1048101_Fundamentals of Social Data Science

December 8, 2020

1 The Initial COVID-19 Responses of the South Korean and US Governments

1.1 Introduction

The United States and South Korea noted their first case of the COVID-19 virus on January 20, 2020 (Holshue, 2020; Lim, 2020). The two countries responded to the virus in different ways. South Korea responded quickly with a proactive government response, combining rigorous contact tracing, early isolation, and free treatment of positive cases (Lee, 2020). The United States, on the other hand, had a delayed and disorganized response, disbanding the Pandemic Emergency Response Task Force and pushing the responsibility of containment and mitigation strategies to individual states (Florida Atlantic University, 2020).

These different responses led to each country having vastly different experiences with the virus. South Korea flattened the curve within weeks, emerging as a "model to emulate in fighting the pandemic" (You, 2020). On the other hand, the United States has emerged as the epicenter of the virus, boasting an exponentially increasing trajectory of infection cases (Balogun, 2020). To date, the US has experienced over ten million total cases and over 200,000 deaths related to the virus. In August, the US was found to account for 25 percent of COVID-19 cases and deaths in the world while comprising less than 5% of the global population (Florida Atlantic University, 2020).

This research paper seeks to understand in what ways the South Korean government responded quicker after the first case of COVID-19 than the US government. A comparison of the South Korean and US government responses is especially compelling because the two countries share date of first COVID-19 infection (January 20), and yet the former is viewed as a success story while the latter is less so. This paper hypothesizes that faster government response in more than one category leads to a more successful COVID-19 containment response in the context of these two countries.

1.2 Data Analysis

This paper examines government response indicators derived from the Oxford COVID-19 Government Response Tracker (Mahdi et al., 2020). The analyses in the following section utilize the following government response indicators: school closures, workplace closures, public event cancellations, public transportation closures, stay at home requirements, internal movement restrictions, and international travel controls. Each indicator can have multiple levels of restrictions, with higher values corresponding with more severe restrictions. For example, `1` denotes *recommended* school closures, whereas `2` denotes *required* school closures.

The analyses also utilize the Government Response Index, an aggregate of several government response indicators calculated by OxCGRT. More details about the index and the specific indicators are listed in the GitHub codebook in the `government response` table (Codebook, 2020).

The cumulative number of confirmed COVID-19 cases for each country is gathered from OxCOVID19's Epidemiology table, and normalized using country population data from OxCOVID19's World Bank table. This data is resampled using a five-day window to smooth out the noise.

Because this paper is interested in the two countries' initial responses to COVID-19, government response and confirmed case data is gathered from January 1 to May 1, 2020. The date of each government response is subtracted from January 20, 2020 to calculate the number of days it took for a certain government response.

When no response is indicated for a particular government response, the null value is filled with 0 under the assumption that null values indicate an intentional lack of response rather than missing data.

[1]:
```
import os
import requests
import matplotlib.pyplot as plt
import seaborn as sns
import pandas as pd
import psycopg2
import re
from datetime import datetime

sns.set()
sns.set_style("dark")
```

1.2.1 Load data from OxCOVID19 for US and South Korea

[2]:
```
conn = psycopg2.connect(
    host='covid19db.org',
    port=5432,
    dbname='covid19',
    user='covid19',
    password='covid19')
cur = conn.cursor()
```

[3]:
```
# govtrack table
sql_command = """SELECT * FROM government_response\
    WHERE date < '2020-05-01' \
    and (country = 'United States' or country='South Korea')\
    ORDER by date ASC"""
df_govtrack = pd.read_sql(sql_command, conn)

# convert to datetime
df_govtrack.date = pd.to_datetime(df_govtrack['date'])

# calculate the timedelta of each response to first covid case
```

```
df_govtrack['response_since_first_infection'] = df_govtrack['date'] -␣
↪datetime(2020, 1, 20)
```

[4]:
```
# epidemiology table
sql_command_all = """SELECT * FROM epidemiology\
    WHERE date < '2020-05-01' \
    and (country = 'United States' or country='South Korea')\
    and adm_area_1 is null\
    ORDER by date ASC"""

df_epi = pd.read_sql(sql_command_all, conn)

# to datetime
df_epi.date = pd.to_datetime(df_epi['date'])
```

[5]:
```
# world bank table (just for population)
sql_command = """SELECT * FROM world_bank\
                 WHERE indicator_name like 'Population, total'
                 AND (country = 'United States' or country='South Korea')
              """
df_wb = pd.read_sql(sql_command, conn)
```

1.2.2 Calculate normalized confirmed cases for each country

[6]:
```
# Confirmed cases for every 10,000 population
df_cases = df_epi[["date", "country", "confirmed", "dead"]]\
    .merge(df_wb[["country", "value"]], on="country")
df_cases.rename(columns={"value": "population"}, inplace=True)
df_cases["confirmed_norm"] = \
    df_cases["confirmed"] / df_cases["population"] * 10000

df_cases.sort_values(by="date", inplace=True)
df_cases.reset_index(inplace=True, drop=True)
```

[7]:
```
# Calculate resampled averages for each country, for 5-day period
us_resampled_cases = df_cases[df_cases.country=="United States"]\
    .resample(on="date", rule='5D').aggregate("mean").reset_index()

kor_resampled_cases = df_cases[df_cases.country=="South Korea"]\
    .resample(on="date", rule='5D').aggregate("mean").reset_index()
```

1.2.3 Extract each of the c__xxxx flags mentioned in the government response tracker

[8]:
```
gov_flags = [re.search("c\d_[^flag]\w*", col).group() \
             for col in df_govtrack.columns if re.match("c\d_[^flag]\w*", col)]
display(gov_flags)
```

```
['c1_school_closing',
 'c2_workplace_closing',
 'c3_cancel_public_events',
 'c4_restrictions_on_gatherings',
 'c5_close_public_transport',
 'c6_stay_at_home_requirements',
 'c7_restrictions_on_internal_movement',
 'c8_international_travel_controls']
```

[9]:

```
# Extend gov_flags to include other relevant column indexes
gov_flags.extend(["date", "response_since_first_infection", "country"])

# Get the containment and closure policies on each row for each flag
df_melt = df_govtrack[gov_flags].sort_values(by="date")\
    .melt(id_vars=["date", "response_since_first_infection", "country"])\
    .dropna()

# Display a few elements
# display(df_melt.tail(3))
```

[10]:

```
# Format the labels to capitalize each word
gov_flag_labels = [' '.join([a.capitalize() for a in c.split('_')[1:]]) \
                   for c in df_melt.variable.unique()]
```

1.2.4 Calculate each country's first response for each category and restriction level

[11]:

```
# First instance of response per country, for each restriction level
first_restrictions_by_country = df_melt[df_melt.value!=0]\
    .groupby(['variable', 'country', 'value'])\
    .first()

# display(first_restrictions_by_country)
```

[12]:

```
# First instance of response per country, regardless of restriction level
first_restrictions_all_levels = df_melt[df_melt.value!=0]\
    .groupby(['variable', 'country'])\
    .first()\
    .unstack()["response_since_first_infection"]

# fill nulls with "0 days" for easier analysis
first_restrictions_all_levels.fillna(pd.Timedelta(seconds=0), inplace=True)

first_restrictions_all_levels["response_difference"] = \
    first_restrictions_all_levels["United States"] - \
    first_restrictions_all_levels["South Korea"]
```

```
# display(first_restrictions_all_levels)
```

[13]:
```
# Average time for response across all indicators and response levels
first_restriction_average = df_melt[df_melt.value!=0]\
    .groupby(['variable', 'country'])\
    .first()\
    .unstack()[["response_since_first_infection"]]\
    .mean()\
    .unstack(0)
first_restriction_average["avg_first_response_in_days"] = \
    first_restriction_average["response_since_first_infection"].dt.days

display(first_restriction_average[["avg_first_response_in_days"]])
```

	avg_first_response_in_days
country	
South Korea	25
United States	54

1.2.5 Render Graphs

[14]:
```
def render_figure_1_1():
    fig, ax1 = plt.subplots(figsize=(15, 7))

    # Axis 1: Plot the government indicators
    sns.lineplot(data=df_govtrack, x="date", y="government_response_index",
                 hue="country", palette="Set2", lw=3, ax=ax1)
    ax1.set_ylabel('Government Response Index')

    # instantiate a second axis that shares the same x-axis
    ax2 = ax1.twinx()

    # Axis 2: Plot the Area graphs
    us_resampled_cases.plot.area(stacked=False, x="date", y="confirmed_norm",
                ax=ax2, legend=None, color='#077863', alpha=0.2, linewidth=5)
    kor_resampled_cases.plot.area(stacked=False, x="date", y="confirmed_norm",
                 ax=ax2, legend=None, color='#EA7E0B', alpha=0.2, linewidth=5)
    ax2.set_ylabel('Confirmed Cases, Normalized (10,000)')

    # Set limits, labels, titles
    plt.xlabel('Date')
    plt.title('Figure 1.1: Government Response and Normalized Confirmed Cases',
          fontsize=20);
```

[15]:
```
def add_line(**kwargs):
    plt.axvline(pd.to_datetime('2020-01-20'), lw=6, label="First Covid Case");
```

```python
def render_figure_1_2():
    x_vars = "date"
    y_vars = df_melt.variable.unique()

    # Seaborn facetgrid for each variable
    g = sns.FacetGrid(df_melt, col="variable", height=1.5, col_wrap=1, aspect=7)
    # Add a line for the First Covid Case
    g.map(add_line, color='black')

    # Lineplot for each government response
    g.map_dataframe(sns.lineplot, x="date", y="value",
                    hue="country", palette="Set2", lw=3)
    g.set_axis_labels("Date", "Response")
    g.set(xlim=(pd.to_datetime('2020-01-15'), pd.to_datetime('2020-04-30')),
          yticks=[1,3,5])

    # Format subplot titles
    g.set_titles(col_template="{col_name}", row_template="{row_name}", y=0.75)

    # Add legends and titles
    g.add_legend()
    plt.subplots_adjust(top=0.95)
    g.fig.suptitle('Figure 1.2: Detailed Government Response of US vs Korea in␣
 ↪First 4 months of Covid',
                   fontsize=20);
```

[16]:
```python
df_bar_data = first_restrictions_all_levels.reset_index()\
        .melt(id_vars=["variable"], value_vars=["South Korea", "United States"])
df_bar_data.sort_values(by=["variable", "country"], inplace=True)
df_bar_data.reset_index(inplace=True, drop=True)

# Map days (datetime object) to integers
df_bar_data["value"] = df_bar_data["value"].apply(lambda a: a.days)
```

[17]:
```python
def render_figure_1_3_left(ax):
    g = sns.barplot(ax=ax,
                    data=df_bar_data,
                    y="variable",
                    x="value",
                    ci=False,
                    alpha=0.7,
                    hue="country",
                    palette="Set2",
                    orient='h')

    # Add the values
```

```python
    for index, row in df_bar_data.iterrows():
        g.text(row.value+2,
               index/2-0.15,
               row.value,
               color='dimgray',
               fontsize=15,
               ha="center")

    g.set_yticklabels(gov_flag_labels)

    # Add labels and title
    g.set_xlabel('Num Days for Response since First Covid Case')
    g.set_ylabel('Government Response Type')

    return g

def render_figure_1_3_right(ax):
    g = sns.barplot(ax=ax,
                    data=df_bar_data,
                    y="country",
                    x="value",
                    alpha=0.7,
                    hue="variable",
                    palette="Set2",
                    ci=False,
                    orient='h')

    for i in range(len(g.patches)):
        g.text(y=g.patches[i].get_y()+0.07,
               x=g.patches[i].get_x()+g.patches[i].get_width()+2,
               s=int(g.patches[i].get_width()),
               color='dimgray',
               fontsize=15,
               ha='center')


    # Format labels in legend properly
    leg = plt.legend(loc='upper right')
    [leg.get_texts()[i].set_text(label) \
         for i, label in enumerate(gov_flag_labels)]

    g.set_ylabel('Country')
    g.set_xlabel('Num Days for Response since First Covid Case')
    g.set_xlim(0, 90)

    return g
```

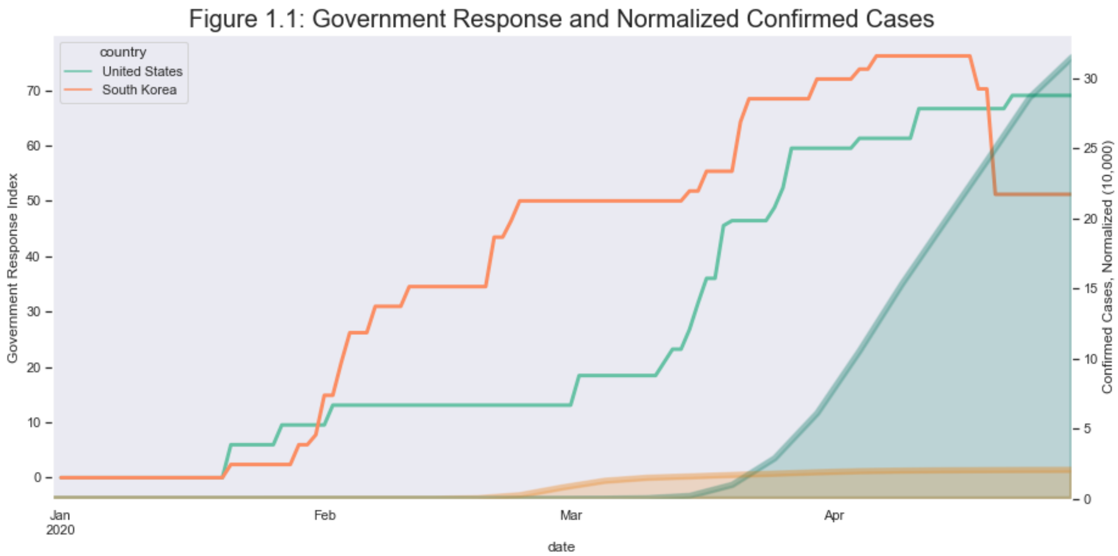
```
def render_figure_1_3():
    # Plot barplot
    fig, ax = plt.subplots(1,2, figsize=(18, 8))
    g0 = render_figure_1_3_left(ax[0])
    g1 = render_figure_1_3_right(ax[1])
    fig.suptitle('Figure 1.3: Government Response of US vs Korea in First 4␣
↪months of Covid, By Response Type',
                 fontsize=30);
    fig.tight_layout(pad=3.0)
```

[18]:
```
# render_figure_1_1()
# plt.savefig('img/1_1.png', bbox_inches = "tight")
# render_figure_1_2()
# plt.savefig('img/1_2.png', bbox_inches = "tight")
# render_figure_1_3()
# plt.savefig('img/1_3.png', bbox_inches = "tight")
```

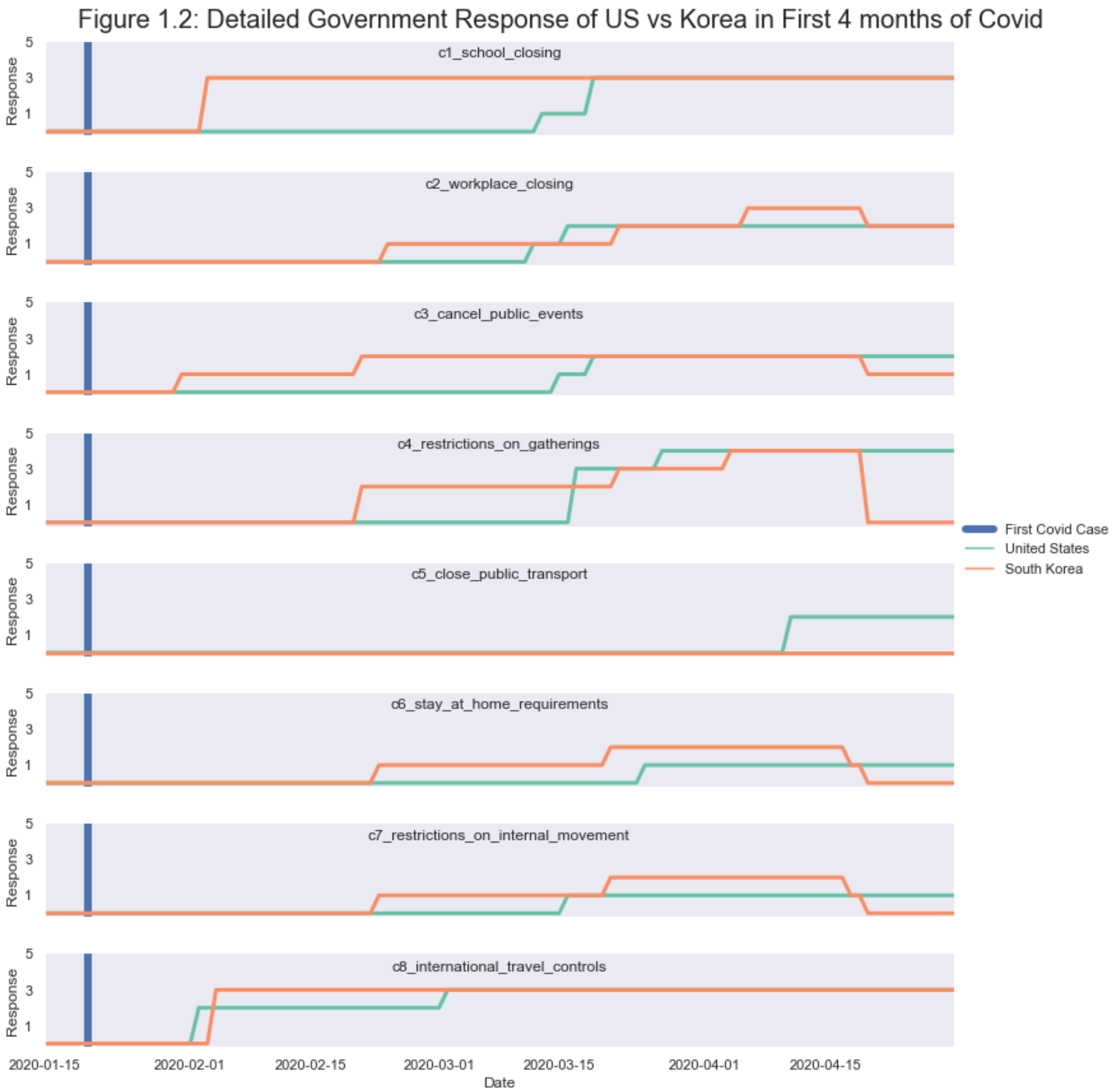
1.3 Results

Despite both South Korea and the United States having confirmed their first case of COVID-19 on the same day, the US took, on average, twice as long (54 days) as Korea (25 days) to respond. The difference in responses of the two governments is evident in the following analyses.

`Figure 1.1` shows the disparity in responses of the two countries by overlaying the overall Government Response Index on top of the confirmed cases. The lines represent the Government Response Index, and the shaded regions represent the daily confirmed cases, normalized for population of 10,000 and resampled in a five-day window to smooth noise. We can see that South Korea takes government action earlier than the US and escalates response at a quicker rate than the US does. The US's response lags far behind Korea's, not escalating their response until mid-March, when cumulative cases begin to pick up at an exponential rate. South Korea's response is almost always higher than the US's. In the end of April, South Korea beings to lower government response, but only long after having flattened the curve.



`Figure 1.2` disaggregates the government responses included in the Government Response Index. The analysis shows the first day that each country's government started implementing a response, and also when the level of that response changed. South Korea responded many days earlier than the US did for nearly every category. Even as the level of restrictions within each category shifted, South Korea's restriction levels tended to stay higher than the US's restriction levels. In some cases (such as in enacting school closure restrictions), South Korea responded up to 39 days faster than the US did.

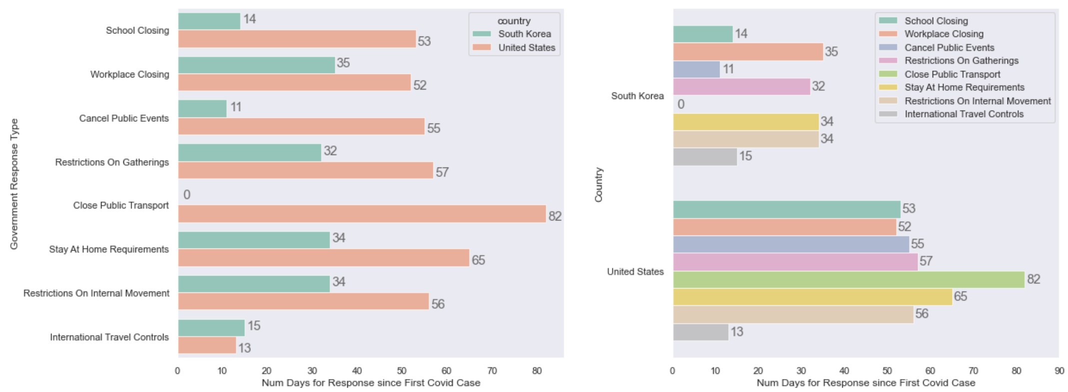


`Figure 1.3` also the first day that each country's government started implementing a response, but this time regardless of severity level. The two graphs show the same information: the one on the left groups restrictions by country, and the one on the right groups countries by restrictions. From these graphs, we can determine that although South Korea tended to respond anywhere from 17 to 39 days faster than the United States in terms of nearly all categories of government response, there are two exceptions.

The first is in the case of public transportation, in which South Korea did not enforce any restrictions. South Korea did not implement public transportation restrictions during the first few months of the COVID-19 pandemic, perhaps due to the fact that mask use was compulsory in public places and cases were relatively low (Tirachini, 2020). In this case, perhaps having no response was a better indicator of COVID-19 success than having a stringent response.

The second was in the case of international travel restrictions, in which the US responded swiftly and promptly, a few days before South Korea's response. According to the US Department of State, President Trump issued the first COVID-19-related proclamation in January 31, 2020, which blocked entry into the US of foreigners who were present in China (Travel.state.gov., 2020). This proclamation went into effect on February 2.

Figure 1.3: Government Response of US vs Korea in First 4 months of Covid, By Response Type



1.4 Limitations and Future Directions

The analyses in this paper showed that South Korea responded faster and with higher restrictions for nearly every category of government response. South Korea responded quicker than the US despite their relatively low case counts, and only began to ease their restrictions after the curve had been flattened. The US, on the other hand, did not escalate government response until their confirmed cases were rising exponentially, with their only early government response being international travel restrictions.

1.4.1 Factors Not Included in this Analysis

Before claiming a causal relationship between South Korea's relative success dealing with COVID-19 and faster government response, it is important to take other factors into account. This analysis did not investigate other factors that may have impacted the two governments' responses, such as public government approval ratings, the proportion of elderly and vulnerable citizens in the population, and the country's history of past pandemics.

This analysis also did not take into account the population size of the respective countries nor of their government structures. The US is a federal republic, meaning that responsibility and power is divided between the central government and the states. Individual states or local governments may have had earlier responses to the pandemic before the central government responded. While state-level and territory-level data is included in the government response table, local-level responses are likely to not be included (Hale et al., 2020). Conversely, South Korea is a centralized democratic republic with a smaller population than the US. This difference in population size and centrality of the federal government probably had an effect on the various government responses to the pandemic as well.

Another limitation of this analysis is that, in quantifying the "first response time", the level of severity of actions was not taken into account. For example, `Figure 1.3` does not include information such as the fact that South Korea's first response to school closure was at a Level 3, while the US's first response to school closure was at a Level 1. While this was necessary for easy comparison, it is important to acknowledge the nuance lost by ignoring the stringency levels.

1.4.2 Validity of Data Sources

The government responses from the database are labeled as discrete values ranging on a scale from 0 to 3 or 4 (depending on the indicator). Because responses had to be mapped to these values, we lose information on the specifics of each country's response. We only know the general level of stringency and category of the government response, but we do not know any details beyond that. The group at the Blatnavik School of Government responsible for collecting government response data acknowledges in their working paper the challenges of measuring the diversity of governments' responses to COVID-19 in a systematic way, and of the abstraction of the nuances of these responses in using composite measures (Hale et al., 2020). We also lose an additional level of nuance because state and national government responses were aggregated in government response data without being separable.

It is also important to acknowledge the likelihood of data inaccuracies in the OxCOVID19 database government response indicators. The data in this table were manually collected by a team at Oxford via Internet searches of public news articles and government press releases (Hale et al., 2020). It is possible that there are some responses were incorrectly included and others neglected to be included.

1.4.3 Future Directions

Future research would benefit from extending this study to better understand the relationships between faster government response and success COVID-19 containment. Examples of other factors to be included in this analysis include topic modeling of each government's official announcements and sentiments of the reactions from each country's public. By seeing how public sentiment or topics change over time for each country, as more scientific research emerges about COVID-19 and as the severity of the global pandemic increases over time.

2 The Relationship between Democracy Index and Restrictive Measures in Response to COVID-19

2.1 Introduction

In the months since the first outbreak of the COVID-19 pandemic, scholars have pondered the indicators that could be used to predict countries' varying responses and experiences. Some scholarship has suggested that democratic governments (rather than authoritarian governments, such as China's) are the key to a successful response for controlling the pandemic, due to democracy's accountability to the people (Alon et al., 2020). Research from the Carnegie Endowment for International Peace offers a more critical view, arguing that even democratic countries such as South Korea and Italy employed methods bordering on authoritarianism, such as privacy-invasive digital contract tracing apps or criminal penalties for breaking quarantine (Kleinfeld, 2020).

In this section, the analyses from Part I are continued to examine the relationship between government response to COVID-19 and country's level of democracy. This research paper examines whether the regime type of a government, as described by the Economist Intelligence Unit (EIU), has an impact on that government's response. This paper hypothesizes that authoritarian countries respond quicker to enact restrictions on internal movement, and that democratic countries respond slower.

2.2 Data Analysis

EIU's 2019 Democracy Index is used to measure democracy and regime type (The Economist Intelligence Unit, 2019). The Democracy Index ingests 60 different indicators for each country to calculate a numeric score representing democracy, with higher values corresponding with more democratic governments. This democracy score is mapped to one of four regime types: Full Democracy, Flawed Democracy, Hybrid, and Authoritarian. The Democracy Index is gathered from its Wikipedia page. While the EIU's website contains a whitepaper with their data, they do not have a public CSV file or API available on their whitepaper or their website. The most recent version on Wikipedia was sourced on 2020-02-04 from the EIU's report (Democracy Index, 2020).

While the Democracy Index has its own criticisms and limitations (which will be discussed in the Limitations section below), several studies, including that of Bashar and Tsokos (2019), claim that it is the most comprehensive democracy indicator.

The date of the first COVID-19 case for each country is calculated from OxCOVID19's epidemiology table by determining the first entry with more than 0 number of cases. The stringency of internal movements is sourced from OxCOVID19's government response table. This specific indicator can take one of the following values: 0 (no measures), 1 (recommended not to travel between regions/cities), 2 (internal movement restrictions in place), and Blank (no data) (Codebook, 2020). This analysis focuses on Level 2 restrictions because it aims to connect the most stringent government measures with authoritarianism.

In combining the data from the Democracy Index and the OxCOVID19 database, several countries were found to have missing data. This will be addressed further in the Limitations section.

[19]:
```
import requests
import matplotlib.pyplot as plt
import seaborn as sns
import pandas as pd
import psycopg2
import re
import datetime as dt
from bs4 import BeautifulSoup

sns.set()
sns.set_style("darkgrid")
```

2.2.1 Obtain Democracy Index

[20]:
```
# Scraping democracy index from Wikipedia page
response = requests.get("https://en.wikipedia.org/wiki/Democracy_Index")
soup = BeautifulSoup(response.text)

countries, scores, regimetypes, regions = [], [], [], []

for line in soup.find_all("table")[2].find_all("tr")[1:]:
    country = line.find("a").text
    score, regimetype = [a.text for a in line.find_all("b")]
```

```
    table_items = [t.text for t in line.find_all("td")]
    table_items = [i for i in table_items if 'Score:' not in i]

    countries.append(country)
    scores.append(score)
    regimetypes.append(regimetype)
    regions.append(table_items[-1].strip('\n'))

    # Last country in the table
    if country == "North Korea": break
```

[21]:
```
# Convert democracy index lists into dataframe
dem_index = pd.DataFrame([countries, scores, regimetypes, regions]).T
dem_index.columns=["country", "dem_score", "regimetype", "region"]
dem_index.dem_score = dem_index.dem_score.apply(float)
```

2.2.2 Load Government Response and Epidemiology from OxCOVID19

[22]:
```
conn = psycopg2.connect(
    host='covid19db.org',
    port=5432,
    dbname='covid19',
    user='covid19',
    password='covid19')
cur = conn.cursor()
```

[23]:
```
# Load government tracking data from OX COVID
sql_command_all = """SELECT * FROM government_response\
    WHERE date < '2020-04-01'\
    ORDER by date ASC"""
df_govtrack_all = pd.read_sql(sql_command_all, conn)

# to datetime
df_govtrack_all.date = pd.to_datetime(df_govtrack_all['date'])
df_govtrack_all.government_response_index = df_govtrack_all.
 ↪government_response_index.apply(float)
```

[24]:
```
# Load epidemiology data from OX COVID
sql_command_epi = """SELECT * FROM epidemiology\
    WHERE date < '2020-04-01'\
    ORDER by date ASC"""
df_epidemiology = pd.read_sql(sql_command_epi, conn)

# to datetime
df_epidemiology.date = pd.to_datetime(df_epidemiology['date'])
```

2.2.3 Determine "first case of COVID-19" for each country

[25]:
```
# Determine "first case of covid" for each country
first_confirmed = df_epidemiology[df_epidemiology.confirmed>0]\
    .sort_values(by="date")[["country", "date", "confirmed", "gid"]]\
    .groupby("country")\
    .first()

# Extract GIDs from arrays for each row
first_confirmed.gid = first_confirmed.gid.dropna().apply(lambda x: x[0])

# Drop rows with null GIDs. These are continents (ex: Africa, America, etc)
first_confirmed = first_confirmed[~first_confirmed.gid.isna()]

# Some GIDs are have extra numbers after them, get rid of them (ex: POL.3.6_1)
first_confirmed.gid = first_confirmed.gid.apply(
    lambda x: re.search("(\w\w\w)",x).group(1))
```

2.2.4 Filter for first record of government's restrictions on internal movement

[26]:
```
# Selecting only "Restrictions on internal movement" government flag
gov_flags = ['c7_restrictions_on_internal_movement']
gov_flags.extend(["date", "country", "gid"])

# Dataframe with all of the government flags from above, melted
df_melt_all = df_govtrack_all[gov_flags]\
    .sort_values(by="date")\
    .melt(id_vars=["date", "country", "gid"])\
    .dropna()

# Merge in first confirmed date for each country
df_melt_all = df_melt_all.merge(first_confirmed, how="left", on=["gid"])\
    .rename(columns={"date_x": "date", "date_y": "first_confirmed_date"})\
    .drop(columns="confirmed")

# Calculate the number of days for each
df_melt_all["response_since_first_infection"] = \
    df_melt_all["date"] - df_melt_all["first_confirmed_date"]
```

[27]:
```
# The countries that do not seem to exist in the OxCovid database
df_melt_all[df_melt_all.first_confirmed_date.isna()].country.unique()
```

[27]:
```
array(['Vanuatu', 'Pitcairn Islands', 'Yemen', 'Falkland Islands',
       'Solomon Islands', 'Hong Kong', 'South Sudan', 'Macao', 'Malawi',
       'Turkmenistan', 'Tajikistan', 'Lesotho'], dtype=object)
```

2.2.5 Merge in data about first confirmed COVID-19 case and Democracy Index

[28]:
```
# Only looking at values above a 1 in score (i.e. most stringent scores)
# 1=Recommended, 2=Restricted
df_all_countries= df_melt_all[df_melt_all.value>1]\
    .groupby(['variable', 'country'])\
    .first()\
    .unstack()["response_since_first_infection"]\
    .melt()\
    .rename(columns={"value": "response_since_first_infection"})

# Extract just the number of "days" from the time detla
df_all_countries["response_since_first_infection"] = \
    df_all_countries["response_since_first_infection"].apply(lambda a: a.days)

# Drop the countries with no data about confirmed cases
df_all_countries = \
    df_all_countries[~df_all_countries["response_since_first_infection"].isna()]

# Merge back in the date of the first case of covid
df_all_countries = df_all_countries\
    .merge(first_confirmed.reset_index()[["country", "gid", "date"]],
           on="country")\
    .rename(columns={"date": "first_case"})
```

[29]:
```
# Merge in democracy score
df_merge = df_all_countries.merge(dem_index, on="country")
```

2.2.6 Convert "first case" date to different time frames for extra analysis

[30]:
```
# week of year
df_merge['first_case_woy'] = df_merge.first_case.dt.isocalendar().week

# every [two weeks] of year
df_merge['first_case_biweekly'] = df_merge.first_case_woy//2

# month of year
df_merge['first_case_month'] = df_merge.first_case.dt.month

# date as ordinal
df_merge['first_case_ordinal'] = pd.to_datetime(df_merge['first_case'])\
    .apply(lambda date: date.toordinal())


# A ranking/ordering for regime type in order of authoritarian to democratic
regimetype_order = {"Authoritarian": 0, "Hybrid regime": 1,
                    "Flawed democracy": 2, "Full democracy": 3}
```

```
df_merge["regimetype_order"] = df_merge.regimetype.map(regimetype_order)
```

2.2.7 Calculate average response time before and after Feb 15 for each regime type

[31]:
```
average_response_time_before_feb_15 = \
    df_merge[df_merge.first_case < datetime(2020,2,15)]\
     .groupby(["regimetype_order", "regimetype"])\
     .mean()["response_since_first_infection"]\
     .to_frame()\
     .rename(columns={"response_since_first_infection": "avg_response_days"})\
     .apply(lambda x: round(x, 2))\
     .reset_index()\
     .drop(columns=["regimetype_order"])

average_response_time_after_feb_15 = \
    df_merge[df_merge.first_case >= datetime(2020,2,15)]\
     .groupby(["regimetype_order", "regimetype"])\
     .mean()["response_since_first_infection"]\
     .to_frame()\
     .rename(columns={"response_since_first_infection": "avg_response_days"})\
     .apply(lambda x: round(x, 2))\
     .reset_index()\
     .drop(columns=["regimetype_order"])
```

2.2.8 Top 3 Countries Per Regime Type with Fastest and Slowest Responses

[32]:
```
fastest_by_regimetype = df_merge\
     .sort_values(by="response_since_first_infection")\
     .groupby("regimetype")\
     .head(3)
fastest_by_regimetype['speed'] = 'fast'

slowest_by_regimetype = df_merge\
     .sort_values(by="response_since_first_infection")\
     .groupby("regimetype")\
     .tail(3)\
     .sort_values(by="regimetype")
slowest_by_regimetype['speed'] = 'slow'

top_response_by_regimetype = fastest_by_regimetype\
     .append(slowest_by_regimetype)\
     .sort_values(by=["speed", "regimetype_order", "first_case"])\
     [["country", "response_since_first_infection", "first_case", "regimetype"]]
top_response_by_regimetype.reset_index(inplace=True, drop=True)
```

2.2.9 Calculate Other Helper Variables

[33]:
```
# order of regimes from most to least authoritarian; used for plotting purposes
regime_order = ["Authoritarian", "Hybrid regime",
                "Flawed democracy", "Full democracy"]
```

2.2.10 Render Graphs

[34]:
```
def render_figure_2_1():
    a4_dims = (10, 5)
    fig, ax = plt.subplots(figsize=a4_dims)

    g = sns.boxplot(ax=ax, x="regimetype", y="response_since_first_infection",
                    order=regime_order,
                    data=df_merge, palette="Set1")
    plt.xlabel('Regime Type')
    plt.ylabel('Response Time (Days) Since First Covid Case')
    plt.title('Figure 2.1: Response Time for Internal Restriction Measures, by␣
↪Regime Type',
              fontsize=20);
```

[35]:
```
def render_figure_2_2():
    df_merge_months = df_merge.copy()

    # Special case: China's first case was december 31, 2019.
    # We will interpret this as january
    df_merge_months.loc[df_merge_months.country=="China",
                        "first_case_month"] = 1

    fig, ax = plt.subplots(1,2, figsize=(18,8))

    g0 = sns.boxplot(x="first_case_month", y="response_since_first_infection",
                     hue_order=regime_order, hue="regimetype", ax=ax[0],
                     data=df_merge_months, palette="Set1")

    g1 = sns.stripplot(x="first_case_woy", y="response_since_first_infection",
                       zorder=1, size=14, linewidth=1, hue="regimetype",
                       ax=ax[1], dodge=True,hue_order=regime_order,
                       data=df_merge_months, palette="Set1")

    g0.set_title('Response Time (By Month)')
    g1.set_title('Response Time (By Week)')

    g0.set_xlabel('First Case of Covid (Month of Year)')
    g1.set_xlabel('First Case of Covid (Week of Year)')

    g0.set_ylabel('Response Time Since First Case (Days)')
```

```
    g1.set_ylabel('Response Time Since First Case (Days)')

    fig.suptitle('Figure 2.2: Response Time, by Regime Type and First Covid␣
↪Case',
                 position=(.5,1), fontsize=25);
```

[36]:
```
def plot_barplot_subplot(df, ax, title_suffix):
    g = sns.barplot(x="regimetype", y="avg_response_days", data=df,
                    ax=ax, palette="Set1")

    for index, row in df.iterrows():
        g.text(row.name, row.avg_response_days+1, row.avg_response_days,
               color='black', fontsize=15, ha="center")

    ax.set_ylim(0,80)
    ax.set_ylabel("Average Response Time (Days)")
    ax.set_xlabel("Regime Type")
    ax.title.set_text(f"Countries with First Case {title_suffix}")

def render_figure_2_3():
    fig, axes = plt.subplots(nrows=1, ncols=2, figsize=(15, 5))

    plot_barplot_subplot(average_response_time_before_feb_15,
                         axes[0], "Before Feb 15")
    plot_barplot_subplot(average_response_time_after_feb_15,
                         axes[1], "After Feb 15")

    fig.suptitle("Figure 2.3: Average Response Times for Internal Movement␣
↪Restrictions, by Regime Type",
                 y=0.98, fontsize=25)
    fig.tight_layout()
```

[37]:
```
def render_figure_2_4():
    plt.rcParams["figure.figsize"] = [15, 5]

    data = df_merge[["country", "response_since_first_infection", "first_case",
                     "dem_score", "regimetype", "region"]]\
        .groupby("regimetype")\
        .apply(lambda x: x.sort_values("response_since_first_infection"))\
        .drop(columns=["regimetype"])\
        .reset_index(0).reset_index(drop=True)

    sns.kdeplot(data=data, x="response_since_first_infection", hue="regimetype",
                hue_order=regime_order, palette="Set1", fill=True, bw_adjust=.6,
                linewidth=3, alpha=0.1)

    plt.xlabel('Response Time Since First Infection (Days)')
```

```
    plt.title('Figure 2.4: Distribution of Response Time, By Regime Type',
              fontsize=23);
```

[38]:
```
def render_figure_2_5():
    # plotting inspired by https://nikkimarinsek.com/blog/
 ↪how-to-make-an-arrow-plot
    data = top_response_by_regimetype
    ax = plt.figure(figsize=(8,12))
    ax = sns.stripplot(data=data, x='first_case', y='country', orient='h',
                       size=12, hue_order=regime_order, hue='regimetype',
                       palette='Set1')

    #add start points
    arrow_starts = data['first_case'].values
    arrow_lengths = data['response_since_first_infection']

    # Add number of days to the label on the y-axis
    new_labels = [f"{c.get_text()} ({val} days)" for (c, val) in \
         zip(ax.get_yticklabels(),
             data.response_since_first_infection.values.astype(int).
 ↪astype(str))]
    ax.set_yticklabels(new_labels)

    #add arrows to plot
    for i, subject in enumerate(data['country']):
        if arrow_lengths[i] != 0:
            ax.arrow(arrow_starts[i],        #x start point
                     i,                      #y start point
                     arrow_lengths[i],       #change in x
                     0,                      #change in y
                     head_width=.3,         #arrow head width
                     head_length=1,        #arrow head length
                     width=0.01,              #arrow stem width
                     fc='gray',             #arrow fill color
                     ec='gray')             #arrow edge color
    plt.axhline(y=11.5, color='gray', linestyle='--')
    plt.xticks(rotation=45)
    plt.legend(loc="upper left", borderaxespad=0.)
    plt.xlabel('Date')


    plt.text(1.03, 0.8, 'Top 3 Countries with Fastest Responses',
        horizontalalignment='left',
        verticalalignment='bottom',
        transform=ax.transAxes)
    plt.text(1.03, 0.3, 'Top 3 Countries with Slowest Responses',
        horizontalalignment='left',
```

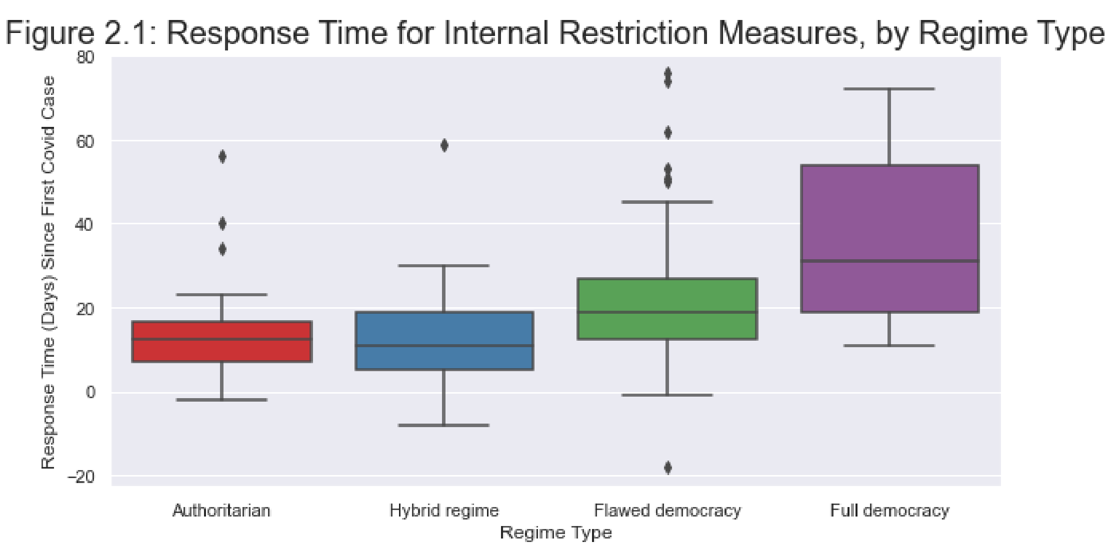
```
        verticalalignment='bottom',
        transform=ax.transAxes)


    plt.title('Figure 2.5: Countries with Fastest and Slowest Responses, by␣
↪Regime Type',
              fontsize=20);
```

[39]:
```
# render_figure_2_1()
# plt.savefig('img/2_1.png', bbox_inches = "tight")
# render_figure_2_2()
# plt.savefig('img/2_2.png', bbox_inches = "tight")
# render_figure_2_3()
# plt.savefig('img/2_3.png', bbox_inches = "tight")
# render_figure_2_4()
# plt.savefig('img/2_4.png', bbox_inches = "tight")
# render_figure_2_5()
# plt.savefig('img/2_5.png', bbox_inches = "tight")
```

2.3 Results

The results of the analysis as follows show that at first glance, authoritarian countries seem to have responded faster than democratic countries in enacting strict rules about internal movements. Some authoritarian countries (such as Libya and Venezuela) enacted restrictions days before reporting their first COVID-19 case.

`Figure 2.1` groups speed of response to enact internal restriction measures by regime type. The more authoritarian the regime type of the government, the quicker the stringent response on internal movement restrictions. This seems to confirm the hypothesis that authoritarian governments act quicker to enact internal restrictive measures, whereas democratic governments are slower to do so.

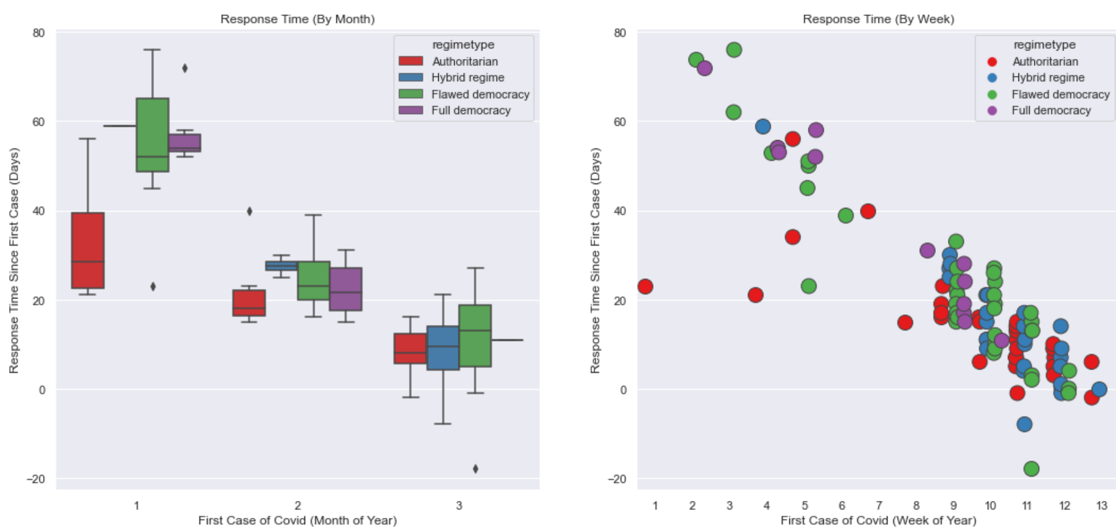


However, upon separating the speed of response by the date of the first COVID-19 case, the analysis shows that the date of first infection has a large influence on quickness of response. `Figure 2.2` shows the government response time, separated by regime type, with the date of the first COVID-19 case aggregated by month and by week. For later dates of first COVID-19 cases, the authoritarian nature of the regime seems to have less impact on response time.

In the response times aggregated by month, the mean of the authoritarian regimes' response times is noticeably quicker in the first two months, compared to other regime types. By the third month, the means seem to equalize across all regime types. In the response times aggregated by week, the downward trend becomes apparent as time goes on. For the countries with earlier first COVID-19 cases (before Week 8), authoritarian regimes tended to respond quicker than other regime types as indicated by the red data points. For the countries with later first COVID-19 dates (i.e. after Week 8), the regime type tended to have less of an influence in response time, as the data points are closely clustered and less variable.

Overall, the date of the first case of COVID-19 is influential upon the number of days it took for a government to enact restrictions, although the regime type of that government is not negligible. One way to interpret this can be that, for countries with earlier first cases of COVID-19, authoritarian regimes were more likely to enact stringent internal movement measures. For countries with later first cases of COVID-19, the regime type had less of an influence on stringency measures.

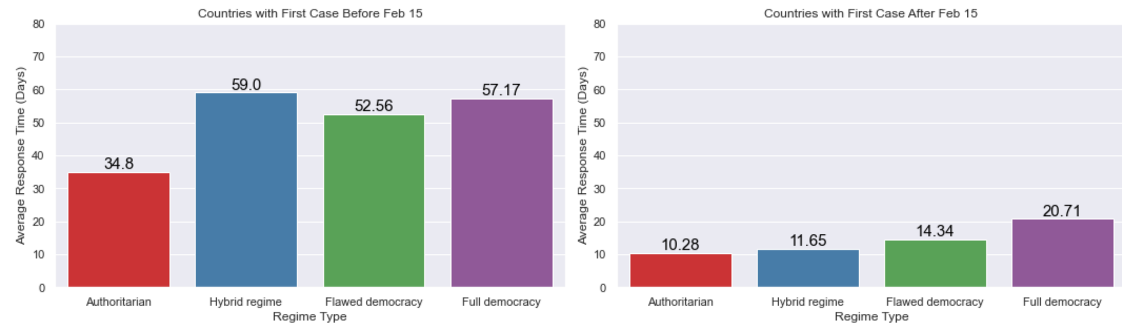
Figure 2.2: Response Time, by Regime Type and First Covid Case



`Figure 2.3` shows a government's response to impose internal movement restrictions for countries that experienced their first case of COVID-19 before and after February 15, 2020. February 15 was chosen as the cutoff date because, as seen in `Figure 2.2`, around Week 8 was when clustering behavior began to emerge. The eighth week of 2020 began with the date January 16.

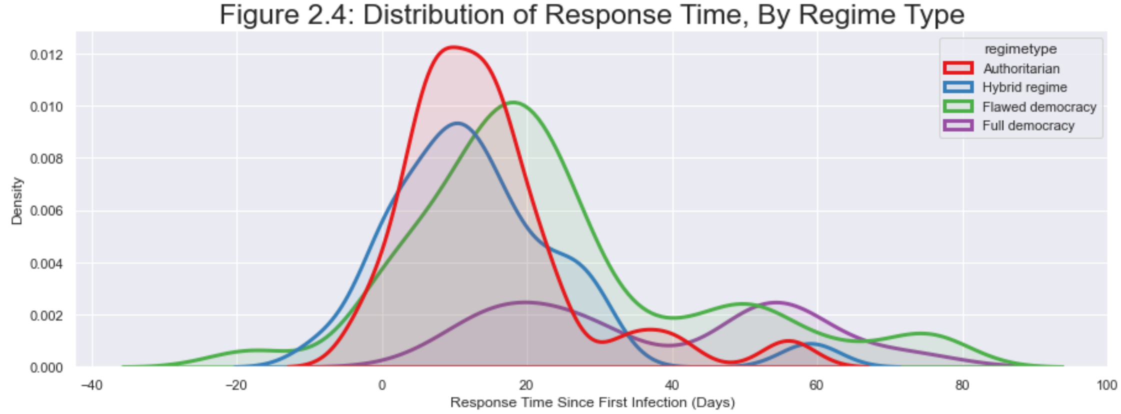
For countries with first case before February 15, authoritarian countries responded on average around 20 days quicker. For countries with first case after February 15, all countries tended to respond quicker, with authoritarian regimes having less of an influence on response time. For countries with first case after February 15, democracies tended to take the longest to respond, while this trend is not as apparent for countries with first cases before February 15.

Figure 2.3: Average Response Times for Internal Movement Restrictions, by Regime Type



`Figure 2.4` shows the distribution of responses for each regime type. Authoritarian, hybrid, and flawed democracy regimes tend to be unimodal with long right tails, meaning that there was some unity in terms of their responses, but with some variety outside of the mode. The distribution of democratic regimes' response time, as indicated by the purple line, are less certain. The distribution of democratic regimes' response time is bimodal and variable, suggesting that the responses for different democratic regimes varied greatly.

Figure 2.4: Distribution of Response Time, By Regime Type

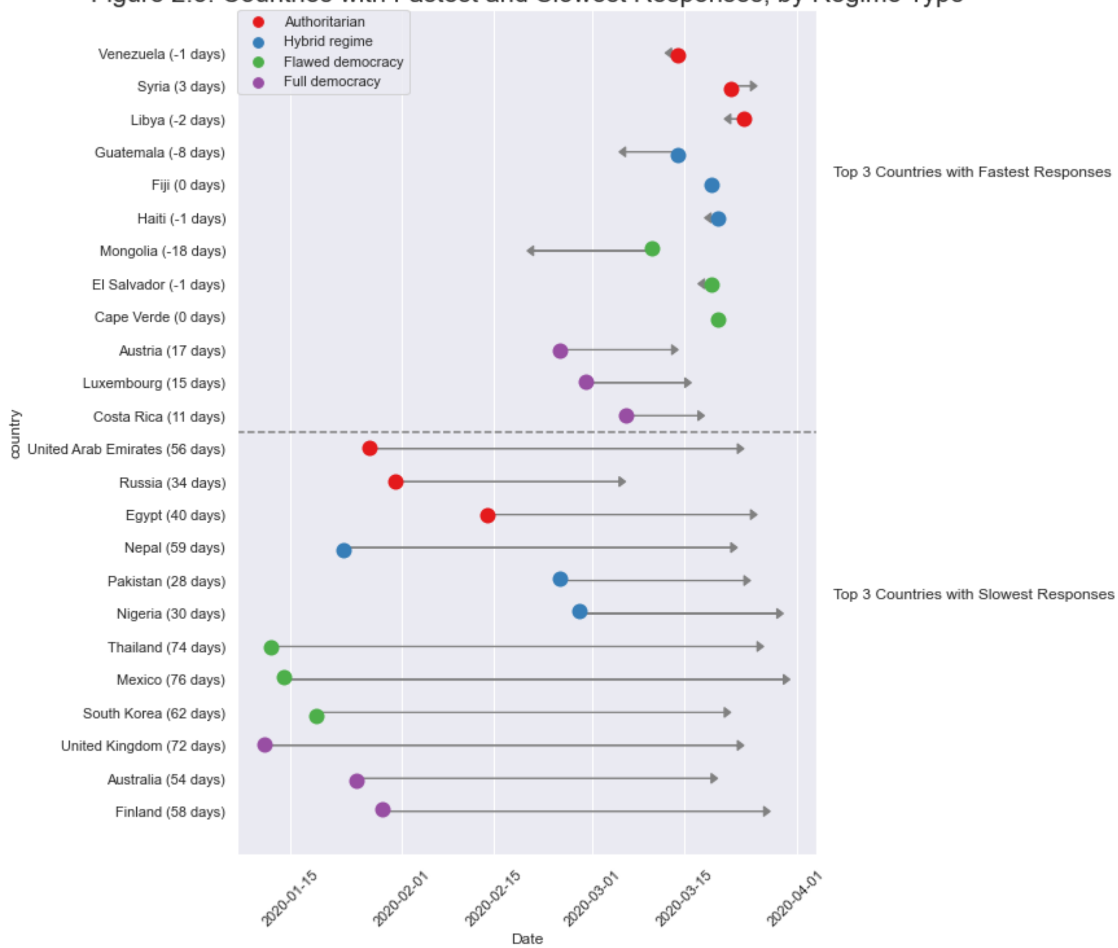


`Figure 2.5` plots the top 3 countries with slowest and top 3 countries with fastest response, for each regime type. The dot indicates the date of the first COVID-19 case, and the end of the arrow indicates the date of the first response to enact internal movement restrictions. An arrow going to the left indicates the country having responded before their first case. Above the dotted line are the top 3 countries per regime type that responded the quickest. Below the dotted line are the top 3 countries per regime type that responded the slowest.

This graph confirms the observations made above, that countries with later first cases of COVID-19 responded quicker than countries with earlier first cases of COVID-19. However, even within this framework, we can note that the response of the quickest democratic countries is vastly different from the response of the quickest countries in the other 3 regime types. Even the fastest democratic countries did not respond proactively (i.e. before a confirmed case of COVID-19), whereas other regime types did.

As for countries with the slowest responses, there seems to be little variability among regime types. Countries with earlier first cases of COVID-19, regardless of regime type, tended to take a longer time to respond than countries with later first cases of COVID-19.

Figure 2.5: Countries with Fastest and Slowest Responses, by Regime Type



2.4 Limitations and Future Directions

This research paper has shown that while in some cases authoritarian regimes responded faster with implementing internal restrictions, many other factors affected this observation. Nearly all regime types with later COVID-19 cases responded quickly, not just authoritarian regimes, and not all authoritarian regimes responded quickly. This aligns with the view that democratic and authoritarian governments have their own strengths and weaknesses, and neither is exclusively better at dealing with the threat of COVID-19 (Stasavage, 2020).

2.4.1 Factors Not Included in the Analysis

Similar to Part I, there are several outstanding factors not included in this analysis. Examples of factors not included in this analysis include country population, COVID-19 severity, and country history with previous pandemics. Future researchers are encouraged to investigate factors such as geographic proximity of countries to China, where the initial outbreak of the virus occurred. Perhaps one of the reasons Mongolia responded so quickly (18 days before their first COVID-19 case) was due to their sharing a border with China.

2.4.2 Validity of Data Sources

It is important to be critical of the data sources used in this analysis. The EIU's Democracy Index was used as a proxy for countries' level of authoritarianism and democracy, but there have been criticisms of the index. For example, Bashar and Tsokos (2019) suggest that the EIU's Democracy Index may not be very accurate, as it does not take into consideration the interactions and correlations among the collected data.

There have also been some gaps in the OxCOVID19 database as well. There was no data about case numbers for the following countries: Falkland Islands, Malawi, Vanatu, Lesotho, Solomon Islands, Tajikistan, Yemen, Turkmenistan, Hong Kong, Macao, South Sudan, and Pitcairn Islands. Further, there are issues (mentioned already in Part 1's Limitation section) about loss of nuance of severity level and human transcription errors in creating the database.

Lastly, there may be concerns about the accuracy of the first case of COVID-19 calculated for each country. One study uses statistical methods to show that authoritarian governments are likely to have manipulated the data they published about their COVID-19 numbers (Kapoor et al., 2020). The dates of the first COVID-19 case may be inaccurate and the analysis of this paper misleading, due to the possibility that the data in the database are inaccurate or falsified.

2.4.3 Future Directions

This study looked only at the time it took countries to enact severe restrictions on internal movement. Future research is encouraged to replicate this study for other kinds of restrictions in conjunction with World Values survey data. Do countries that value trade more tend to be slower enacting restrictions of international travel controls? Do countries that value education more tend to be slower in enacting restrictions on school closures? This analyses in this study can be enriched with additional data about each country, such as GDP, state of health infrastructure, and history with previous pandemics. There are many directions for extending this current study into new understandings about countries' responses to the global pandemic.

3 Works Cited

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4 Word Counts

[44]:
```
import io
from nbformat import current
nbk_path = '1048101_Fundamentals of Social Data Science.ipynb'
```

[45]:
```python
with io.open(nbk_path, 'r', encoding='utf-8') as f:
    nb = current.read(f, 'json')

word_count = 0
for cell in nb.worksheets[0].cells:
    if cell.cell_type == "markdown":
        if "# Works Cited" in cell['source']: continue
        curr_wc = len(cell['source'].replace('#', '').lstrip().split(' '))
        print(cell['source'][:15], curr_wc)
        word_count += curr_wc

print(f"The word count, excluding references, is {word_count}")
```

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## Data Analysi 243
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`Figure 1.3` al 224
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## Introduction 177
## Data Analysi 272
### Calculate a 13
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However, upon s 278
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![Figure 2.5](i 2
This research p 493
The word count, excluding references, is 3452
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