COVID-19: Economic Impact

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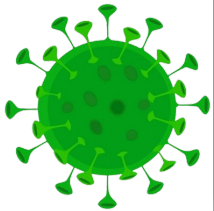
Fall 2025

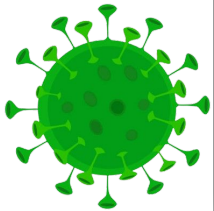
Background

- The COVID-19 pandemic resulted in 700 million cases worldwide, 7 million deaths, and global lockdowns and travel restrictions.
- Supply chains for necessities, including food and medical equipment, were halted, leading to price increases and shortages in hospitals.
- Beyond the disruption in health systems, the pandemic also triggered large-scale unemployment, GDP contraction (decline), and business shutdowns.



Significance

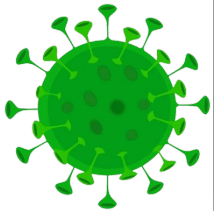
- COVID-19 led to one of the most significant economic downturns in world history.
- Understanding how different economic and policy factors shaped the world during this time is important for building resilience and guiding future crisis management.
- In this project, we will explore the long-term economic impacts of the COVID-19 pandemic across the world.



Data

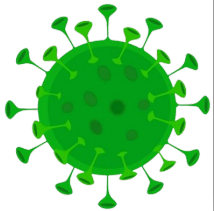
Datasets from WHO, World Bank, Our World in Data (9 in total)

- Predictors of interest:
  - Vaccination rates
  - Testing rates
  - Workplace closures
- COVID death rate & HDI are included as predictors to control for pandemic severity & economic similarity.
- Responses:
  - Gross Domestic Product (GDP)
  - Consumer Price Index (CPI)



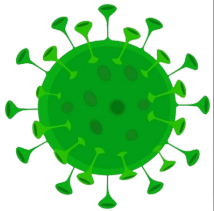
Data Cleaning

- Removed unneeded columns/rows
- Wide -> Long
- Standardized column names & formatting between files
- Added additional columns
  - % change in GDP & CPI
- Aggregated data into yearly averages
- Combined into a single CSV



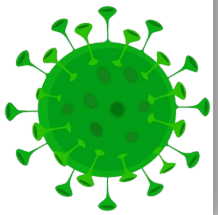
Research Objectives

- Assess the relationship between public-health interventions (vaccination, testing, workplace closures) and economic indicators (GDP growth and CPI changes) from 2019-2024
- Determine which COVID-19 response factors were most strongly associated with economic recovery
- Compare whether predictors (vaccination, restrictions, testing) had different economic effects across various regions

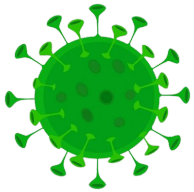


Expected Outcomes

- Countries with higher vaccination rates will experience faster GDP recovery, as vaccination can lead to earlier reopening and increased economic activity.
- Stricter workplace closures are associated with lower CPI growth because reduced business operations can slow down inflation.
- There will be regional differences, where economically vulnerable regions will show stronger sensitivity from CPI to vaccination, testing, and workplace closures.



Results



```
> # Regression: GDP
> model_gdp <- lm(GDP_growth ~ annual_vaccinations_per_million +
+                   annual_tests_per_thousand +
+                 .... [TRUNCATED]

> coeftest(model_gdp, vcov = vcovHC(model_gdp, type = "HC1"))

t test of coefficients:

                               Estimate  Std. Error t value  Pr(>|t|)
(Intercept)                  3.4002e+00  1.3079e+00  2.5997  0.009919 **
annual_vaccinations_per_million 7.2794e-06  1.2181e-06  5.9760 8.374e-09 ***
annual_tests_per_thousand      -1.7370e-04  2.1360e-04 -0.8132  0.416930
avg_workplace_closure           6.5074e-01  1.1886e+00  0.5475  0.584554
covid_deaths_per_million       -4.6758e-04  9.9689e-04 -0.4690  0.639475
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
> # Regression: CPI
> model_cpi <- lm(CPI_growth ~ annual_vaccinations_per_million +
+                   annual_tests_per_thousand +
+                 .... [TRUNCATED]

> coeftest(model_cpi, vcov = vcovHC(model_cpi, type = "HC1"))

t test of coefficients:

                               Estimate  Std. Error t value Pr(>|t|)
(Intercept)                  2.8854e+02  1.2453e+02  2.3171  0.02139 *
annual_vaccinations_per_million -1.9665e-04  1.4164e-04 -1.3884  0.16637
annual_tests_per_thousand     2.0422e-02  2.3035e-02  0.8866  0.37625
avg_workplace_closure        -1.3176e+02  6.4047e+01 -2.0572  0.04081 *
covid_deaths_per_million      1.7115e-02  6.5582e-02  0.2610  0.79435
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Comments:

- GDP Growth: positive coefficient (7.28% increase for every 1,000,000 vaccinations per million people) & small p-value for vaccinations, suggesting that countries that vaccinated more tend to recover faster economically from 2019-2024
    - Testing, workplace restrictions, and COVID deaths do not show a meaningful relationship
- CPI growth: negative coefficient (-0.0137) & small p-value, suggesting that stronger workplace closures are associated with lower CPI growth (slower price growth) from 2019-2024
    - Testing, vaccination, and COVID deaths do not show a meaningful relationship

Results

Selected countries in Africa (2020-2022)

```
t test of coefficients:

                                 Estimate  Std. Error  t value  Pr(>|t|)
(Intercept)                     8.1855e+01  1.2165e+01   6.7285 0.0067022 **
annual_vaccinations_per_million -1.2438e-04  1.5953e-05  -7.7967 0.0043913 **
annual_tests_per_thousand        1.6792e+00  5.2708e-02  31.8578 6.797e-05 ***
avg_workplace_closure           -3.9470e+01  5.1554e+00  -7.6560 0.0046282 **
covid_deaths_per_million        -6.6643e-01  3.1700e-02 -21.0227 0.0002354 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

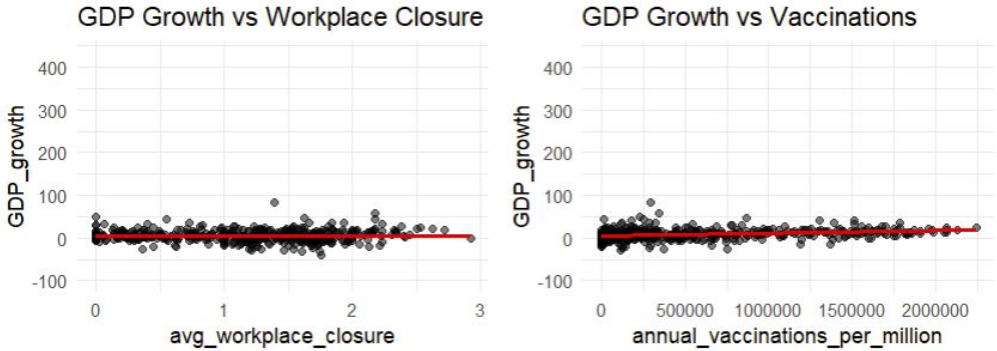
Selected countries in Asia (2020-2022)

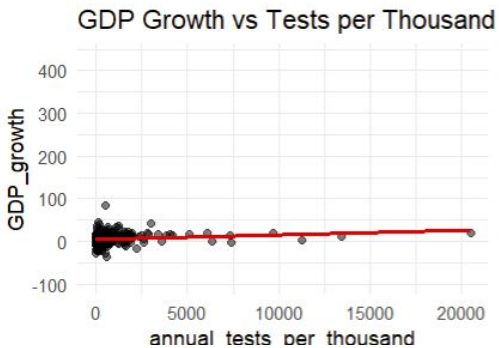
```
t test of coefficients:

                                 Estimate  Std. Error t value Pr(>|t|)
(Intercept)                     4.3146e+01  1.1798e+02  0.3657  0.72954
annual_vaccinations_per_million -2.6326e-04  1.7307e-04 -1.5211  0.18871
annual_tests_per_thousand        3.2505e-02  1.1827e-02  2.7484  0.04039 *
avg_workplace_closure           -1.0808e+01  4.3358e+01 -0.2493  0.81306
covid_deaths_per_million         6.6790e-01  4.5481e-01  1.4685  0.20189
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

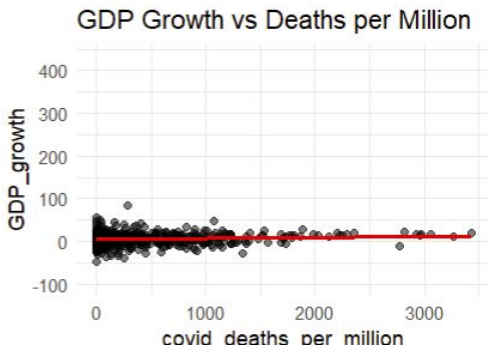
Comments:

- Africa: more testing leads to higher CPI growth, and more vaccinations, closures, and higher mortality leads to lower CPI growth
  - In Africa, we see that all of these predictors have a strong impact on inflation from 2020 to 2022
- Asia: more testing slightly leads to higher CPI growth
  - The other predictors are not statistically significant, suggesting that Asia’s economy is not as sensitive to changes in CPI compared to Asia

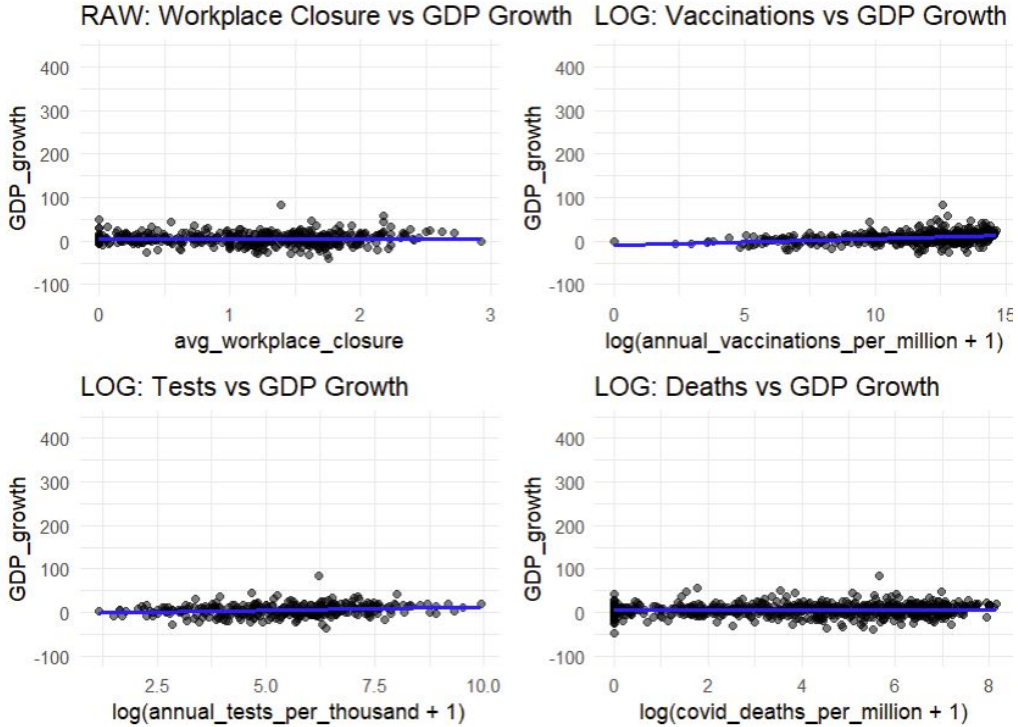
Results: Log Transformation



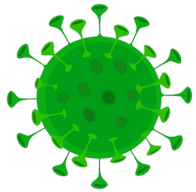




Results: Log Transformation

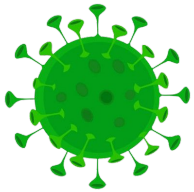


Results: Log Transformation (GDP)



```
Coefficients:
                                          Estimate Std. Error t value Pr(>|t|)
(Intercept)                               -9.3667     6.3155  -1.483   0.1394
avg_workplace_closure                      2.1217     1.0367   2.047   0.0418 *
log(annual_vaccinations_per_million + 1)   1.8058     0.2820   6.404 8.23e-10 ***
log(annual_tests_per_thousand + 1)         1.7610     0.7141   2.466   0.0144 *
log(covid_deaths_per_million + 1)         -0.3225     0.4975  -0.648   0.5175
human_development_index                  -18.5174     8.9491  -2.069   0.0396 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 10.33 on 234 degrees of freedom
  (14301 observations deleted due to missingness)
Multiple R-squared:  0.2456,    Adjusted R-squared:  0.2294
F-statistic: 15.23 on 5 and 234 DF,  p-value: 5.88e-13

> vif(model_1D_log)
                    avg_workplace_closure log(annual_vaccinations_per_million + 1)
                                 1.174715                                 1.142995
      log(annual_tests_per_thousand + 1)       log(covid_deaths_per_million + 1)
                                 2.988104                                 1.635674
                 human_development_index
                                 3.195857
```

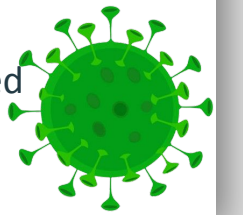
Results: Log Transformation (CPI)



```
                                    Estimate Std. Error t value Pr(>|t|)
(Intercept)                           41.354    559.637   0.074   0.9412
avg_workplace_closure               -158.443     90.958  -1.742   0.0829 .
log(annual_vaccinations_per_million + 1)   1.716     25.288   0.068   0.9460
log(annual_tests_per_thousand + 1)    -51.301     63.450  -0.809   0.4196
log(covid_deaths_per_million + 1)      -4.059     43.724  -0.093   0.9261
human_development_index               583.603    793.535   0.735   0.4628
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 899.4 on 227 degrees of freedom
  (14308 observations deleted due to missingness)
Multiple R-squared:  0.0234,    Adjusted R-squared:  0.001886
F-statistic: 1.088 on 5 and 227 DF,  p-value: 0.368

> vif(model_1D_CPI_log)
                  avg_workplace_closure log(annual_vaccinations_per_million + 1)
                               1.160946                                1.143667
     log(annual_tests_per_thousand + 1)       log(covid_deaths_per_million + 1)
                               3.037804                                1.619952
                 human_development_index
                               3.203018
```

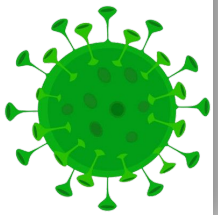
Analysis

- Countries with higher vaccination rates generally experienced faster GDP recovery, suggesting that widespread vaccination played a key role in reopening economies and restoring business activity.
- Only stronger workplace closure policies are associated with lower CPI growth, indicating that reduced consumer movement and business activity helped slow down inflation during the pandemic.
- Different regions witnessed different outcomes.
    - In Africa, most predictors—including vaccination, testing, mortality, and restrictions—had strong impacts on inflation.
    - In Asia, only testing rates had a mild effect on CPI (greater economic resilience).
- Log-transformed models show similar patterns, confirming that vaccination and workplace restrictions remain the main economic drivers even after adjusting for skewed data.



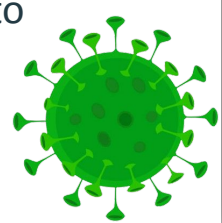
Conclusion

- Vaccination and testing rates are strong predictors of GDP recovery, suggesting that countries with better COVID control witnessed earlier economic recovery.
- CPI results show no significant predictors, which is consistent with ongoing research showing that inflation after COVID was primarily due to supply-chain disruptions, not domestic health policies.
- HDI shows a negative relationship with GDP growth, which correlates with what the world witnessed in 2020.
- Ultimately, while public health responses shaped GDP recovery, post-COVID inflation was due to other factors.



Limitations & Future Directions

- Many observations were dropped due to missing data, which is common in a global COVID dataset.
- Regional differences may be hidden in the global model when all countries are pooled together (as illustrated in the Africa and Asia example).
- One idea is to incorporate other global indicators (shipping costs, oil prices) that can explain inflation dynamics.
- One can further go in-depth with regional analysis. Use region-specific models to capture economic patterns that are hidden.



Thank you!