

Setup

```
setwd("/Users/adazhong/Library/Mobile Documents/com~apple~CloudDocs/DSO 545/project/submission")

library(tidyverse)
library(rvest)
library(Quandl)

options(scipen = 999)
theme_set(theme_bw())
```

Prep

```
bit_fp = as.data.frame(read_csv("BECI_TWh - TWh per Year.csv")) # bitcoin energy consumption
bit_fp$Date = as.Date(bit_fp$Date)
bit_tr = Quandl("BCHAIN/NTRAN") # bitcoin daily transaction
## match the dates of energy consumption and transaction dataset
tr_filtered = bit_tr %>%
  filter(Date >= as.Date(min(bit_fp$Date)) & Date <= as.Date(max(bit_fp$Date)))

btc = left_join(bit_fp, tr_filtered, by = "Date") %>%
  rename(Est_TWh_per_Year = "Estimated TWh per Year",
         Min_TWh_per_Year = "Minimum TWh per Year",
         Num_Tr = "Value") %>%
  # kwh per transaction
  mutate(kWh_per_Tr = (Est_TWh_per_Year*1000000000/365)/Num_Tr) %>%
  # co2(kg) emission per transaction
  # used weighted global average for carbon intensity (475 gCO2eq/kWh)
  # ref: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2965436
  mutate(co2_per_Tr = (Est_TWh_per_Year*1000000*475/365)/Num_Tr)

## scrape data for major bitcoin miners worldwide
url = "https://digiconomist.net/bitcoin-energy-consumption#assumptions"
web = url %>%
  read_html() %>%
  html_nodes(xpath = '//*[@id="tablepress-110"]') %>%
  html_table() %>%
  as.data.frame()

web$Location[3] = "USA"

web[8, ] = str_remove(web[8, ], "b>")
location = web %>%
  mutate(Power.consumption..megawatts. = as.numeric(Power.consumption..megawatts.),
         X.of.surveyed.facilities = as.numeric(X.of.surveyed.facilities),
         Carbon.intensity..gCO2eq.kWh. = as.numeric(Carbon.intensity..gCO2eq.kWh.))

map = map_data("world")
worldmap = left_join(map, head(location,7), by = c("region" = "Location"))
worldmap[is.na(worldmap)] = 0
```

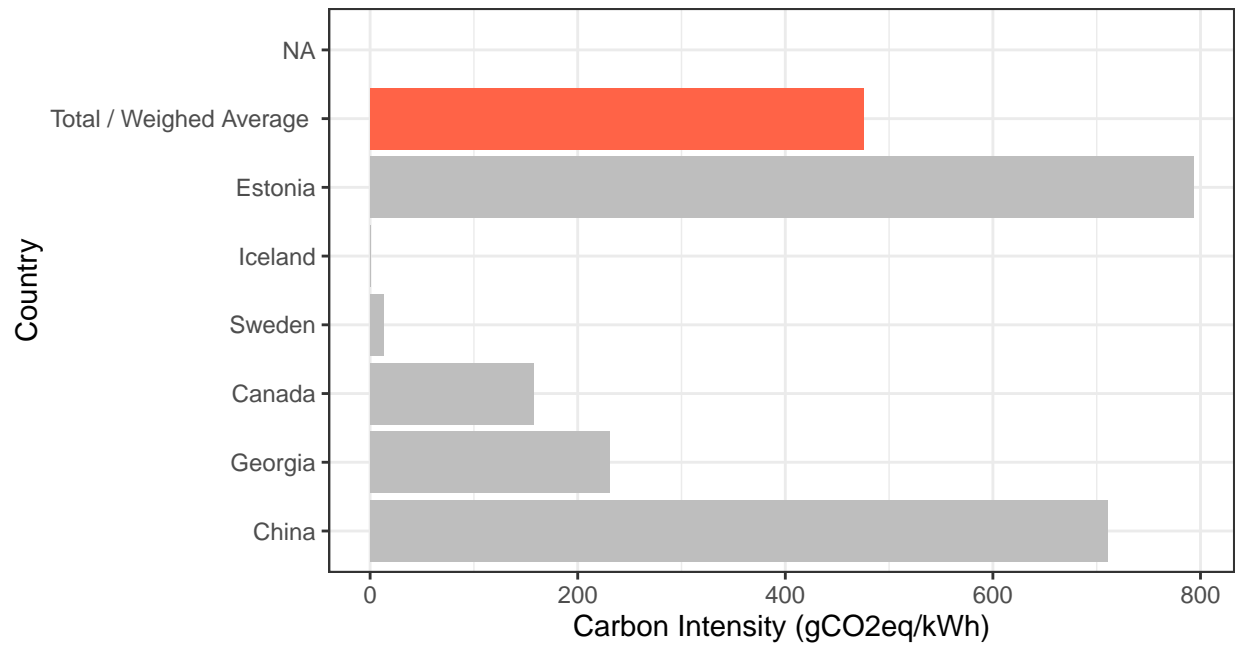
Visualization - Major Miners

```
## visualize major miners in the world
ggplot(worldmap, aes(long, lat, group = group, fill = Power.consumption..megawatts.))+
  geom_polygon(color = "grey")+
  scale_fill_gradient(low = "white", high = "red", name = "Power Consumption\n(megawatts)") +
  theme_void()
```



```
## visualize major miners carbon intensity (gCO2eq/kWh)
location$Location = factor(location$Location,
  levels = c("China", "Georgia", "United States", "Canada",
    "Sweden", "Iceland", "Estonia", "Total / Weighed Average "))
location = mutate(location, highlight = ifelse(Location == "Total / Weighed Average ", T, F))
ggplot(location, aes(Location, Carbon.intensity..gCO2eq.kWh.)) +
  geom_bar(stat = "identity", aes(fill = highlight)) + # highlight the weighed avg.
  scale_fill_manual(values = c("grey", "tomato")) +
  theme(legend.position = "none") +
  coord_flip() +
  ylab("Carbon Intensity (gCO2eq/kWh)") +
  xlab("Country") +
  ggtitle("Carbon Intensity of Major Bitcoin Miner Countries")
```

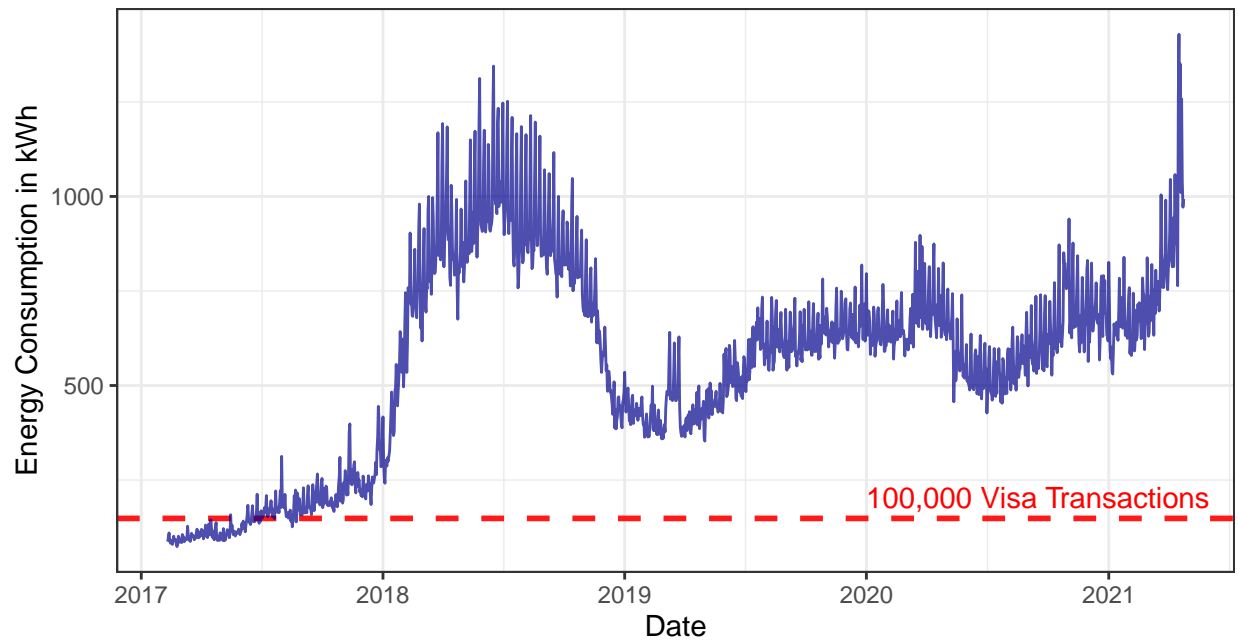
Carbon Intensity of Major Bitcoin Miner Countries



Visualization - Energy Consumption

```
# visualize energy consumption per 1 btc transaction vs. 100k visa transaction
# the spike during 2018-19 was caused by drop in transaction volume due to bearish speculations
ggplot(btc, aes(Date, kWh_per_Tr)) +
  geom_hline(yintercept = 148.63, color = "red", alpha = 0.9,
             linetype = "dashed", size = 1) +
  annotate(geom = "text", label = "100,000 Visa Transactions", color = "red",
          x = max(bit_fp$Date)-220, y = 148.63, vjust = -0.5) +
  geom_line(color = "darkblue", alpha = 0.7) +
  ggtitle("Energy Consumption per Transaction") +
  ylab("Energy Consumption in kWh")
```

Energy Consumption per Transaction



Visualization - Carbon Footprint

```
# visualize carbon footprint per 1 btc transaction vs. per 100k visa transaction
# using latest data point available when this research is conducted
btc_co2 = last(btc, 1)$co2_per_Tr
visa_co2 = 0.45/1000
carbon = data_frame(name = c("Visa", "100,000 Visa", "Bitcoin"),
                    co2 = c(visa_co2, visa_co2*100000, btc_co2))
```

```
## Warning: 'data_frame()' was deprecated in tibble 1.1.0.
## Please use 'tibble()' instead.
```

```
carbon$name = factor(carbon$name, levels = c("Visa", "100,000 Visa", "Bitcoin"))
ggplot(carbon, aes(name, co2)) +
  geom_bar(stat = "identity", fill = "darkorange", color = "darkorange") +
  xlab("") +
  ylab("CO2 Emissions in kg") +
  ggtitle("Carbon Footprint of Bitcoin vs. Visa Transactions")
```

