

# Human Freedom Index Project

Team Platypus: Lynne Wang, Neel Gajjar, Kate Neal

```
library(tidyverse)
library(ggplot2)
library(dplyr)
require(maps)
require(viridis)

theme_set(
  theme_void()
)
hfi <- read_csv("data/hfi_cc_2019.csv")
```

```
glimpse(hfi)
```

```
## Rows: 1,620
## Columns: 120
## $ year                <dbl> 2017, 2017, 2017, 2017, 2017, 20...
## $ ISO_code            <chr> "ALB", "DZA", "AGO", "ARG", "ARM...
## $ countries           <chr> "Albania", "Algeria", "Angola", ...
## $ region              <chr> "Eastern Europe", "Middle East &...
## $ hf_score             <chr> "7.84", "4.99", "5.4", "6.86", "...
## $ hf_rank             <chr> "38", "155", "151", "77", "54", ...
## $ hf_quartile          <chr> "1", "4", "4", "2", "2", "1", "1...
## $ pf_rol_procedural    <chr> "6.7", "-", "-", "7.1", "-", "8....
## $ pf_rol_civil         <chr> "4.5", "-", "-", "5.8", "-", "7....
## $ pf_rol_criminal      <chr> "4.7", "-", "-", "4.3", "-", "7....
## $ pf_rol              <chr> "5.3", "3.8", "3.4", "5.7", "4.9...
## $ pf_ss_homicide       <chr> "9.1", "9.5", "8.1", "8", "9", "...
## $ pf_ss_disappearances_disap <chr> "10", "10", "10", "5", "10", "10...
## $ pf_ss_disappearances_violent <chr> "10", "9.5", "9.7", "10", "10", ...
## $ pf_ss_disappearances_organized <chr> "10", "5", "7.5", "7.5", "7.5", ...
## $ pf_ss_disappearances_fatalities <chr> "10", "9.9", "9.9", "10", "10", ...
## $ pf_ss_disappearances_injuries <chr> "10", "9.9", "7.2", "10", "10", ...
## $ pf_ss_disappearances <chr> "10", "8.9", "8.9", "8.5", "9.5"...
## $ pf_ss_women_fgm      <chr> "10", "10", "10", "10", "10", "1...
## $ pf_ss_women_inheritance_widows <chr> "-", "-", "-", "-", "-", "-", "...
## $ pf_ss_women_inheritance_daughters <chr> "-", "-", "-", "-", "-", "-", "...
## $ pf_ss_women_inheritance <chr> "7.5", "0", "5", "10", "7.5", "1...
## $ pf_ss_women          <chr> "8.8", "5", "7.5", "10", "8.8", ...
## $ pf_ss                <chr> "9.3", "7.8", "8.1", "8.8", "9.1...
## $ pf_movement_domestic <chr> "10", "10", "5", "10", "10", "10...
## $ pf_movement_foreign  <chr> "10", "5", "5", "10", "5", "10",...
## $ pf_movement_women    <chr> "10", "2.5", "10", "10", "10", "...
## $ pf_movement          <chr> "10", "5.8", "6.7", "10", "8.3",...
## $ pf_religion_estop_establish <chr> "-", "-", "-", "-", "-", "-", "...
```

## \$ pf_religion_estop_operate	<chr> "-", "-", "-", "-", "-", "-", "-...
## \$ pf_religion_estop	<chr> "10", "5", "10", "7.5", "5", "10...
## \$ pf_religion_harassment	<chr> "9.6", "6.9", "8.9", "9", "8.6",...
## \$ pf_religion_restrictions	<chr> "8", "3", "7.5", "6.9", "5.1", "...
## \$ pf_religion	<chr> "9.2", "4.9", "8.8", "7.8", "6.2...
## \$ pf_association_association	<chr> "10", "5", "2.5", "7.5", "7.5", ...
## \$ pf_association_assembly	<chr> "10", "5", "2.5", "10", "7.5", "...
## \$ pf_association_political_establish	<chr> "-", "-", "-", "-", "-", "-", "-...
## \$ pf_association_political_operate	<chr> "-", "-", "-", "-", "-", "-", "-...
## \$ pf_association_political	<chr> "10", "5", "2.5", "5", "5", "10"...
## \$ pf_association_prof_establish	<chr> "-", "-", "-", "-", "-", "-", "-...
## \$ pf_association_prof_operate	<chr> "-", "-", "-", "-", "-", "-", "-...
## \$ pf_association_prof	<chr> "10", "5", "5", "7.5", "5", "10"...
## \$ pf_association_sport_establish	<chr> "-", "-", "-", "-", "-", "-", "-...
## \$ pf_association_sport_operate	<chr> "-", "-", "-", "-", "-", "-", "-...
## \$ pf_association_sport	<chr> "10", "5", "7.5", "7.5", "7.5", ...
## \$ pf_association	<chr> "10", "5", "4", "7.5", "6.5", "1...
## \$ pf_expression_killed	<chr> "10", "10", "10", "10", "10", "1...
## \$ pf_expression_jailed	<chr> "10", "9.5", "10", "10", "10", "...
## \$ pf_expression_influence	<chr> "5", "2.7", "2.7", "5.7", "3.3",...
## \$ pf_expression_control	<chr> "5.3", "4", "2.5", "5.5", "4.3",...
## \$ pf_expression_cable	<chr> "10", "10", "7.5", "10", "7.5", ...
## \$ pf_expression_newspapers	<chr> "10", "7.5", "5", "10", "7.5", "...
## \$ pf_expression_internet	<chr> "10", "7.5", "7.5", "10", "7.5",...
## \$ pf_expression	<chr> "8.6", "7.3", "6.5", "8.7", "7.2...
## \$ pf_identity_legal	<chr> "0", "-", "10", "10", "7", "7", ...
## \$ pf_identity_sex_male	<chr> "10", "0", "0", "10", "10", "10"...
## \$ pf_identity_sex_female	<chr> "10", "0", "0", "10", "10", "10"...
## \$ pf_identity_sex	<chr> "10", "0", "0", "10", "10", "10"...
## \$ pf_identity_divorce	<chr> "7.5", "0", "5", "10", "7.5", "1...
## \$ pf_identity	<chr> "5.8", "0", "5", "10", "8.2", "9...
## \$ pf_score	<chr> "8.01", "5.2", "5.98", "8.04", "...
## \$ pf_rank	<chr> "46", "146", "121", "41", "72", ...
## \$ ef_government_consumption	<chr> "8.1", "2.7", "6.3", "5.4", "7.2...
## \$ ef_government_transfers	<chr> "7.3", "7.8", "8.9", "6.3", "7.3...
## \$ ef_government_enterprises	<chr> "8", "0", "6", "6", "8", "10", "...
## \$ ef_government_tax_income	<chr> "9", "7", "10", "7", "5", "6", "...
## \$ ef_government_tax_payroll	<chr> "7", "2", "9", "1", "5", "5", "3...
## \$ ef_government_tax	<chr> "8", "4.5", "9.5", "4", "5", "5....
## \$ ef_government_soa	<chr> "6.2", "2.9", "3.1", "6.9", "9.5...
## \$ ef_government	<chr> "7.5", "3.6", "6.8", "5.7", "7.4...
## \$ ef_legal_judicial	<chr> "2.5", "4.3", "1.4", "3.6", "4",...
## \$ ef_legal_courts	<chr> "3.1", "4.3", "1.7", "3", "4.2",...
## \$ ef_legal_protection	<chr> "4.6", "4.8", "3.3", "4.4", "5.8...
## \$ ef_legal_military	<chr> "8.3", "4.2", "3.3", "7.5", "5.8...
## \$ ef_legal_integrity	<chr> "4.2", "5", "4.2", "3.3", "5", "...
## \$ ef_legal_enforcement	<chr> "4.4", "4.4", "2.3", "3.6", "5.2...
## \$ ef_legal_restrictions	<chr> "6.6", "6.6", "5.5", "6.9", "9.8...
## \$ ef_legal_police	<chr> "6.8", "6.1", "3.4", "3.7", "5.8...
## \$ ef_legal_crime	<chr> "6.2", "6.7", "4.3", "4.1", "7",...
## \$ ef_legal_gender	<chr> "1", "0.8", "0.8", "0.8", "1", "...
## \$ ef_legal	<chr> "5.1", "4.7", "3", "4", "5.9", "...
## \$ ef_money_growth	<dbl> 9.3, 7.0, 9.4, 5.0, 8.6, 9.0, 8....
## \$ ef_money_sd	<chr> "9.7", "8.5", "4.2", "6", "9.5",...

```
## $ ef_money_inflation      <dbl> 9.6, 8.9, 3.7, 4.9, 9.8, 9.6, 9....
## $ ef_money_currency      <chr> "10", "5", "5", "10", "10", "10"...
## $ ef_money               <chr> "9.6", "7.3", "5.6", "6.5", "9.5...
## $ ef_trade_tariffs_revenue <chr> "9.6", "8.5", "9.2", "6.7", "9",...
## $ ef_trade_tariffs_mean   <chr> "9.3", "6.2", "7.7", "7.3", "8.8...
## $ ef_trade_tariffs_sd     <chr> "8.1", "5.9", "4.3", "5.9", "8.1...
## $ ef_trade_tariffs       <chr> "9", "6.9", "7.1", "6.6", "8.6",...
## $ ef_trade_regulatory_nontariff <chr> "6", "4.8", "4.9", "4.6", "5.7",...
## $ ef_trade_regulatory_compliance <chr> "9.4", "0.5", "2.5", "5.2", "9",...
## $ ef_trade_regulatory     <chr> "7.7", "2.6", "3.7", "4.9", "7.4...
## $ ef_trade_black         <chr> "10", "0", "0", "10", "10", "10"...
## $ ef_trade_movement_foreign <chr> "6.3", "3.7", "2.9", "5.4", "5.1...
## $ ef_trade_movement_capital <chr> "5.4", "0", "3.1", "0.8", "5.4",...
## $ ef_trade_movement_visit <chr> "8.3", "1.1", "0.1", "8", "10", ...
## $ ef_trade_movement      <chr> "6.7", "1.6", "2", "4.7", "6.8",...
## $ ef_trade               <chr> "8.3", "2.8", "3.2", "6.5", "8.2...
## $ ef_regulation_credit_ownership <chr> "10", "0", "5", "5", "10", "10",...
## $ ef_regulation_credit_private <chr> "9.1", "5.3", "9.2", "4.3", "7.8...
## $ ef_regulation_credit_interest <chr> "10", "10", "6", "9", "10", "10"...
## $ ef_regulation_credit     <chr> "9.7", "5.1", "6.7", "6.1", "9.3...
## $ ef_regulation_labor_minwage <chr> "5.6", "5.6", "10", "2.8", "6.7"...
## $ ef_regulation_labor_firing <chr> "5.4", "4.1", "4.4", "2.2", "5.7...
## $ ef_regulation_labor_bargain <chr> "6.4", "6", "7.2", "3.3", "6.8",...
## $ ef_regulation_labor_hours <chr> "8", "6", "4", "10", "10", "10",...
## $ ef_regulation_labor_dismissal <chr> "6.3", "7.8", "6.6", "2.5", "9.3...
## $ ef_regulation_labor_conscription <chr> "10", "3", "0", "10", "0", "10",...
## $ ef_regulation_labor      <chr> "6.9", "5.4", "5.4", "5.1", "6.4...
## $ ef_regulation_business_adm <chr> "6.3", "3.7", "2.4", "2.5", "4.6...
## $ ef_regulation_business_bureaucracy <chr> "6.7", "1.8", "1.3", "7.1", "6.2...
## $ ef_regulation_business_start <chr> "9.7", "9.3", "8.7", "9.6", "9.9...
## $ ef_regulation_business_bribes <chr> "4.1", "3.8", "1.9", "3.3", "4.6...
## $ ef_regulation_business_licensing <chr> "6", "8.7", "8.1", "5.4", "9.3",...
## $ ef_regulation_business_compliance <chr> "7.2", "7", "6.8", "6.5", "7.1",...
## $ ef_regulation_business    <chr> "6.7", "5.7", "4.9", "5.7", "6.9...
## $ ef_regulation            <chr> "7.8", "5.4", "5.7", "5.6", "7.5...
## $ ef_score                 <chr> "7.67", "4.77", "4.83", "5.67", ...
## $ ef_rank                 <chr> "30", "159", "158", "147", "27",...
```

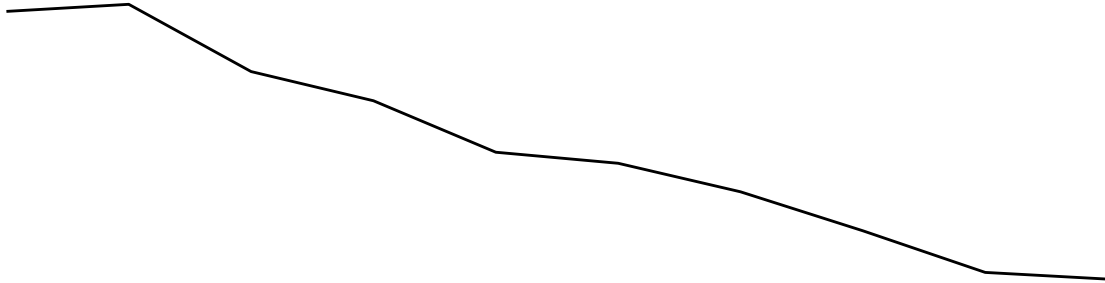
## Question 1

How has overall freedom around the world changed over time?

```
hfscore_by_year <- hfi %>%
  filter(hf_score != "-") %>%
  group_by(year) %>%
  summarize(mean_hf = mean(as.numeric(hf_score)))

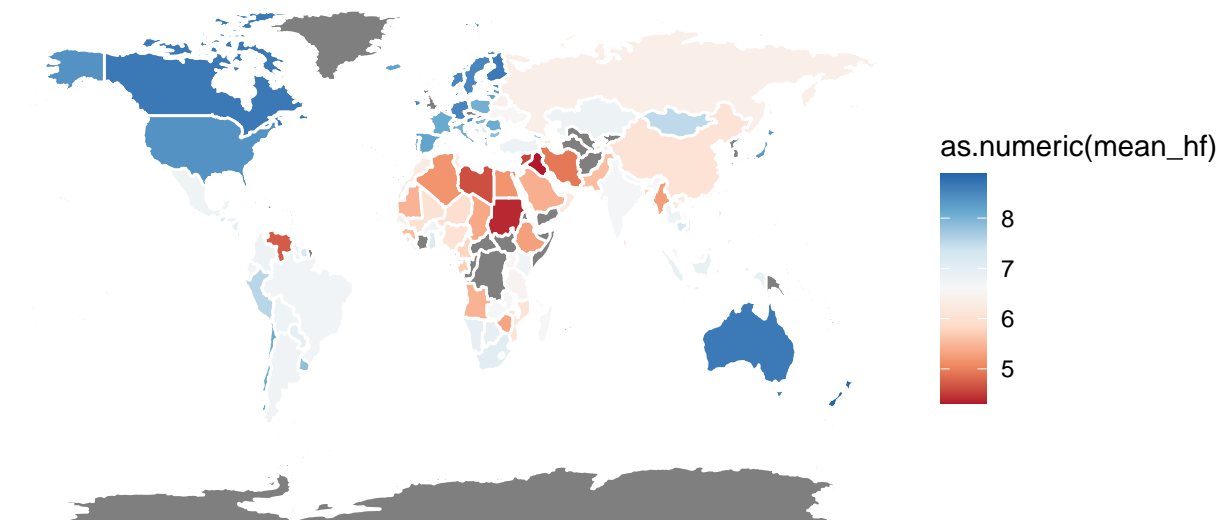
ggplot(data = hfscore_by_year,
  aes(x = as.factor(year), y = mean_hf, group = 1)) +
  geom_line(stat = "identity") +
  ylim(6.75, 7.25) +
  labs(x = "Year", y = "Human Freedom Score",
  title = "Overall Human Freedom on the Decline",
  subtitle = "2008 to 2017")
```

## Overall Human Freedom on the Decline 2008 to 2017



## Average Freedom Around the World

```
summarized_hfi <- hfi %>%  
  filter(hf_score != "-") %>%  
  group_by(countries) %>%  
  mutate(mean_hf = mean(as.numeric(hf_score))) %>%  
  slice(1) %>%  
  mutate(countries = ifelse(countries == "United States", "USA", countries)) %>%  
  summarize(countries, mean_hf)  
  
## `summarise()` ungrouping output (override with `.groups` argument)  
  
world_map <- map_data("world")  
freedom_map <- left_join(world_map, summarized_hfi, by = c("region" = "countries"))  
  
# Create the map  
ggplot(freedom_map, mapping = aes(long, lat, group = group)) +  
  coord_fixed(1.3) +  
  geom_polygon(aes(fill = as.numeric(mean_hf)), color = "white") +  
  scale_fill_distiller(palette = "RdBu", direction = 1)
```



## Economic and Personal Freedom

How do different countries' economic and personal freedom scores compare?

```
no_na_hfi <- hfi %>%
  filter(pf_score != "-" & ef_score != "-")

clean_hfi <- no_na_hfi %>%
  group_by(countries) %>%
  mutate(mean_pf = mean(as.numeric(pf_score)),
         mean_ef = mean(as.numeric(ef_score))) %>%
  mutate(diff_ef_pf = mean_ef - mean_pf) %>%
  slice(1) %>%
  summarize(countries, mean_ef, mean_pf, diff_ef_pf)

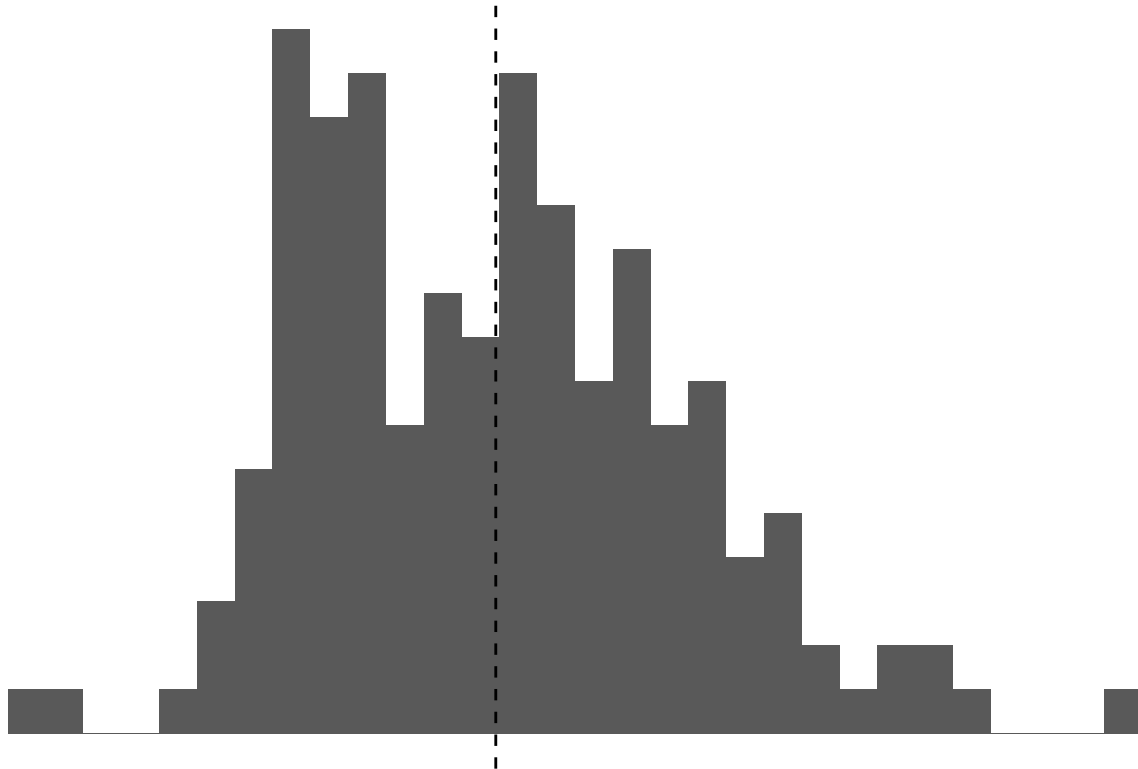
## `summarise()` ungrouping output (override with `.groups` argument)

mean_diff <- clean_hfi %>%
  summarize(mean_diff = mean(diff_ef_pf))

ggplot(data = clean_hfi, aes(x = diff_ef_pf)) +
  geom_histogram(bins = 30) +
  geom_vline(linetype = "dashed", xintercept = c(mean_diff$mean_diff)) +
  labs(x = "Difference in Economic and Personal Freedom Score",
       y = "Count",
       title = "Histogram of Differences in Economic and Personal Freedom Score",
       subtitle = "Average Diffs from 2008 to 2017, 162 Countries")
```

## Histogram of Differences in Economic and Personal Freedom Score

Average Diffs from 2008 to 2017, 162 Countries



### Economic and Personal Freedom Differences - Bootstrap Simulation

On average, is there a difference between a country's economic freedom score and personal freedom score?

Null Hypothesis: the difference between mean economic freedom score and mean personal freedom score is greater than or equal to zero.

Alternative Hypothesis: the difference between mean economic freedom score and mean personal freedom score is less than zero.

$$H_0: \mu \geq 0$$

$$H_A: \mu < 0$$

```
set.seed(10)
n_sims <- 500
boot_dist = numeric(n_sims)
for(i in 1:n_sims){
  indices <- sample(1:nrow(clean_hfi), replace = T)
  boot_mean <- clean_hfi %>%
    slice(indices) %>%
    summarize(boot_mean = mean(diff_ef_pf)) %>%
    pull()
  boot_dist[i] <- boot_mean
}

boot_means = tibble(boot_dist)
mu_0 <- 0
offset <- boot_means %>%
```

```

    summarize(mu_0 - mean(boot_dist)) %>%
    pull()
boot_means <- boot_means %>%
  mutate(shifted_means = boot_dist + offset)
boot_1 <- boot_means %>%
  summarize(lower = quantile(shifted_means, 0.025),
            upper = quantile(shifted_means, 0.975))
boot_1

## # A tibble: 1 x 2
##   lower upper
##   <dbl> <dbl>
## 1 -0.153 0.148

obs_mean <- clean_hfi %>%
  summarize(mean(diff_ef_pf)) %>%
  pull()
obs_mean

## [1] -0.3217562

obs_diff <- mu_0 - obs_mean
boot_means %>%
  mutate(extreme = ifelse(shifted_means <= mu_0 - obs_diff |
                        shifted_means >= mu_0 + obs_diff, 1, 0)) %>%
  summarize(p_val = mean(extreme))

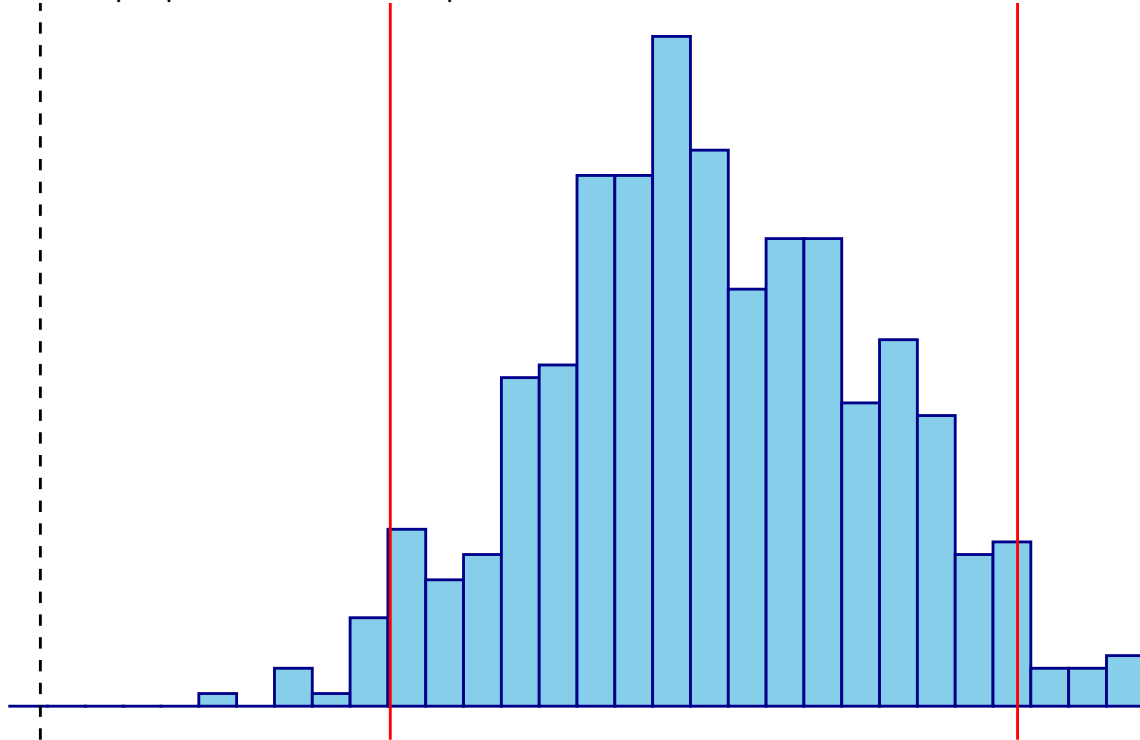
## # A tibble: 1 x 1
##   p_val
##   <dbl>
## 1     0

ggplot(data = boot_means, aes(x = shifted_means)) +
  geom_histogram(color = "darkblue", fill = "skyblue") +
  labs(x = "Difference in Economic and Personal Freedom Score", y = "Count",
       title = "Sufficient Evidence to Suggest Difference Between
               Economic and Personal Freedom Scores is Less than Zero",
       subtitle = "500 bootstrap reps with Observed Prop and 95% CI shown") +
  geom_vline(xintercept = c(boot_1$lower, boot_1$upper),
            color = "red") +
  geom_vline(linetype = "dashed", xintercept = c(mean_diff$mean_diff))

```

## Sufficient Evidence to Suggest Difference Between Economic and Personal Freedom Scores is Less than Zero

500 bootstrap reps with Observed Prop and 95% CI shown



Our p-value is 0, and so we reject the null hypothesis at the  $\alpha = 0.05$  significance level. There is sufficient evidence to suggest that the difference between mean economic freedom score and mean personal freedom score is less than zero. In other words, on average, economic freedom scores tend to be lower than personal freedom scores around the world.

## Economic and Personal Freedom Difference By Region

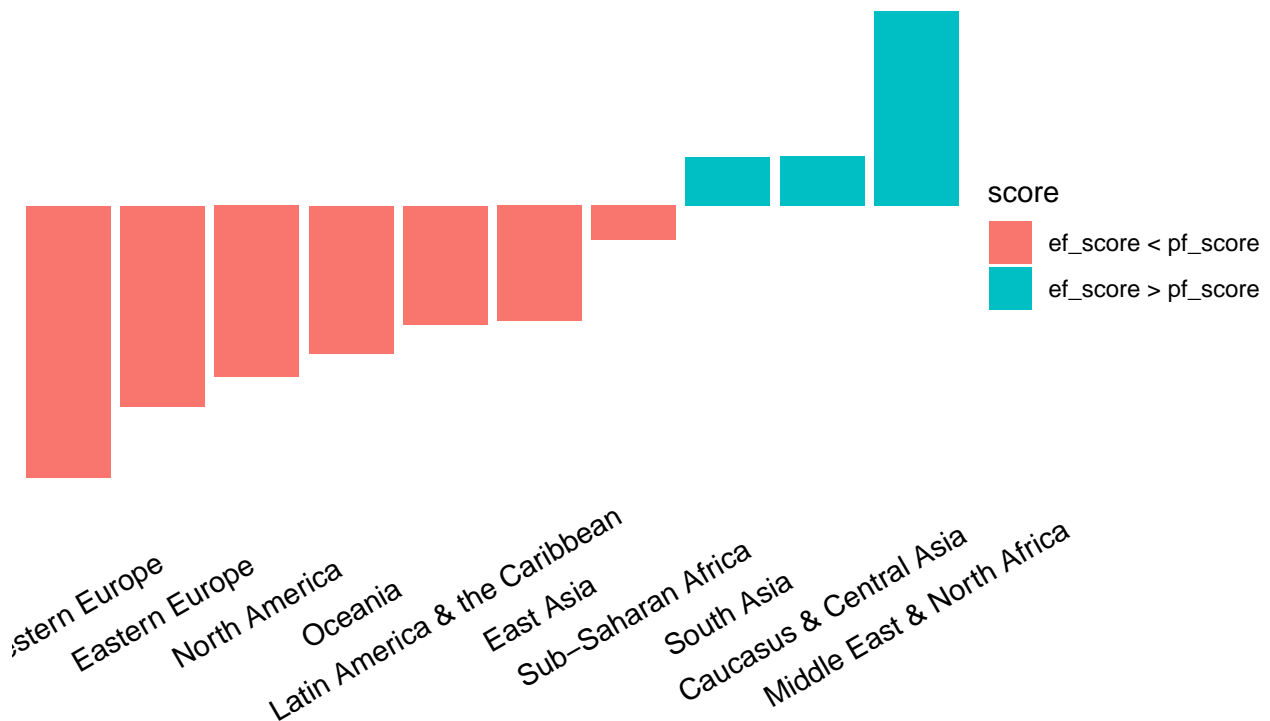
```
region_hfi <- no_na_hfi %>%
  group_by(region) %>%
  mutate(mean_pf = mean(as.numeric(pf_score)),
         mean_ef = mean(as.numeric(ef_score))) %>%
  mutate(diff_ef_pf = mean_ef - mean_pf,
         score = ifelse(diff_ef_pf > 0,
                        "ef_score > pf_score", "ef_score < pf_score")) %>%
  slice(1) %>%
  summarize(region, mean_ef, mean_pf, diff_ef_pf, score)

ggplot(data = region_hfi, aes(x = reorder(region, diff_ef_pf),
                             y = diff_ef_pf, fill = score)) +
  geom_col() +
  theme(axis.text.x = element_text(angle = 30)) +
  labs(x = "Region", y = "Diff in EF and PF Scores",
       title = "Personal Freedom Lagging Behind
Economic Freedom in Developing Countries",
       subtitle = "Data from 162 countries from 2008-2017")
```



## Personal Freedom Lagging Behind Economic Freedom in Developing Countries

Data from 162 countries from 2008–2017



From our graph, it appears that economic freedom is significantly higher than personal freedom in developing countries, particularly in the Middle East & North Africa. Meanwhile, personal freedom appears to be much higher than economic freedom in developed countries, particularly in Western countries.

### Correlation Between Economic and Personal Freedom

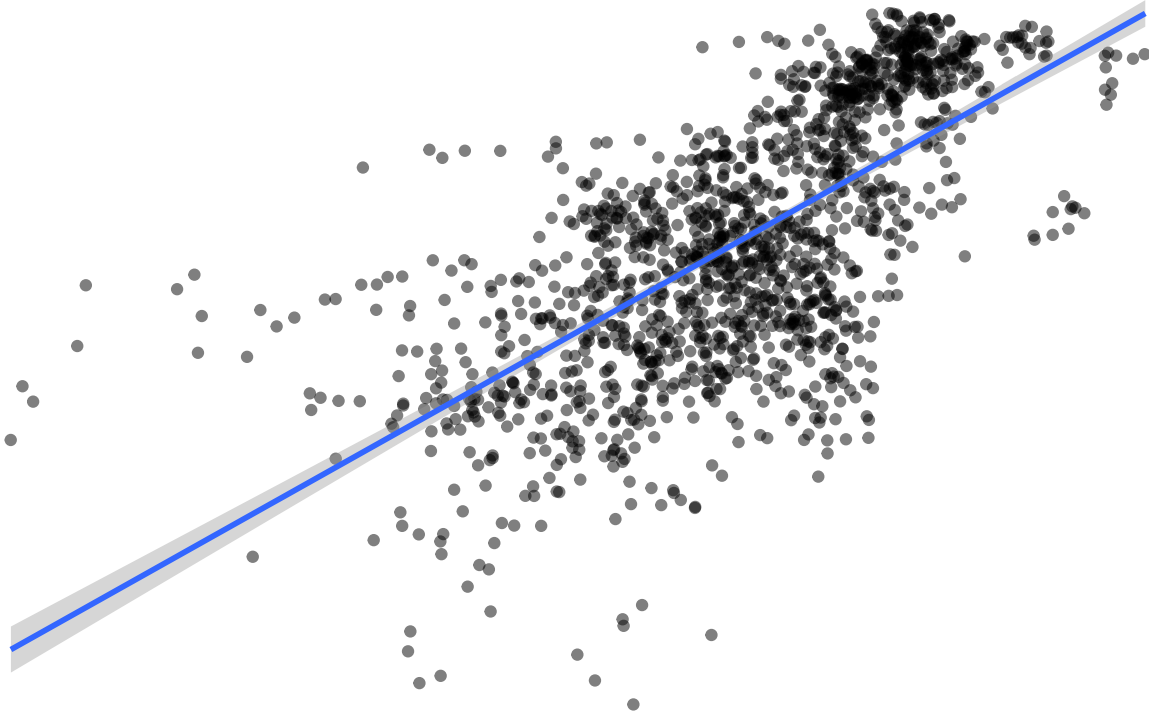
```
corr_efpf <- no_na_hfi %>%
  summarize(cor_ef_pf = cor(as.numeric(ef_score), as.numeric(pf_score)))
corr_efpf

## # A tibble: 1 x 1
##   cor_ef_pf
##   <dbl>
## 1      0.674

ggplot(data = no_na_hfi, aes(x = as.numeric(ef_score),
                             y = as.numeric(pf_score))) +
  geom_point(alpha = 0.5, position = "jitter") +
  geom_smooth(method="lm") +
  labs(x = "Economic Freedom Score", y = "Personal Freedom Score",
       title = "Positive Correlation Between Economic and Personal Freedom",
       subtitle = "Data from 162 countries from 2008-2017")
```

## Positive Correlation Between Economic and Personal Freedom

Data from 162 countries from 2008–2017



It appears that there is a positive and linear relationship between economic freedom score and personal freedom score.

### Relationship Between Freedom and Cold War Status

- It appears that there is a lower limit to economic freedom, compared to personal freedom.

Remaining Questions to Explore: - It appears that a bit of economic regulation could be beneficial toward a region's personal freedom and overall freedom. Examine certain lower scores in economic freedom in areas with high overall freedom. - Look at relationship between size of government and freedom - Look at relationship between regulation and overall freedom