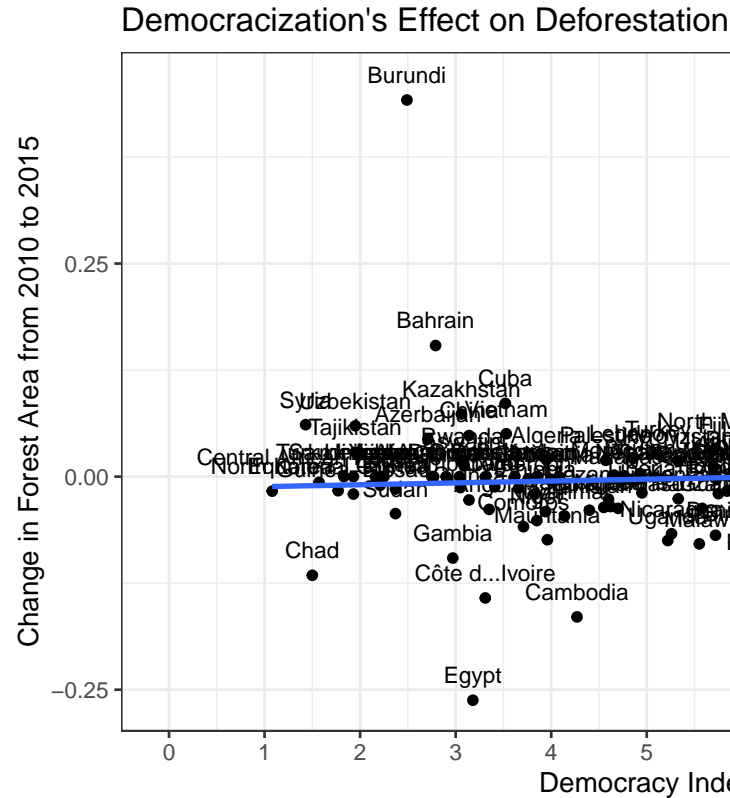


Effect of Democratization on Deforestation

Students: Albert Yao and Takeo Tokunari

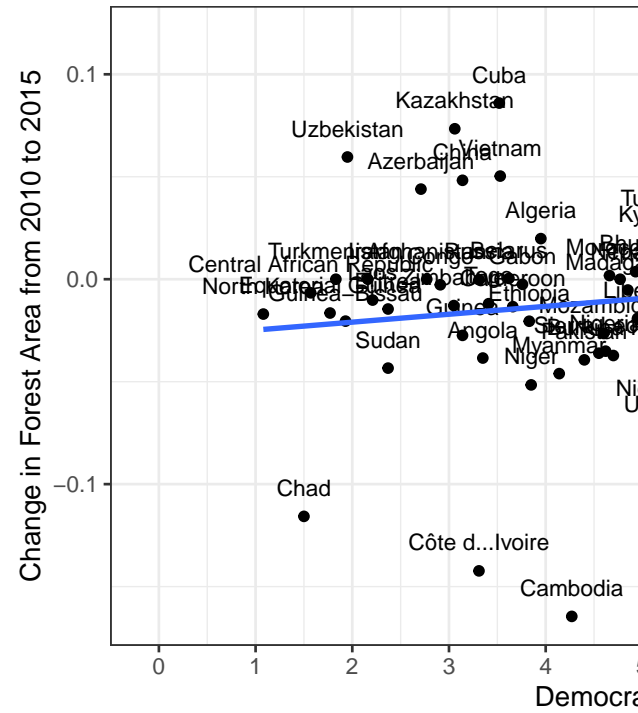


1. Effect of democratization on deforestation (all countries)

	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

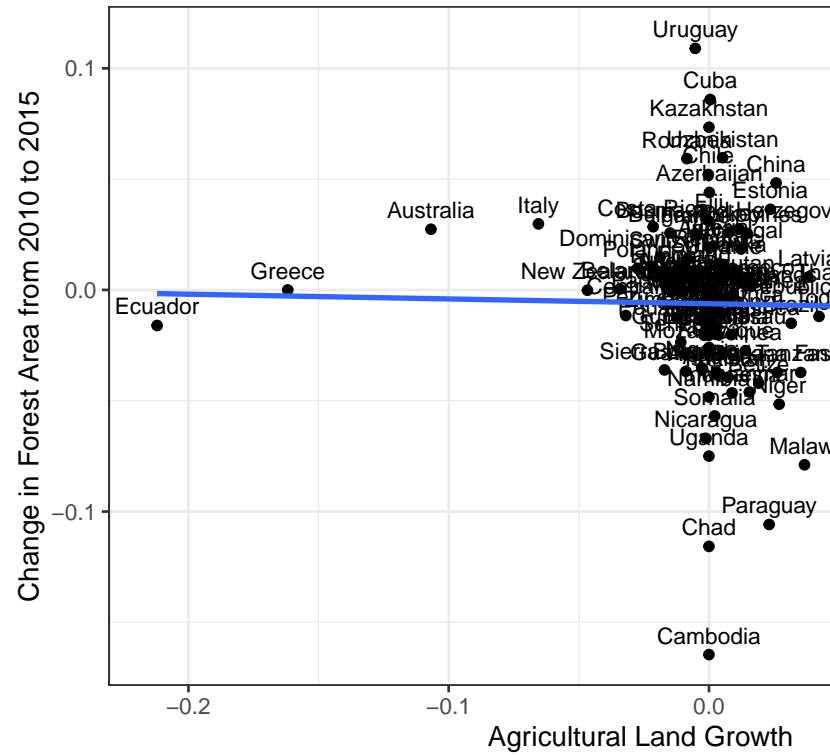
Democracization's Effect on Defores
 Countries with forest land over one million h



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	

Agricultural Land Growth and Deforestation, 2015



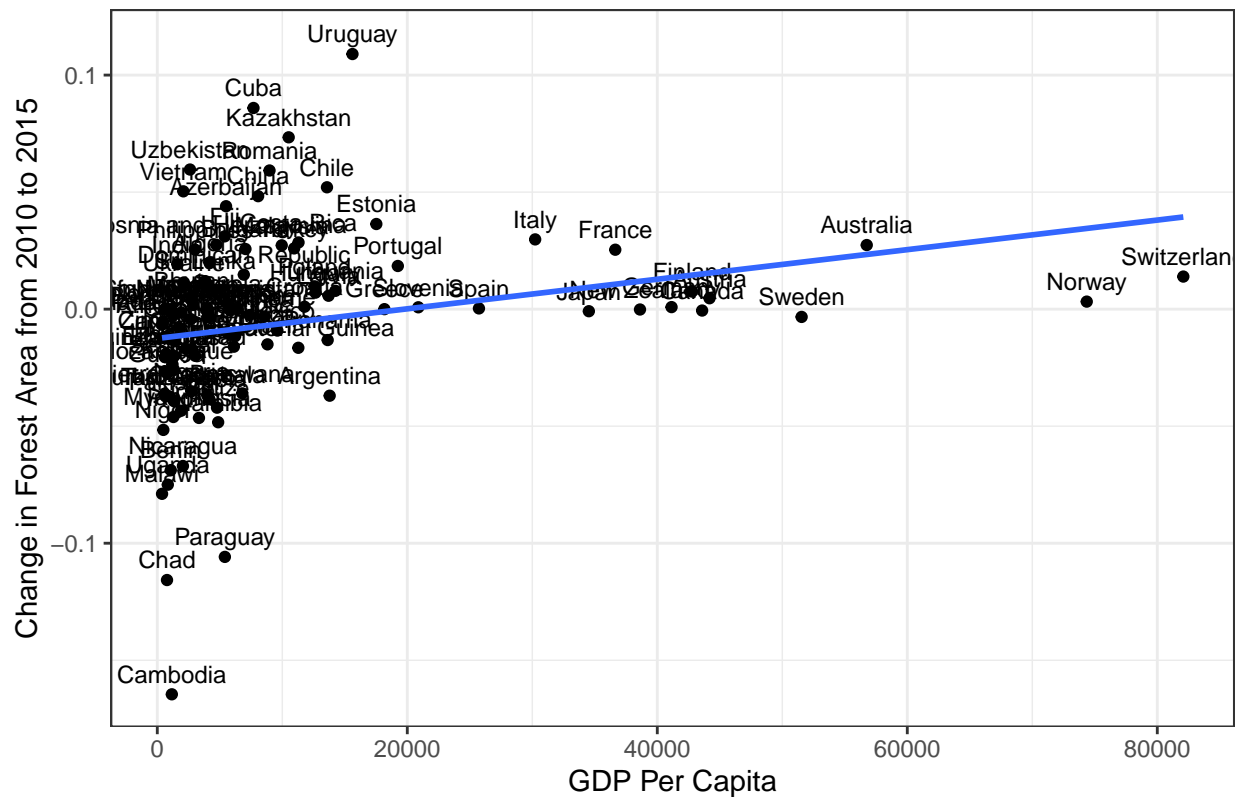
3. Agricultural land growth (countries with forest)

	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	

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)
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).
```

A scatter plot illustrating the relationship between GDP Per Capita (X-axis) and Life Expectancy at Birth (Y-axis). The X-axis ranges from 0 to 20,000, and the Y-axis ranges from 60 to 90 years. A positive linear trendline is shown, indicating that as GDP per capita increases, life expectancy also tends to increase.

The following table lists the countries plotted on the graph, ordered by their position from bottom-left to top-right:

Country	GDP Per Capita (approx.)	Life Expectancy at Birth (years)
Cambodia	~1,000	~68
Chad	~1,000	~70
Mali	~1,000	~72
Niger	~1,000	~72
Burkina Faso	~1,000	~72
Uganda	~1,000	~72
Benin	~1,000	~72
Paraguay	~5,000	~72
Indonesia	~4,000	~73
Guinea	~3,000	~73
Sierra Leone	~2,000	~73
Liberia	~2,000	~73
Ivory Coast	~3,000	~74
Senegal	~3,000	~74
South Africa	~4,000	~74
Ecuador	~5,000	~74
Botswana	~6,000	~74
Malawi	~2,000	~75
Zambia	~3,000	~75
Angola	~3,000	~75
Cameroon	~3,000	~75
Kenya	~3,000	~75
Tanzania	~3,000	~75
Rwanda	~3,000	~75
DRC	~3,000	~75
Ukraine	~2,000	~76
Sri Lanka	~3,000	~76
Algeria	~4,000	~76
Vietnam	~1,000	~77
Philippines	~2,000	~77
India	~2,000	~77
Kazakhstan	~10,000	~78
China	~8,000	~78
Romania	~9,000	~78
Cuba	~7,000	~79
Azerbaijan	~5,000	~79
Uzbekistan	~2,000	~79
Malaysia	~10,000	~79
Costa Rica	~11,000	~79
Panama	~13,000	~79
Argentina	~14,000	~79
Chile	~13,000	~80
Poland	~12,000	~80
Lithuania	~14,000	~80
Croatia	~12,000	~80
Equatorial Guinea	~12,000	~80
Portugal	~19,000	~80
Greece	~18,000	~80
Estonia	~17,000	~81
Uruguay	~16,000	~82

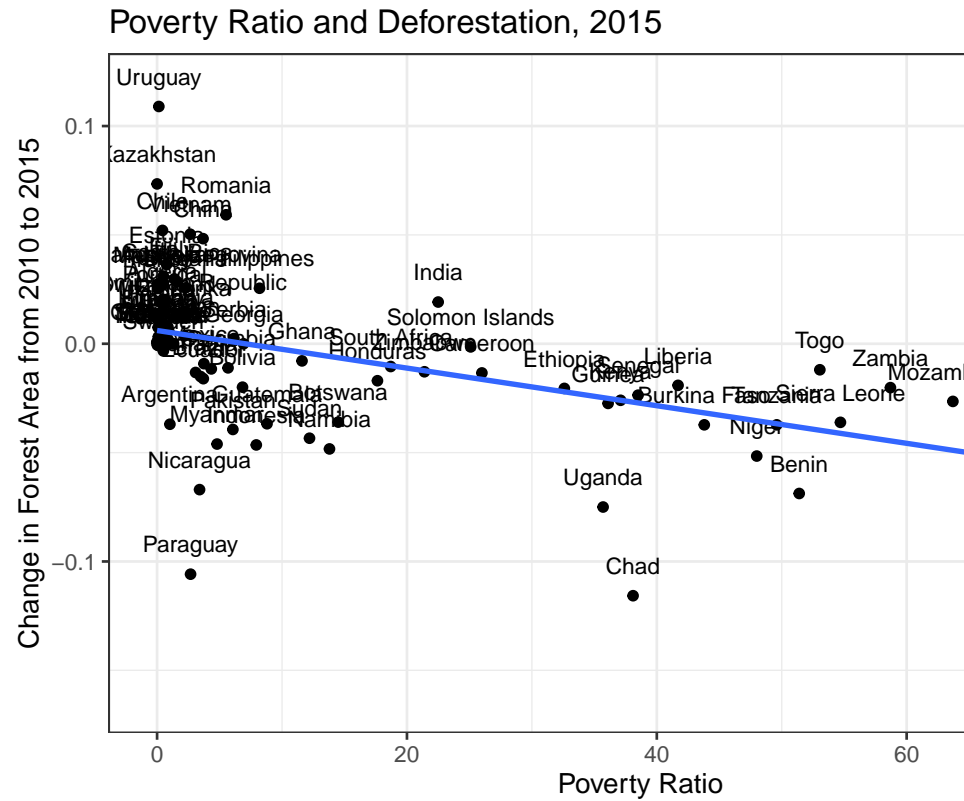
Scatter plot showing the relationship between GDP Growth Per Capita (X-axis) and Change in Forest Area from 2010 to 2015 (Y-axis). The X-axis ranges from -15 to 5, and the Y-axis ranges from -0.15 to 0.15. A blue regression line indicates a positive correlation. Data points are labeled with country names.

Country	GDP Growth Per Capita (approx.)	Change in Forest Area (approx.)
Uruguay	0.5	0.11
Kazakhstan	-1.5	0.08
Chile	1.5	0.06
Azerbaijan	0.5	0.05
Ukraine	-9.5	0.02
South Sudan	-12.5	0.00
South Africa	-13.5	-0.02
Belarus	-4.5	0.01
Suriname	-4.0	0.00
Brazil	-4.0	-0.02
Afghanistan	-2.5	-0.02
Liberia	-2.0	-0.03
Botswana	-3.0	-0.03
Angola	-2.5	-0.04
Benin	-1.5	-0.07
Malawi	-0.5	-0.08
Chad	-0.5	-0.12
Niger	0.0	-0.05
Guinea	0.5	-0.04
Uganda	1.0	-0.08
Paraguay	1.5	-0.10

6

	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

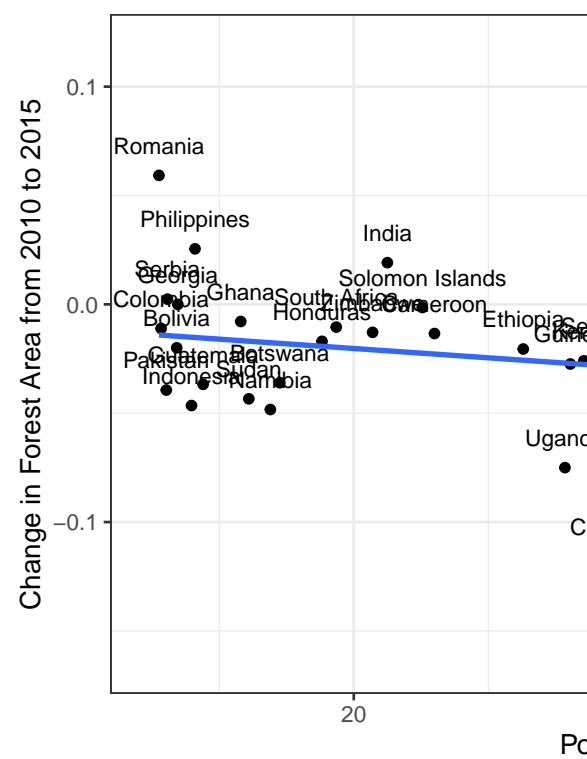


7. Poverty ratio (countries with forest)

	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

Poverty Ratio and Deforestation,

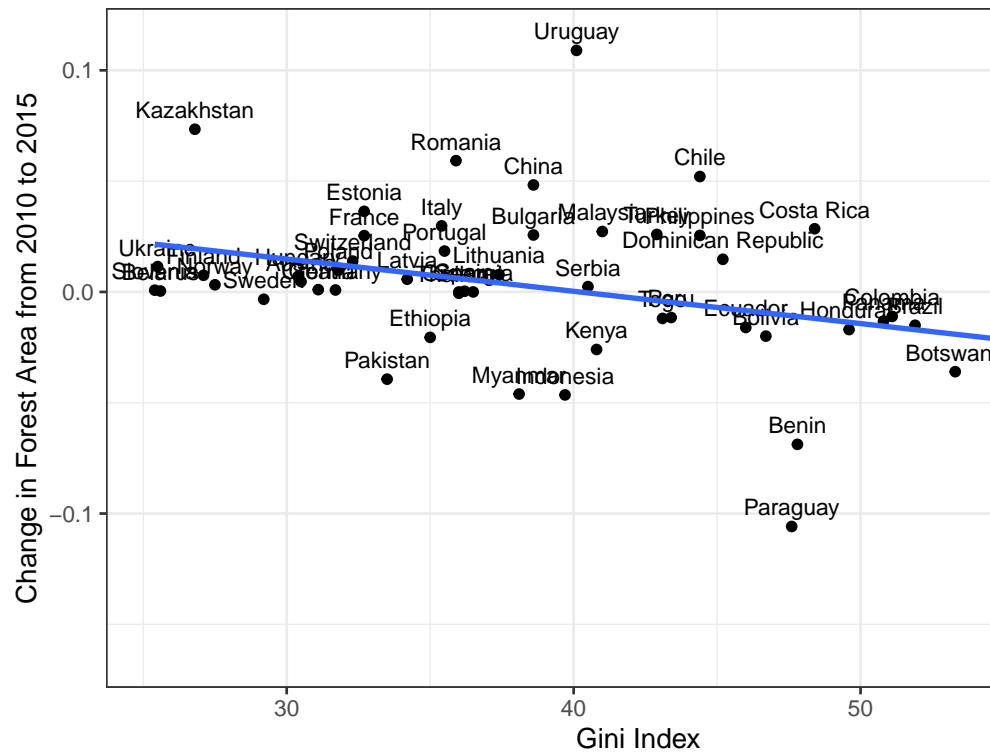


8. Poverty ratio (countries with forest and poverty ratio of 5% or higher)

	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

Gini Index and Deforestation, 2015



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 = "Democratization'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 = "Democratization'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 = 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()

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 = TR

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 = TR

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)
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)

```

```

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

```

```

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"
)
#modelssummary::modelssummary(all_lm, coef_map = coefs, gof_omit = "AIC|BIC|Log.Lik.|F", stars = TRUE)

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

```