The Impact of COVID-19 Spread on GDP Growth in the United States

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1 Abstract

This paper investigates the impact of the spread of COVID-19 on GDP growth (Gross Domestic Product) in the United States, at the state level. It observed macroeconomic performance when the cases of COVID-19 are increasing. GDP growth is used to evaluate macroeconomic performance. The analysis will incorporate a multiple regression model with the following as the regressor: COVID-19 case counts, retail sales, unemployment rates, mobility, population. Each measure will be taking at a quarterly, or aggregates to quarterly frequency at state level. The study aims to isolate the direct impact of COVID-19 on GDP growth, while taking into account demographic and policy factors that contribute to virus spread and economic recession. The results are expected to provide information on the complex relationship between global pandemic and economic stability, provide recommendations on increase performance on future pandemic situation.

2 Introduction

The COVID-19 pandemic has caused an unprecedented economic disruptions across the United states, with all states various degrees of economic recession. During early stage of the pandemic, the increasing infection rates resulted in mandatory business closures, and rapid reduction in mobility. The economic impact of the COVID-19 pandemic is complex, stemming not only from the health impacts of the virus but also from government policy responses such as lockdown, social distancing, and unemployment. All of the above factor contributed to the GDP decline. Those challenges were further compounded with shifts in consumer behavior, and inflation.

Understanding the quantitative relationship between the spread of the COVID-19 and GDP fluctuations is critical for assessing the economic impact and guiding future epidemic responses. The study adopts a regression model to explore the quarterly changes in COVID-19 cases and impact of GDP growth across U.S. states.

By performing a multiply linear regression model, this research is focusing to describe the economic impact of increasing COVID-19 cases, by controlling various regressor on GDP. The result of the research are expected to gave reference on policymaking and balancing health

with economic stability in potential future pandemic crisis. The research should also offer a framework to better understand the trade-offs between pandemic control and economic stability.

3 Literature review

The COVID-19 pandemic has had a profound impact on the U.S. economy, with significant differences across states due to their policy responses and economic structures. Several studies have analyzed these effects, providing insights into the relationship between the pandemic and economic performance.

Chetty et al (2024) studied how the pandemic has affected consumer spending, corporate revenue, job postings, and employment rates across different demographics and regions. Find that high-income people cut back sharply on spending, especially in areas that require face-to-face interactions, leading to sharp declines in corporate revenue and employment in these industries. Meanwhile, *Walmsley et al (2020)* estimates that the net loss of U.S. GDP due to the coronavirus pandemic will be between $3.2 trillion and $4.8 trillion over two years. The study attributes these losses primarily to mandatory business closures and partial reopenings, which significantly reduced economic output.

Studies from the *International Monetary Fund (IMF) in 2020* and *Martin et al (2023)* have shown an increasing in COVID-19 cases lead to decline in economic activity.

Due to the lack of access into data with monthly frequency for Personal Consumption Expenditures (PCE), the model adopts retail sales as a replacement. During the pandemic, the volatility in retail sales highlights the consumer sector vulnerability to the spread of the virus and the policy response. Studies by *Dorfman (2022)* and *Garner et al (2022)* indicated a substantial decline in retail sales shifts the consumer taste, choosing over online shopping versus in person shopping. Thus, we can use retail sales as an important proxy for economic resilience during COVID-19.

One of the most direct measures of economic overall well-being is unemployment rate. In the reports by *Karabarbounis et al (2020)* and the *Bureau of Labor Statistics (BLS) (2022)* shown an sudden increase in unemployment rate after the lockdown and business closures, across states.

By including unemployment rate as a regressor, allows us to capture the response of Labor Market during the COVID-19 pandemic, indicates how job losses across sectors contributed to GDP decline.

Mobility tracked physical movement in key areas, such as workplaces, retail and recreation. Studies from *Dockerty et al (2021)* have indicated a correlation between mobility reduction and economic recession. State policies, such as lockdowns, significantly influence mobility patterns. Regions with stricter restrictions typically experience reduced mobility, which can limit economic output while mitigating the spread of COVID-19. Conversely, areas with more lenient policies often exhibit higher mobility, leading to increased economic activity but also a greater risk of COVID-19 transmission. Including this data allow us to underscore the trade-off between controlling virus spread versus economic performance.

Population is one of the most direct indicator of COVID-19 spread. Areas with higher population density typically experiences faster spread of the virus, *(Garner et al 2020)*. Faster spread areas often have more restrictions on government policies, resulting in reducing consumer and business activities. This makes it a key factor in our analysis on the economic performance, during pandemic.

Government response during COVID-19, includes mask mandates, business closure, and travel restrictions varies widely across states. Studies by *Zhou et al. (2022)*, explores the impact of the government response on pandemic control in the long run. Their research suggests that stricter public health policies would initially reduce GDP by restricting business operations and mobility, but in the long run could prevent severe economic losses by limiting the health crisis.

4 Data

The study utilizes state-level data from a range of sources to investigate the impact of the COVID-19 pandemic on GDP growth across the United States. To ensure consistency and capture the dynamic nature of the pandemic, all data are aggregated to a quarterly frequency for analysis.

COVID-19 case counts are sourced from the *Dartmouth Atlas Project*. These data are

reported daily at the county level. The data is aggregated to provide quarterly case counts across state. With the adoption of this comprehensive dataset, detailed insights into the spread of COVID-19 across state are provided, allowing for a robust assessment of its economic impacts. Gross Domestic Product (GDP) data, obtained from the *Bureau of Economic Analysis (BEA)*, are reported quarterly frequency. GDP data is the key indicator of macroeconomic performance measure, enabling comparisons across states.

To capture the consumer facing economic trends, retail sales data are derived from the *Census Bureau* and reported monthly. The dataset is aggregated to quarterly frequency. Retail sales reflects changes in consumer spending patterns, which are often influenced by mobility restrictions and public health concerns during the pandemic. *Bureau of Labor Statistics (BLS)* provides data on the unemployment rate, the dataset is also reported monthly and then aggregated to quarterly frequency. The dataset serves as a crucial measure regarding the health condition of labor market and the broader economic impact of COVID-19 disruptions.

Google Mobility Reports, offered insights on population movement. These data are reported daily and aggregated to quarterly frequency. This mobility data, provides the residential percent change from baseline. These data tracks mobility trends, offering an essential perspective on the relationship between state policies, mobility, and economic output.

Additionally, population data are included to control for demographic differences across states. This metric is provided by the *U.S. Census Bureau*. However, with the natural of population, one assumption made is population remains static over one year. Thus, population dataset is on a yearly basis. This variable provide context for interpreting differences in COVID-19 spread and economic impacts across states.

By combining the above data selection, enable a comprehensive analysis of COVID-19's effects on GDP growth. These dataset captures key dimensions of public health, economic activity, and demographic variation. Each data source is carefully chosen consider its relevance and reliability, contributing to a nuanced understanding of how COVID-19 influenced economic output at the state level.

5 Methodology

This research will be conducted using a multiple linear regression model, with panel data, state fixed effects and quarter fixed effect. The model is aiming to understand the impact of COVID-19 spread on GDP growth across the United States. The model will include retail sales as a direct measure of consumer demand, uses the unemployment rate as a indication of the status of labor market to observe the influence of inflation by related supply disruption during the pandemic. The model also incorporate additional factors, such as mobility data, population, provide insights into how each state reacted to the pandemic differently, to capture the regional differences in control COVID-19 spread, and economic recession. By adopting panel data, with state-level data overtime, we are able to control the confounder in our model. By imposing fixed effects, we are able to further eliminate selection bias. Details will be explained later in the section.

$$\begin{aligned}\text{GDP Growth}_{it} = \; & \beta_1 \text{COVID Cases}_{it} + \beta_2 \text{Population}_{it} \\ & + \beta_3 \text{Retail Sales}_{it} + \beta_5 \text{Mobility}_{it} \\ & + \beta_6 \text{Unemployment Rate}_{it} + \alpha_i + \lambda_t + \varepsilon_{it}. \end{aligned} \tag{1}$$

Equation (1) represents the regression model used to analyze the impact of COVID-19 on GDP growth across U.S. States. The dependent variable, GDP growth ($GDPGrowth_{it}$), measures the quarterly change in economic output for each state i in quarter t. The primary regressor (independent variable) is the COVID cases ($COVIDcase_{it}$), indicates the COVID-19 cases, in which we hypothesize to have a negative effect on GDP growth.

Other independent variables including in the model serves the rule of limiting omitted variable bias, in the attempt of getting more accurate results. Retail sales ($RetailSale_{it}$) are included as a proxy for consumer spending, reflecting economic activity at the consumer level. The unemployment rate ($UnemploymentRate_{it}$) serves as an indicator of the health of the labor market, capturing the effects of job losses during the pandemic. Mobility ($Mobility_{it}$) measures trends in consumer and business activity, predicts how movement restrictions and

behavioral changes influenced economy output. Population ($Population_{it}$) takes into account for differences in the potential rate of virus transmission across states.

The inclusion of state fixed effect (α_i) in the model controls for unobserved, time-invariant confounder that may differ across states and influence both the spread of COVID-19 and GDP growth. Potential confounders including state-level characteristics such as political policies, healthcare policies, industrial composition and baseline economic conditions, which are constant over time but vary across states. The inclusion of quarter fixed effect (λ_t) accounts for common shocks or trends over time, such as COVID-19 trends, nationwide pandemic development, federal policy changes, and seasonal economic cycles, ensuring these do not bias the results.

Including fixed effects is ideal for this study due to its ability on helping isolating the within-state variation over time, allowing for a more precise estimation of the relationship between COVID-19 spread and GDP growth. By imposing the fixed effects, controlling confounders, reduce the risk of omitted variable bias, ensuring that the estimated coefficients reflect the causal effect of the included independent variable rather than confounding factors. With the quarter fixed effect, we can account for COVID-19 type changes, vaccination rates, test rate, and further more shifts in consumer behavior. With both fixed effects, we can enhance the robustness of the model by addressing potential biases arising from unobserved variables, making the result more reliable and interpretable.

The Figure (1) below provide a graphical description of the causal relationship in the model.

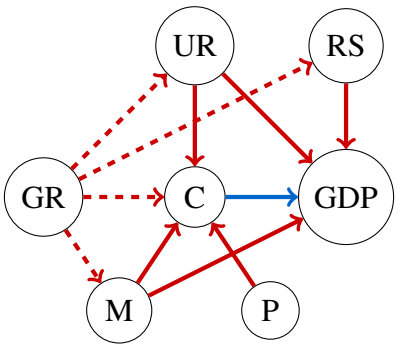

Figure 1: Causal relationship of the model

As indicated in the figure, we would expect the COVID-19 cases (C) have direct impact on GDP growth. Population (P) affects the COVID-19 case counts,people who live in a dense population area are more likely to get infected. Unemployment rate (U), retail sales (RS),

mobility (M) and Government response (GR) are the confounder in the model, which we expect to have impact on both COVID-19 Cases and GDP. We are able to control for mobility, unemployment rate and retail sales, since we have corresponding dataset on those variables, they are observed. However, government response is an unobserved variables, that needs some attention. We are able to shut down the backdoor path, that goes through government response, by controlling for mobility, unemployment rate and retail sales. Thus, even though government response is a unobserved variable, our model will remain unbiased.

6 Results

This section presents the findings of the regression analysis and discusses the relationship between COVID-19 cases and GDP growth across U.S. states from 2020 to 2022. The results are summarized in Tables (1) and (2). Table (1) provides descriptive statistics for the variables included in the analysis, while Table (2) presents the regression results from seven model specifications, each progressively incorporating additional controls and fixed effects to refine the estimation of the economic impact of COVID-19.

Variables	Mean	Standard Deviation	Source
GDP Growth	0.79	6.51	*Bureau of Economic Analysis (BEA)*
COVID Cases	6.79×10^7	1.13×10^8	*Dartmouth Atlas Project*
Population	6.52×10^6	7.34×10^6	*U.S. Census Bureau*
Retail Sales	10.30	15.49	*Census Bureau*
Mobility	5.45	3.36	*Google COVID-19 Community Mobility Reports*
Unemployment Rate	5.33	2.95	*Bureau of Labor Statistics (BLS)*

Table 1: Summary Statistics for Variables

The summary statistics in Table (1) provide an overview of the variables included in the analysis. The mean of GDP growth is 0.79, with a standard deviation of 6.51, implying substantial variability in economic performance during the studied time period. COVID-19 cases have a mean of approximately 67.9 million, but we log-transformed the cases for later analysis. However, standard deviation of 113 million is relatively high, reflecting the uneven spread of virus across states and time.

Population data show a mean of 6.52 million people per state, with less variability, but depends highly on the size of the state. Retail sales contains a mean of 10.30 with a relatively high standard deviation of 15.49, captures shifts in consumer spending patterns during the COVID-19 pandemic; those shifts might be influenced by lockdowns, shifting to online shopping, etc.

Mobility, measured as a percentage change from baseline, indicates a mean of 5.45 and a standard deviation of 3.36. This result suggesting a notable difference in movement patterns across state, due to different state policies, and varying level of restriction with public health measure. The average of unemployment rate is 5.33% , with s standard deviation of 2.95%, highlighting the challenges labor market face due to the pandemic.

Overall, table (1) highlight significant heterogeneity in many variables, indicates the quick change in the dynamics causing by COVID-19 pandemic. This variability underscores the important using a regression approach to disentangle the effects of COVID-19 cases from other confounding factors.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Log of Covid Cases	0.0689***	3.0630***	0.5628***	0.2811**	-0.0057	-0.3348**	0.0112
	(0.0044)	(0.1907)	(0.1475)	(0.1407)	(0.1694)	(0.1494)	(0.7461)
Log of Population		-3.3520***	-1.0531***	-0.5598***	-0.1637	115.25***	144.86***
		(0.2088)	(0.1712)	(0.1643)	(0.2136)	(20.894)	(23.822)
Log of Retail Sales			3.8476***	3.8320***	3.8820***	4.1089***	0.4501
			(0.3668)	(0.2587)	(0.2513)	(0.2688)	(0.3688)
Mobility				-0.5639***	-0.4464***	-0.4441***	0.0333
				(0.0602)	(0.0691)	(0.0614)	(0.1215)
Unemployment Rate					-0.3765***	-0.6001***	-1.2415***
					(0.1409)	(0.1602)	(0.3176)
State Fixed Effects	No	No	No	No	No	Yes	Yes
Quarter Fixed Effects	No	No	No	No	No	No	Yes

Table 2: Significant at 10% level, **: Significant at 5% level, ***: Significant at 1% level

The regression analysis result in Table (1) investigates the relationship between COVID-19 cases and GDP growth in U.S. states during the 2020-2022 time period. The log of COVID-19 cases serves as the primary independent variable. The coefficient shown a notable changes in magnitude, sign, and statistical significance across the seven regressions.

In the short regression, the coefficient of 0.0689 shows a statistically significant result of a 1% level. The short regression include no other additional control variables or fixed effects. This positive relationship between the log of COVID-19 cases and GDP growth is counterintuitive, as higher COVID-19 cases are generally expected to negatively impact GDP growth. Regression

(1) is a biased result, due to the lack of control variables, and also potential omitted variable bias.

As we kept adding addition variables, such as log of population, log of retail sales, and mobility, in regression (2), (3) and (4). Surprisingly the coefficient of COVID-19 cases remains positive, but decreases in magnitude. While the results are still statistically significant, these results suggest that much of the initially observed positive relationship is likely due to omitted variable bias in regression (1). The remaining positive coefficient could still reflect reverse causality or implies omitted variable bias is still a big problem of the model.

In regression (5), the coefficient switch from positive sign to negative, becoming -0.0057, when we included unemployment rate. However, the result is no longer statistical significant. This implies in earlier models, when unemployment rate is omitted, we are experiencing omitted variable bias. The unemployment rate can mediate the relationship between COVID-19 cases and GDP growth, since higher case counts leading to increased unemployment leading to reduced GDP Growth. Thus, when we put unemployment in our model, it can captures part of the negative economic impact associated with COVID-19 cases. This isolated the direct effect of COVID-19 cases on GDP growth, causing the coefficient to turn negative. Our regression model may also suffers from multicellularity, since COVID-19 cases and unemployment rates are likely correlated. This correlation between COVID-19 cases and unemployment might altar the distribution of variance among independent variables. By including the unemployment rate, it may also indirectly capture the effects of state-level policy response, however, with lack of state fixed effect, the power of that is limited.

In regression (6), we have a negative coefficient of -0.3348, it is a statistically significant result at 5% level. This indicating that an increase in COVID-19 cases causes the GDP decline 33%. This result is consistent with our hypothesize, and literature review. The inclusion of state fixed effects controls for time-invariant characteristics specific to each state. This shows a successful and accurate approximation of our model, since we have controlled for the different government policies or government culture varies by different states. By including the state fixed effect, likely eliminates upward bias from unobserved state-specific factors that could inflate the earlier coefficients.

In regression (7), when including both state fixed effects and quarter fixed effect, the coefficient turns positive at 0.0112 but statistically insignificant. The switching signs and statistically significance is likely caused by issue of multicellularity. The time fixed effects in this model, is likely controlling for the COVID-19 disease that changes over time, such as nationwide trends, vaccines, stimulus measures, and policy shifts. This is highly correlated with our primary independent variable, which is COVID-19 case count, thus creating an inaccurate model.

In conclusion, regression (6) captures a significant negative relationship between COVID-19 cases and GDP growth by including state fixed effects, regression (6) effectively controlled for unobserved state specific culture. Although in regression (7), we have added quarter fixed effect, it seems to be controlling broader dynamics, but at a risk of over-fitting and multicellularity. Thus regression (6) is the most accurate, interpretable and focused result we have.

7 Conclusion

This study investigated the impact of COVID-19 spread on GDP growth across U.S. states during the 2020-2022 period using a multiple regression model on panel data. The regression contains variables, including COVID-19 case counts, unemployment rate, mobility, retail sales, and population, while leveraging state and quarter fixed effects to control for unobserved characteristics. The key result shown when COVID-19 cases are rising, it has a negative impact on macroeconomic performance, leading to decline in GDP growth. This is significant particularly when we controlled for unemployment rate and impose the state fixed effect. Unemployment rate emerges as a critical driver of GDP fluctuation, underscoring the importance of labor market intervention during crises.

Despite those findings, several open questions remain. Future research could explore the role of government policy measures, including the impose of vaccination, number of stimulus check that were issued, in mitigating the economic impact of pandemic. In additionally to that, more focused data on industry specific response or state level healthcare expenditures might offer more observations into the interplay between public health and macroeconomic performance.

These open options for deeper investigation can further enhance our understanding of how to balance public health priorities with economic stability during future global crises.

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