Early Analysis of Relative Lock Down Efficacy in Fighting COVID-19

Difference in Differences Modeling by World Bank Groupings

Glen Haynes

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Contents

Introduction

The spirit of this analysis is exploratory. COVID-19 is a recent phenomenon and many measures of the effects it has on a given population are still being refined. The work here is not meant to be a fully rigorous treatment, but instead the laying out of framework trying to better understand how to approach a problem like this one, and seek ways to understand the effectiveness or our responses to the situation. Identifying and linking relevant data sources from The Center for Systems Science and Engineering (CSSE) at John's Hopkins University with economic and social data from the World Bank along reports of the stay-at-home or lock down order policies governments is one of the efforts put forward here. The goal is to identify the groupings of similar populations with differing policy in place to begin to examine the effectiveness of the policy. Specifically, is there a measureable effect from the implemntation of a lock down order. To explore this we'll look at correlations of the World Bank's relevant COVID-19 indicators among their regional and economic groupings. Finally we'll examine some basic differnce-in-difference modeling among countries grouped by World Bank regions and income level groupings. [https://github.com/CSSEGISandData/COVID-19/blob/master/csse_covid_19_data/csse_covid_19_time_series/time_series_covid19_confirmed_US.csv; http://datatopics.worldbank.org/universal-health-coverage/coronavirus/; https://en.wikipedia.org/wiki/COVID-19_pandemic_lockdowns].

Data

This section describes the data sources and the data gathering process.

```
## Load functions ##

source("R/csse_covid_dat.R")
source("R/csse_merge.R")

## List CSSE files ##

csse_list <- list(
  "time_series_covid19_confirmed_US.csv",
  "time_series_covid19_confirmed_global.csv",
  "time_series_covid19_deaths_US.csv",
  "time_series_covid19_deaths_global.csv",
  "time_series_covid19_recovered_global.csv"
)

csse_dat <- csse_list %>% map(~{
  csse_covid_dat(.x,
                 use_saved_file = params$use_saved_files)
})

csse_us_merge <- csse_merge(csse_dat, 'us', 'Series')

csse_global_merge <- csse_merge(csse_dat, 'global', 'Series')

rm(csse_dat)
```

```
source("R/wrld_bk_dat.R")
source("R/wb_ind_lst.R")

## Get World Bank meta data ##

wb_meta <- wrld_bk_dat(use_local_json = params$use_saved_files)

## List of relevant indicators ##

if(params$use_saved_files)
{
  wb_relevant_indicators <- wb_ind_lst(dat_loc = "data/covid-indicators.csv")
}else
{
  wb_relevant_indicators <- wb_ind_lst()
}

## Limit relevant indicators ##

wb_relevant_indicators <- wb_relevant_indicators[c(1, 5, 18, 25, 37, 47),]

## Relevant indicators and other data ##

wb_rel_ind_List <- map2(
```

```
  c(wb_relevant_indicators$id, 'SP.POP.TOTL'), ## Add Population
  c(wb_relevant_indicators$topic, "Extra_to_rel"),
  function(x,y){wrld_bk_dat(indicator = x,
                            date='2015:2020',
                            use_local_json = TRUE,
                            save_file = FALSE,
                            save_dir = 'data/wb-rel-ind-data',
                            dat_addrs = NULL) %>%
      mutate(topic = y) %>%
      group_by(countryiso3code) %>%
      group_map(~ .x %>%
                  filter(!is.na(value)) %>%
                  filter(date == max(date))) %>%
      bind_rows()}) %>%
  bind_rows()
```

```
if(params$use_wiki_csv)
{
  wiki_lock <- read_csv(wiki_lock, "data/wiki_lock.csv")
  wiki_no_lock<- read_csv(wiki_no_lock, "data/wiki_no_lock.csv")
}else
{
  if(params$use_saved_files & !params$use_wiki_csv)
  {
    use_python("c/Miniconda3/python")
    wiki_covid_lockdown <- import("wiki_covid_lockdown")

    wiki_lock_status <- wiki_covid_lockdown$wiki_covid_lockdown(
      source = "web_page_references/COVID-19 pandemic lockdowns - Wikipedia.html"
    )

    wiki_lock <- wiki_lock_status[[1]] %>%
      map(~sapply(.x, function(y){
        as.character(y) %>% gsub("^\\s+|\\s+$", "", .)
      })) %>% bind_cols()

    wiki_no_lock <- wiki_lock_status[[2]] %>%
      map(~sapply(.x, function(y){
        as.character(y) %>% gsub("^\\s+|\\s+$", "", .)
      })) %>% bind_cols()
  }else
  {

    ## Check Wikipeida still allowing bots ##

    wiki_rbt_status <- robotstxt(domain="en.wikipedia.org")

    # Check access permission (returns true/false)

    wiki_scrape_allowed <- wiki_rbt_status$check(
      paths = "wiki/COVID-19_pandemic_lockdowns",
      bot = "*")
```

```
    if(wiki_scrape_allowed)
    {

      use_python("c/Miniconda3/python")
      wiki_covid_lockdown <- import("wiki_covid_lockdown")

      wiki_lock_status <- wiki_covid_lockdown$wiki_covid_lockdown()

    }

    wiki_lock <- wiki_lock_status[[1]] %>%
      map(~sapply(.x, function(y){
        as.character(y) %>% gsub("^\\s+|\\s+$", "", .)
      })) %>% bind_cols() %>%
      ## Convert start and end dates to R date type ##
      mutate(`Start date` = as.Date(`Start date`, format = "%Y-%m-%d")) %>%
      mutate(`End date` = as.Date(`End date`, format = "%Y-%m-%d")) %>%
      rename(start_date = `Start date`, end_date = `End date`)

    wiki_no_lock <- wiki_lock_status[[2]] %>%
      map(~sapply(.x, function(y){
        as.character(y) %>% gsub("^\\s+|\\s+$", "", .)
      })) %>% bind_cols()
  }
}
```

Create crosswalks

CSSE Data Transfomrations

Filter for number of events less than 1000, get totals, and calculate growth rates. Filter to exclude sub-country regions.

Data exploration

Sort and plot CSSE Data

First 4 data plots shown below. To see all click the link below.

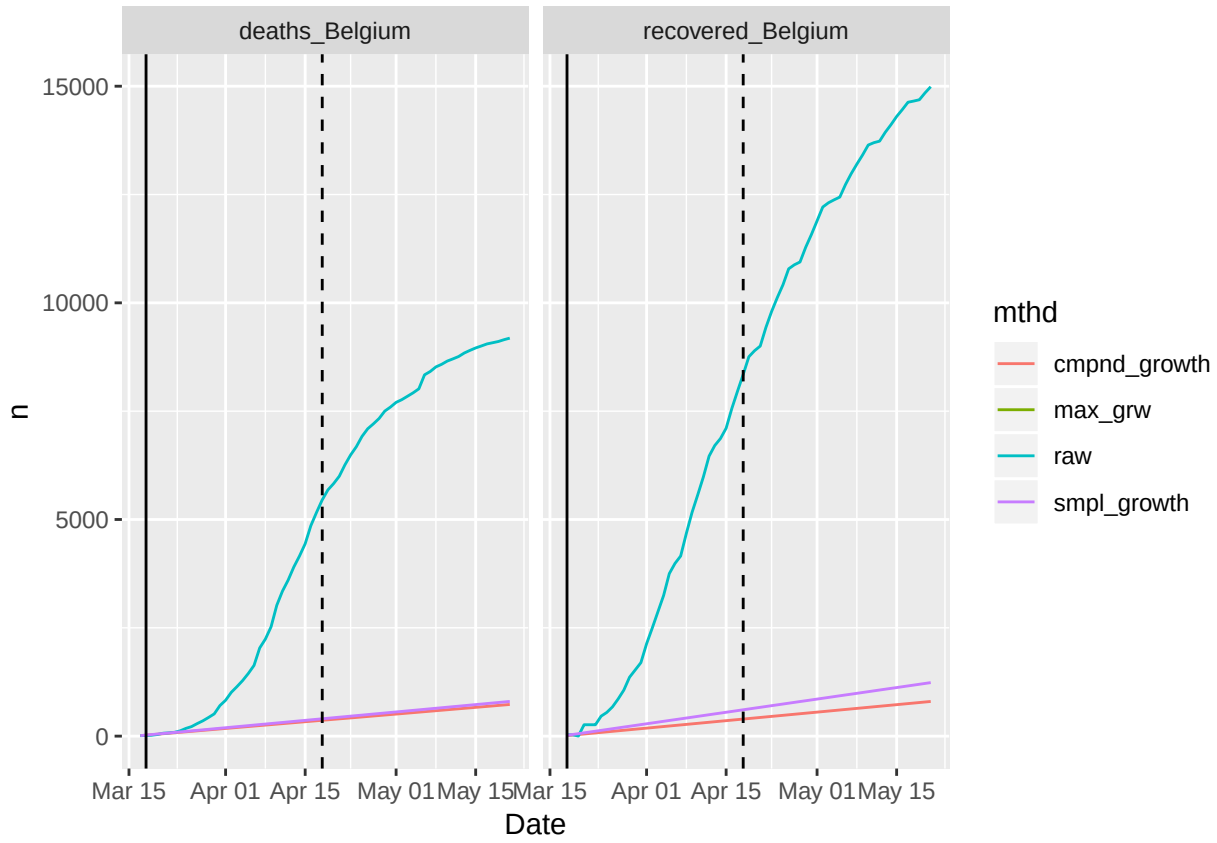
Solid line is lockdown date, as reported by Wikipedia. The dashed line is the lockdown date plus 31 days to account for time to recovery or mortality. (https://www.who.int/docs/default-source/coronaviruse/who-china-joint-mission-on-covid-19-final-report.pdf#:~:text=Using%20available%20preliminary%20data%2C,severe%20or%20critical% p.13

Raw Data with Growth Rate and Stay at Home Order

```
plts[1:4]
```

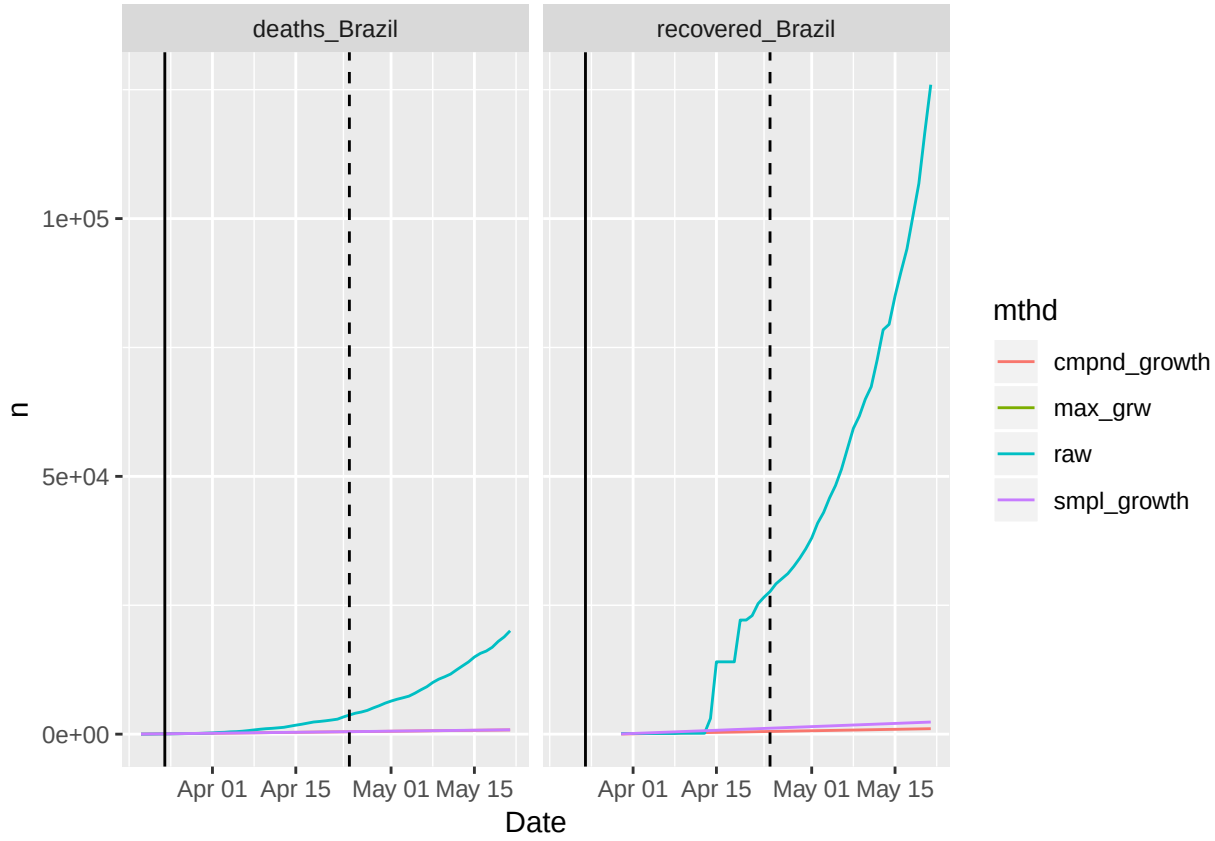
```
## $`Country/Region1`
```

```
## Warning: Removed 131 rows containing missing values (geom_path).
```



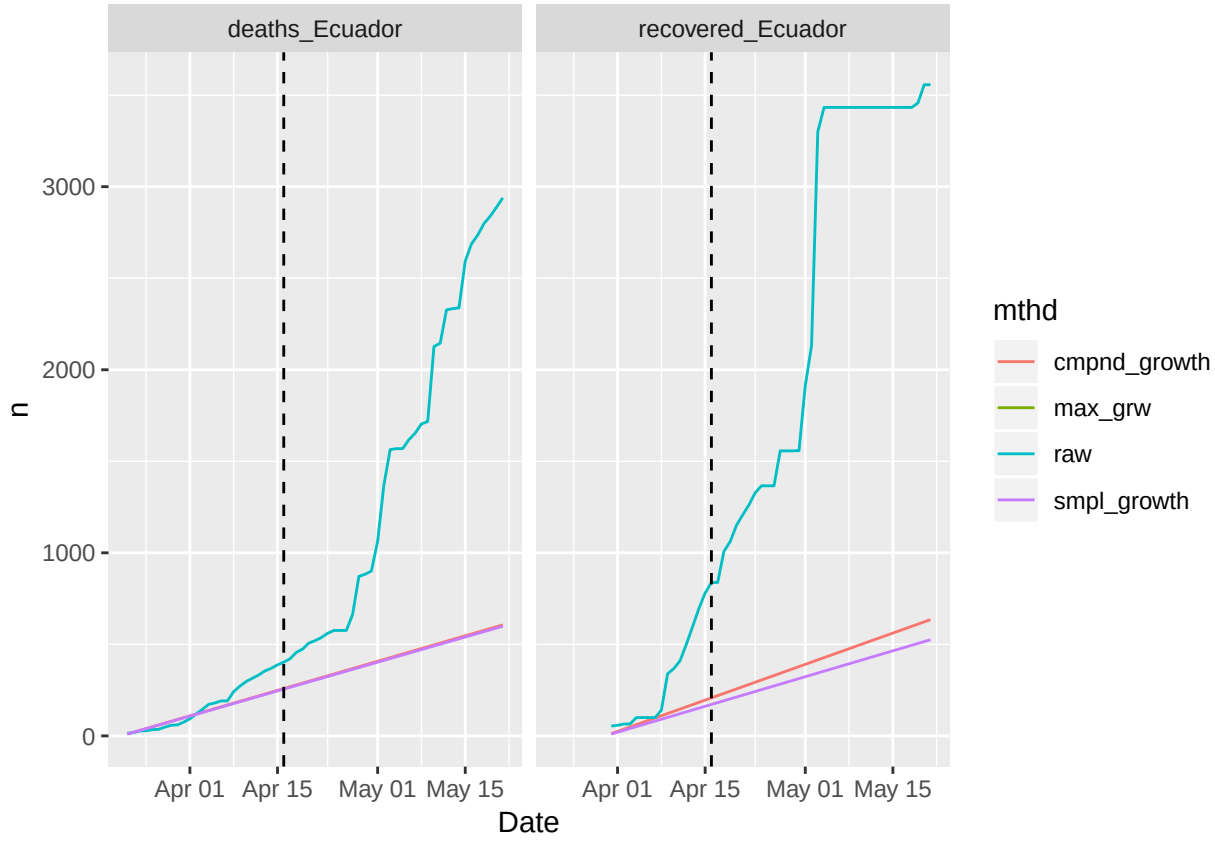

```
##
## $`Country/Region2`

## Warning: Removed 116 rows containing missing values (geom_path).
```



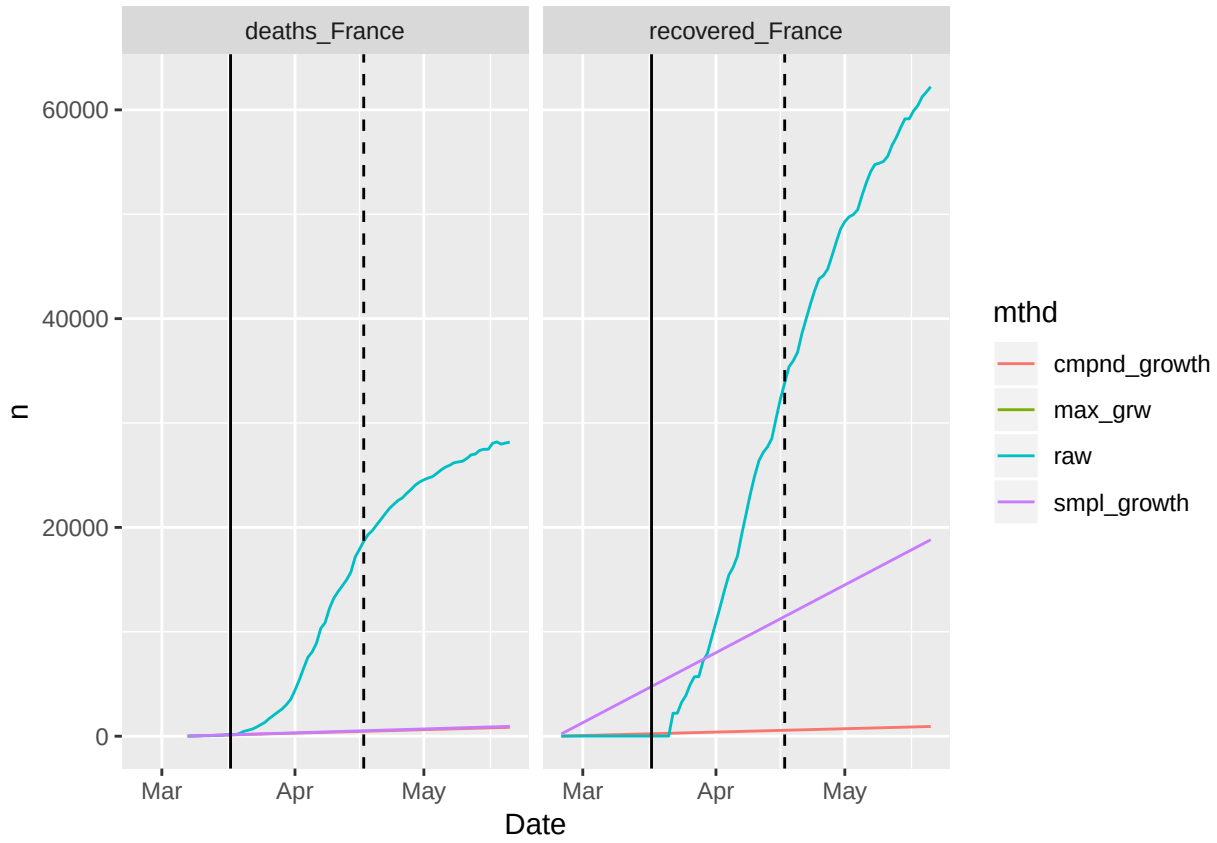

```
##
## $`Country/Region3`

## Warning: Removed 113 rows containing missing values (geom_path).
```




```
##
## $`Country/Region4`

## Warning: Removed 163 rows containing missing values (geom_path).
```



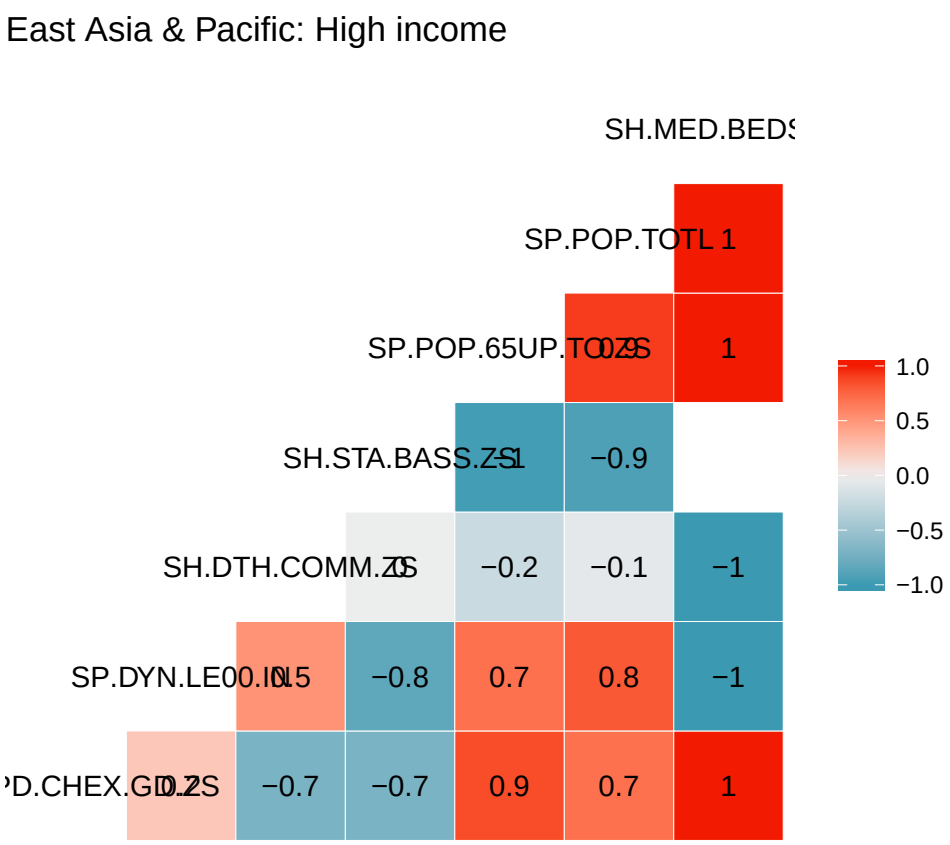
Correlation Plots

Correlation plots are or World Bank Relavent COVID-19 indicators (http://datatopics.worldbank.org/universal-health-coverage/coronavirus/), grouped by World Bank Region and income level. The idea was to seek homeogenous groupings between countries with regards to the impact of COVID-19. East Asia & Pacific: High income shows some correlatoin, but more research is needed.

To see all correlation plots

```
corr_plts[3]
```

```
## $`East Asia & Pacific: High income`
```



Data treatment and linkage

Filter CSSE data with world bank categories and link with Wikipedia lockdown information Take countries with no lockdown order and group them by their 'region.value' and 'incomeLevel.value from the World Bank. Format the sorted data by creating before and after lockdown dummy and dummy for in-or-out of lockdown set. (Actually take 31 days after lockdown imposed as binary turning point for the time dummy accounting for the lag effect in mortality and recovery.)

```
source("R/fltr_crss_wb_cat.R")
no_lock_countries <- c(wiki_no_lock$`Countries and territories`[
  wiki_no_lock$`Countries and territories` %in%
    global_csse_crs$wb_name][-5], "Korea, Rep.")

csse_no_lock <- no_lock_countries %>% map(~
                            {
                              wb_meta %>% filter(
                                {
                                  name %in% .x
                                }
                              )%>%
                                {
                                  left_join(select(.,
                                                   incomeLevel.value,
                                                   region.value),
                                            wb_meta,
```

```
                                    by = c("incomeLevel.value",
                                           "region.value")) %>%
                        select(name)
                    } %>%
                    unlist() %>%
                    paste(collapse = "|") %>%
                    fltr_crss_wb_cat(name, .) %>%
                    select(csse_cntry) %>%
                    {
                      filter(bind_rows(sort_csse),
                             country %in% unlist(.)) %>%
                        #### Create treatment effect dummy  ##
                        ## Filter out all non-locked except ##
                        ## non-locked of interest in list the  ##
                        ## element. Later each locked country ##
                        ## will be run in a seperate equation ##
                        ## against the locked in it's group/list. ##
                        mutate(lock = ifelse(wb_name %in%
                                               no_lock_countries,
                          0, 1)) %>%
                        filter(!(lock == "N" & wb_name == .x)) %>%
                        mutate(Start_Lag = mx_start + 31) %>%
                        filter(mthd == "raw" & grepl("death|recov",
                                                     Series)) %>%
                        select(country, Series,
                               Date, Start_Lag, n, lock)
                    }
                })
```

Results

Model difference-in-difference equations and report findings.

Differnce in difference for lockdown effect on mortality.

Looking at mortality and recovery rates, rather than confirmed cases, as a better indicator of disease spread under nascent testing. As, such a 31 day lag was added to the indicator to adjust for the time to recovery and or mortality. (https://www.who.int/docs/default-source/coronaviruse/who-china-joint-mission-on-covid-19-final-report.pdf#:~:text=Using%20available%20preliminary%20data%2C,severe%20or%20critical%20disease.), p. 14

Diff-in-diff Mortality

This site was helpful in setting up the difference-in-difference equations.

Analysis

The analysis here is preliminary. We do see from the results of these basic difference in difference tests, significant results on the differnce-in-difference in some cases. Usually the sign is negative meaning that the lock downs may reduce mortality and recovery. This makes sense, as these are both proxies for spread of the disease at this point.

###In the results below country: 1-country: 0 indicate the lockdown, treatment case, and no lockdown case respectively.

```
map2(diff_in_diff_mortality, names(diff_in_diff_mortality), function(x, y)
  {
  if(summary(x[[2]])$r.squared > .65)
  {
    y
    summary(x[[2]])
  }
  })
```

```
## $`Belgium:1-Sweden:0`
##
## Call:
## lm(formula = n ~ time + lock + diff_in_diff, data = model_dat)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -2229.2  -655.5  -117.2   716.1  3780.2
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    2848.0      136.4   20.89   <2e-16 ***
## time          -2372.8      194.3  -12.21   <2e-16 ***
## lock           5064.2      192.8   26.26   <2e-16 ***
## diff_in_diff  -3866.6      273.8  -14.12   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1108 on 258 degrees of freedom
## Multiple R-squared:  0.8691, Adjusted R-squared:  0.8676
## F-statistic: 571.1 on 3 and 258 DF,  p-value: < 2.2e-16
##
##
## $`France:1-Sweden:0`
##
## Call:
## lm(formula = n ~ time + lock + diff_in_diff, data = model_dat)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -5544.5 -1297.6  -133.8   891.2 13391.4
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    2808.6      437.2   6.424 5.74e-10 ***
## time          -2366.9      633.1  -3.739 0.000225 ***
## lock          22038.9      618.3  35.644  < 2e-16 ***
## diff_in_diff -17211.0      864.1 -19.917  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 3605 on 278 degrees of freedom
```

```
## Multiple R-squared:  0.8749, Adjusted R-squared:  0.8735
## F-statistic:   648 on 3 and 278 DF,  p-value: < 2.2e-16
##
##
## $`Germany:1-Sweden:0`
##
## Call:
## lm(formula = n ~ time + lock + diff_in_diff, data = model_dat)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -1888.4  -630.0   -99.7   662.2  3675.6
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    3040.7      151.1   20.12   <2e-16 ***
## time          -2390.7      200.3  -11.94   <2e-16 ***
## lock           4181.1      213.7   19.57   <2e-16 ***
## diff_in_diff  -2931.6      280.9  -10.44   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1131 on 262 degrees of freedom
## Multiple R-squared:  0.8176, Adjusted R-squared:  0.8155
## F-statistic: 391.5 on 3 and 262 DF,  p-value: < 2.2e-16
##
##
## $`Ireland:1-Sweden:0`
##
## Call:
## lm(formula = n ~ time + lock + diff_in_diff, data = model_dat)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -1680.54  -279.27    19.59   341.46  1271.46
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)   2599.54      63.21  41.127  < 2e-16 ***
## time         -2299.27      99.94 -23.006  < 2e-16 ***
## lock         -1454.00      89.39 -16.266  < 2e-16 ***
## diff_in_diff  1302.01     150.47   8.653 7.35e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 558.2 on 240 degrees of freedom
## Multiple R-squared:  0.7572, Adjusted R-squared:  0.7542
## F-statistic: 249.5 on 3 and 240 DF,  p-value: < 2.2e-16
##
##
## $`Italy:1-Sweden:0`
##
## Call:
## lm(formula = n ~ time + lock + diff_in_diff, data = model_dat)
```

```
##
## Residuals:
##    Min     1Q Median     3Q    Max
##  -8413  -1717    -96   1288  12517
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    2477.1      437.6   5.661 3.52e-08 ***
## time          -2253.1      735.6  -3.063  0.00239 **
## lock          24784.6      618.8  40.052  < 2e-16 ***
## diff_in_diff -19246.3      954.6 -20.162  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 4010 on 300 degrees of freedom
## Multiple R-squared:  0.8812, Adjusted R-squared:   0.88
## F-statistic: 741.9 on 3 and 300 DF,  p-value: < 2.2e-16
##
##
## $`Netherlands:1-Sweden:0`
## NULL
##
## $`Portugal:1-Sweden:0`
##
## Call:
## lm(formula = n ~ time + lock + diff_in_diff, data = model_dat)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -1308.84  -267.99   -28.59   226.98  1032.55
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)   2888.84      54.66   52.85   <2e-16 ***
## time         -2381.39      76.71  -31.04   <2e-16 ***
## lock         -1837.25      77.30  -23.77   <2e-16 ***
## diff_in_diff  1637.30     109.81   14.91   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 437.3 on 250 degrees of freedom
## Multiple R-squared:  0.8464, Adjusted R-squared:  0.8446
## F-statistic: 459.2 on 3 and 250 DF,  p-value: < 2.2e-16
##
##
## $`Spain:1-Sweden:0`
##
## Call:
## lm(formula = n ~ time + lock + diff_in_diff, data = model_dat)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -6488.0 -1287.3   -18.3  1055.7 11558.0
##
```

```
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    2687.3      427.5   6.285 1.26e-09 ***
## time          -2338.8      651.4  -3.590  0.00039 ***
## lock          21868.6      604.6  36.168  < 2e-16 ***
## diff_in_diff -15719.1      883.5 -17.792  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 3678 on 278 degrees of freedom
## Multiple R-squared:  0.8716, Adjusted R-squared:  0.8703
## F-statistic: 629.3 on 3 and 278 DF,  p-value: < 2.2e-16
##
##
## $`Switzerland:1-Sweden:0`
## NULL
##
## $`United Kingdom:1-Sweden:0`
##
## Call:
## lm(formula = n ~ time + lock + diff_in_diff, data = model_dat)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -7465.4  -635.2  -177.2   687.8 14765.2
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    3040.7      494.7   6.147 4.34e-09 ***
## time          -2390.7      655.7  -3.646 0.000341 ***
## lock          27216.7      856.8  31.765  < 2e-16 ***
## diff_in_diff -20844.8     1116.1 -18.677  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 3702 on 196 degrees of freedom
## Multiple R-squared:  0.8761, Adjusted R-squared:  0.8742
## F-statistic: 462.1 on 3 and 196 DF,  p-value: < 2.2e-16
```

Diff-in-diff Recovered

```
map2(diff_in_diff_recovered, names(diff_in_diff_recovered), function(x, y)
  {
  if(summary(x[[2]])$r.squared > .65)
  {
    y
    summary(x[[2]])
  }
  })
```

```
## $`Armenia:1-Belarus:0`
##
```

```
## Call:
## lm(formula = n ~ time + lock + diff_in_diff, data = model_dat)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -4240.3  -194.7  -135.9   297.9  6243.7
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    5813.3      309.0  18.816  < 2e-16 ***
## time          -5603.6      411.2 -13.627  < 2e-16 ***
## lock          -4445.1      436.9 -10.174  < 2e-16 ***
## diff_in_diff   4458.4      587.4   7.589 8.51e-12 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1605 on 117 degrees of freedom
## Multiple R-squared:  0.6682, Adjusted R-squared:  0.6597
## F-statistic: 78.54 on 3 and 117 DF,  p-value: < 2.2e-16
##
##
## $`Azerbaijan:1-Belarus:0`
##
## Call:
## lm(formula = n ~ time + lock + diff_in_diff, data = model_dat)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -4012.1  -408.8  -248.0   422.1  4928.0
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    7129.1      281.6   25.32   <2e-16 ***
## time          -6612.0      342.1  -19.33   <2e-16 ***
## lock          -5356.8      398.2  -13.45   <2e-16 ***
## diff_in_diff   5258.5      483.9   10.87   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1259 on 120 degrees of freedom
## Multiple R-squared:  0.7902, Adjusted R-squared:  0.785
## F-statistic: 150.7 on 3 and 120 DF,  p-value: < 2.2e-16
##
##
## $`Bosnia and Herzegovina:1-Belarus:0`
## NULL
##
## $`Kazakhstan:1-Belarus:0`
## NULL
##
## $`North Macedonia:1-Belarus:0`
## NULL
##
## $`Romania:1-Belarus:0`
```

```
##
## Call:
## lm(formula = n ~ time + lock + diff_in_diff, data = model_dat)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -4281.3  -714.2  -195.1   714.8  6080.7
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    5976.3      362.7  16.480   <2e-16 ***
## time          -5728.8      475.9 -12.037   <2e-16 ***
## lock            784.5      444.2   1.766    0.079 .
## diff_in_diff   -238.8      578.8  -0.413    0.680
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1849 on 190 degrees of freedom
## Multiple R-squared:  0.7148, Adjusted R-squared:  0.7103
## F-statistic: 158.7 on 3 and 190 DF,  p-value: < 2.2e-16
##
##
## $`Russia:1-Belarus:0`
##
## Call:
## lm(formula = n ~ time + lock + diff_in_diff, data = model_dat)
##
## Residuals:
##    Min     1Q Median     3Q    Max
## -30533  -2288   -409   1519  48928
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)      6928       2584   2.681  0.00802 **
## time            -6470       3178  -2.036  0.04321 *
## lock            36825       3165  11.634  < 2e-16 ***
## diff_in_diff   -34930       3892  -8.974 3.49e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 11840 on 182 degrees of freedom
## Multiple R-squared:  0.6868, Adjusted R-squared:  0.6816
## F-statistic:   133 on 3 and 182 DF,  p-value: < 2.2e-16
##
##
## $`Serbia:1-Belarus:0`
## NULL
##
## $`Turkey:1-Belarus:0`
## NULL
##
## $`Philippines:1-Indonesia:0`
##
## Call:
```

```
## lm(formula = n ~ time + lock + diff_in_diff, data = model_dat)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -1610.3  -318.1  -155.3   383.8  1973.7
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)   2864.29      94.66  30.258  < 2e-16 ***
## time         -2511.15     119.19 -21.069  < 2e-16 ***
## lock          -961.67     163.96  -5.865 1.98e-08 ***
## diff_in_diff   882.07     208.44   4.232 3.62e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 655.8 on 188 degrees of freedom
## Multiple R-squared:  0.7447, Adjusted R-squared:  0.7407
## F-statistic: 182.8 on 3 and 188 DF,  p-value: < 2.2e-16
##
##
## $`Korea, South:0-Japan:0`
## NULL
##
## $`New Zealand:1-Japan:0`
##
## Call:
## lm(formula = n ~ time + lock + diff_in_diff, data = model_dat)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -4934.5  -379.4   -66.9   278.3  5838.5
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    6833.5      296.9   23.02   <2e-16 ***
## time          -6419.8      344.6  -18.63   <2e-16 ***
## lock          -5478.4      419.8  -13.05   <2e-16 ***
## diff_in_diff   5535.4      521.2   10.62   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1484 on 152 degrees of freedom
## Multiple R-squared:  0.7127, Adjusted R-squared:  0.7071
## F-statistic: 125.7 on 3 and 152 DF,  p-value: < 2.2e-16
##
##
## $`Singapore:1-Japan:0`
##
## Call:
## lm(formula = n ~ time + lock + diff_in_diff, data = model_dat)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -4729.3  -569.6  -315.4   371.6  5091.7
```

```
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    9910.6      364.0  27.228  < 2e-16 ***
## time          -9056.0      391.1 -23.153  < 2e-16 ***
## lock          -2885.3      514.8  -5.605 7.11e-08 ***
## diff_in_diff   2460.1      552.5   4.453 1.43e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1312 on 193 degrees of freedom
## Multiple R-squared:  0.813,  Adjusted R-squared:  0.8101
## F-statistic: 279.7 on 3 and 193 DF,  p-value: < 2.2e-16
##
##
## $`Austria:1-Sweden:0`
##
## Call:
## lm(formula = n ~ time + lock + diff_in_diff, data = model_dat)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -3636.2 -1871.8    43.4  1249.2  5237.8
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    2876.8      206.6  13.926  < 2e-16 ***
## time          -2715.2      306.9  -8.848 7.94e-16 ***
## lock          10178.0      357.8  28.447  < 2e-16 ***
## diff_in_diff  -6591.4      561.5 -11.739  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1728 on 181 degrees of freedom
## Multiple R-squared:  0.8758, Adjusted R-squared:  0.8738
## F-statistic: 425.5 on 3 and 181 DF,  p-value: < 2.2e-16
##
##
## $`Belgium:1-Sweden:0`
##
## Call:
## lm(formula = n ~ time + lock + diff_in_diff, data = model_dat)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -3580.4 -1920.4    18.4  1773.6  5095.1
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    3017.8      241.8  12.480  < 2e-16 ***
## time          -2831.2      347.4  -8.149 1.68e-14 ***
## lock           9319.6      342.0  27.252  < 2e-16 ***
## diff_in_diff  -6253.3      489.4 -12.778  < 2e-16 ***
## ---
```

```
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1964 on 254 degrees of freedom
## Multiple R-squared:  0.8471, Adjusted R-squared:  0.8453
## F-statistic: 469.2 on 3 and 254 DF,  p-value: < 2.2e-16
##
##
## $`Croatia:1-Sweden:0`
## NULL
##
## $`Czechia:1-Sweden:0`
## NULL
##
## $`Denmark:1-Sweden:0`
## NULL
##
## $`Estonia:1-Sweden:0`
## NULL
##
## $`Finland:1-Sweden:0`
##
## Call:
## lm(formula = n ~ time + lock + diff_in_diff, data = model_dat)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -2862.38  -363.18   -35.69   727.72  1836.82
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)   3867.37     144.11  26.836   <2e-16 ***
## time         -3553.50     182.29 -19.494   <2e-16 ***
## lock            95.13     249.61   0.381    0.704
## diff_in_diff   254.18     312.12   0.814    0.416
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 998.4 on 192 degrees of freedom
## Multiple R-squared:  0.7416, Adjusted R-squared:  0.7376
## F-statistic: 183.7 on 3 and 192 DF,  p-value: < 2.2e-16
##
##
## $`France:1-Sweden:0`
##
## Call:
## lm(formula = n ~ time + lock + diff_in_diff, data = model_dat)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -15212.0  -5630.5   -158.5   2025.8  25643.1
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    2945.2      912.7   3.227  0.00139 **
```

```
## time          -2770.7     1333.1  -2.078  0.03853 *
## lock          47645.8     1290.8  36.913  < 2e-16 ***
## diff_in_diff -39629.3     1773.3 -22.348  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 7526 on 298 degrees of freedom
## Multiple R-squared:  0.8711, Adjusted R-squared:  0.8698
## F-statistic: 671.5 on 3 and 298 DF,  p-value: < 2.2e-16
##
##
## $`Germany:1-Sweden:0`
##
## Call:
## lm(formula = n ~ time + lock + diff_in_diff, data = model_dat)
##
## Residuals:
##    Min     1Q Median     3Q    Max
## -27646 -20046   -178   1513  81297
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)      3458       2933   1.179    0.239
## time            -3221       3911  -0.824    0.411
## lock           133988       4148  32.298   <2e-16 ***
## diff_in_diff  -112223       5249 -21.380   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 21950 on 312 degrees of freedom
## Multiple R-squared:  0.8335, Adjusted R-squared:  0.8319
## F-statistic: 520.6 on 3 and 312 DF,  p-value: < 2.2e-16
##
##
## $`Greece:1-Sweden:0`
##
## Call:
## lm(formula = n ~ time + lock + diff_in_diff, data = model_dat)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -2453.46  -221.08    81.86   312.92  1512.54
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    3458.5      137.6  25.128  < 2e-16 ***
## time          -3221.4      183.5 -17.554  < 2e-16 ***
## lock          -2255.2      238.4  -9.461  < 2e-16 ***
## diff_in_diff   2205.3      319.2   6.910 7.41e-11 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1030 on 187 degrees of freedom
## Multiple R-squared:  0.6604, Adjusted R-squared:  0.655
```

```
## F-statistic: 121.2 on 3 and 187 DF,  p-value: < 2.2e-16
##
##
## $`Hungary:1-Sweden:0`
##
## Call:
## lm(formula = n ~ time + lock + diff_in_diff, data = model_dat)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -2986.83  -225.61    44.58   335.58   979.17
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    3991.8      123.4   32.34   <2e-16 ***
## time          -3661.1      154.2  -23.74   <2e-16 ***
## lock          -3007.2      213.8  -14.07   <2e-16 ***
## diff_in_diff   2838.9      269.6   10.53   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 837.2 on 185 degrees of freedom
## Multiple R-squared:  0.7807, Adjusted R-squared:  0.7772
## F-statistic: 219.5 on 3 and 185 DF,  p-value: < 2.2e-16
##
##
## $`Iceland:1-Sweden:0`
## NULL
##
## $`Ireland:1-Sweden:0`
## NULL
##
## $`Italy:1-Sweden:0`
##
## Call:
## lm(formula = n ~ time + lock + diff_in_diff, data = model_dat)
##
## Residuals:
##    Min     1Q Median     3Q    Max
## -48272  -5702    -68   2506  55833
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)      2465       1949   1.265    0.207
## time            -2381       3324  -0.716    0.474
## lock            76262       2756  27.667   <2e-16 ***
## diff_in_diff   -68309       4308 -15.855   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 17860 on 294 degrees of freedom
## Multiple R-squared:  0.7823, Adjusted R-squared:  0.7801
## F-statistic: 352.2 on 3 and 294 DF,  p-value: < 2.2e-16
##
```

```
##
## $`Lithuania:1-Sweden:0`
## NULL
##
## $`Luxembourg:1-Sweden:0`
## NULL
##
## $`Poland:1-Sweden:0`
## NULL
##
## $`Portugal:1-Sweden:0`
## NULL
##
## $`Slovakia:1-Sweden:0`
## NULL
##
## $`Slovenia:1-Sweden:0`
## NULL
##
## $`Spain:1-Sweden:0`
##
## Call:
## lm(formula = n ~ time + lock + diff_in_diff, data = model_dat)
##
## Residuals:
##    Min     1Q Median     3Q    Max
## -44553  -7635   -123   2225  48316
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)      2746       2099   1.308    0.192
## time            -2607       3232  -0.807    0.420
## lock           112660       2969  37.949   <2e-16 ***
## diff_in_diff   -93611       4363 -21.457   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 18060 on 276 degrees of freedom
## Multiple R-squared:  0.8767, Adjusted R-squared:  0.8753
## F-statistic:   654 on 3 and 276 DF,  p-value: < 2.2e-16
##
##
## $`Switzerland:1-Sweden:0`
## NULL
```