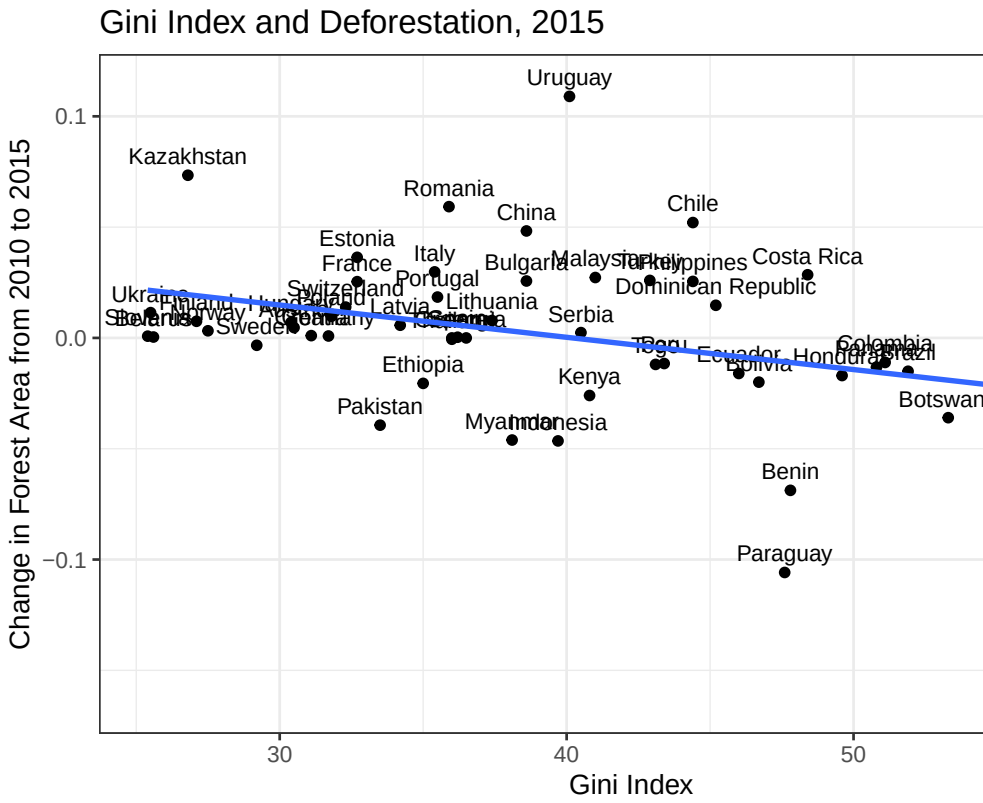
* p < 0.1, ** p < 0.05, *** p < 0.01



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

	Model 1
Intercept	-0.012
	(0.009)
Poverty ratio (2011-2015 average)	0.000*
	(0.000)
Num.Obs.	35
R2	0.080
R2 Adj.	0.052

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



9. Gini Index (countries with forest)

	Model 1
Intercept	0.059***
	(0.022)
Gini Index in 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)
Democracy.Index.in.2015	-0.028*
	(0.014)
Gini.Index.in.2015	-0.007**
	(0.003)
Democracy.Index.in.2015 × Gini.Index.in.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()

coefs <- c(
  "(Intercept)" = "Intercept",
  "`2015`" = "Democracy Index in 2015"
)
modelsummary::modelsummary(df2015_lm, coef_map = coefs, 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()

coefs <- c(
  "(Intercept)" = "Intercept",
  "`2015`" = "Democracy Index in 2015"
)

modelsummary::modelsummary(df2015_big_lm, coef_map = coefs, gof_omit = "AIC|BIC|Log.Lik.|F", stars = TRU


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)
```

```r
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()

coefs <- c(
  "(Intercept)" = "Intercept",
  "agri_change" = "Change in agricultural land"
)

modelsummary::modelsummary(agri_lm, coef_map = coefs, 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)
coefs <- c(
  "(Intercept)" = "Intercept",
  "GDPcap_2015" = "GDP per capita in 2015"
)

modelsummary::modelsummary(gdp_lm, coef_map = coefs, 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)
coefs <- c(
  "(Intercept)" = "Intercept",
  "GDPcap_2015" = "GDP per capita in 2015"
)
modelsummary::modelsummary(gdp_less_20000_lm, coef_map = coefs, gof_omit = "AIC|BIC|Log.Lik.|F", stars =

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`) %>%
  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()

coefs <- c(
  "(Intercept)" = "Intercept",
  "GrowthCap_2015" = "GDP growth per capita in 2015"
)
modelsummary::modelsummary(gdp_growth_lm, coef_map = coefs, gof_omit = "AIC|BIC|Log.Lik.|F", stars = TRU

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)
```

```r
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)
coefs <- c(
  "(Intercept)" = "Intercept",
  "`Average_2011-2015`" = "Poverty ratio (2011-2015 average)"
)
modelsummary::modelsummary(pov_lm, coef_map = coefs, 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)
coefs <- c(
  "(Intercept)" = "Intercept",
  "`Average_2011-2015`" = "Poverty ratio (2011-2015 average)"
)
modelsummary::modelsummary(pov_lm_5, coef_map = coefs, 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)
```

```r
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()

coefs <- c(
  "(Intercept)" = "Intercept",
  "Gini_2015" = "Gini Index in 2015"
)
modelsummary::modelsummary(gini_lm, coef_map = coefs, 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)) %>%
  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
```

```r
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`)) %>%
  rename("Democracy.Index.in.2015" = `2015`) %>%
  rename("Gini.Index.in.2015" = `Gini_2015`) %>%
  select(!`2019`)

all_lm <- lm(change2015 ~ Democracy.Index.in.2015 + Gini.Index.in.2015 + Gini.Index.in.2015 * Democracy

# I do not seem to understand how to show the interaction term
coefs <- c(
  "(Intercept)" = "Intercept",
  "`2015`" = "Democracy Index in 2015",
  "Gini_2015" = "Gini Index in 2015",
  "`2015` × Gini_2015" = "test"
)
#modelsummary::modelsummary(all_lm, coef_map = coefs, gof_omit = "AIC|BIC|Log.Lik.|F", stars = TRUE)

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