Government Stringency on Covid-19 Fatality and Economic Recovery
——A Panel Data Regression Approach

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ABSTRACT
Since the beginning of 2020, there have been ongoing debates on the necessity of investing significant resources in governmental health intervention. However, many have questioned its economic cost could surpass the damage caused by the virus. This study aims to focus on the gap between the necessary government intervention and COVID-19 fatality. We implemented robust panel data on Organization for Economic Co-operation and Development (OECD) countries' data since early 2020 to interpret the significance of stringency index (a government-effort measuring index collected by the Oxford University), along with other vital health and economic indicator. This research's key results are the model and the economic interpretation of the significant difference between governmental effort and the number of COVID-19 deaths. Our result indicates a unit increase in stringency index would decrease the number of COVID-19 deaths per million by an estimate of 13. Noteworthy that this article aims to help officials recognize the understand the economic recovery from authority intervention.

Keywords: *Covid-19 fatality, Stringency index, Government intervention*

1. INTRODUCTION

The first case of Corona Virus disease (COVID-19) was detected in a province of China and is now one of the most severe pandemics in history. It has caused tens of millions of infections and millions of deaths globally. It has case fatality rates (CFRs) ranging from 0 to 8.91% in different global regions. The world's health and economy continued to suffer as the new delta variant spread. As of July 2021, the variant was found nearly twice as transmissible as the original SARS-CoV-2 train [1]. Many cities in the U.S., such as Boston, have renounced indoor mask mandates to prevent the spread of disease [2]. More than 80% of new COVID cases in the U.S. are reported to be the new variant. The situation continues to exacerbate in consideration of relatively low vaccinated rate in the U.S. (i.e., 52%) [3]. This situation has undoubtedly hit the economies of many countries, including the United States.

When the disease started to spread globally in 2020, many authorities underestimated the severity of the pandemic, resulting in an ignorant public health reaction toward the infection [4]. When the pandemic engulfed rapidly, many officials altered their initial views on the virus, but others were still less cautious about passing on the information. Some even belittled the importance of mask-wearing and social distancing [5]. Undoubtedly, effective and up-to-date official guidance is essential amid the unprecedented challenging situation. As a result, views have arisen on demanding a more significant government intervention to fight the pandemic, especially with the occurrence of the Delta variant [6].

The consequences of the global pandemic include economic, political, and social turbulence. Martinho et al. assessed COVID 19's severe negative impact on the economic convergence in countries of the OECD [7]. Natuhoyila et al. found discrepancies in the influence of COVID19 among different social classes in the Democratic Republic of the Congo. The result showed a more severe financial impact on the lower social class (farmers and blue-collar laborers) than on the higher class (lawyers and professors) [8]. Other economic indexes, such as oil price, have been thoroughly studied by Jawadi et al. revealed how volatile oil prices under the pandemic caused significant negative influence on the U.S. stock market and the U.S. dollar exchange rate [9].

On the other hand, economists found a country's COVID19 response capacity is not entirely associated with its economic development. Wu et al.'s research on 14 countries' medical resources investment and COVID 19 trends showed that even some developed courtiers had trouble mitigating the spread of the pandemic [10]. Wang et al. looked at the specific case of the U.S.'s performance in the pandemic and suggested the importance of earlier official intervention [11]. Additionally, the aging group is another concern of the pandemic victims. Tan et al.'s research on four countries suffering from the disease found a significant correlation between the infection and the aging population [12]. It is consistent with CDC's warning that higher risk for the severeness with COVID19 increase with age [13].

As one of the most severe viruses in the history of humankind, understanding death caused by COVID19 is also essential. Asfahan et al. researched several socio-economic and health indicators to explain the variation of case fatality rate among different countries, which consolidate those developing countries with a poor economy are especially vulnerable [14]. Additionally, the government ought to carefully consider the economic impact of lockdown and found a balanced time. Gupta and Zhu found that a lockdown in India decreased poor households' weekly income by NR 1,022 (US$ 13.5) in the following month, indicating the economic cost of mandatory quarantine [15]. Logically, a lockdown should be implemented when the cost of not doing so is higher. The research also consolidates a higher economic impact on poorer individuals.

Previous studies have extensively demonstrated that actively responding to pandemics at early stage could reduce the overall cost of financial and human resources. Pasquini-Descomps, Brender, and Maradan researched on the previous studies and concluded the high cost effectiveness of hospital quarantine, vaccination, and antiviral stockpile for pandemics [16]. By reacting quickly and effectively, the affected population could be limited, eventually decreasing COVID 19 mortality. However, there is a lack of in-depth understanding of how government interventions lower case fatality rates.

Besides, it is reasonable to expect the world may need to coexistent with Covid-19 in long term, so it is unreasonable to expect very strict anti-virus applications permanently. Huge burden on economic running may caused other serious social issues such as increasing unemployment rate and CPI.

The COVID19 dataset is from Our World in Data, containing up to 240 countries and 65 updated daily and weekly variables. Please be advised the date of data retrieval was August 20th, 2021.

Therefore, this study aims to focus on the gap between government intervention and COVID-19 case fatality. During the earlier stage, countries like Vietnam and Korea have effectively controlled the spread of disease with early stringency plans and mandatory quarantine. The question is to ask the necessity and level of extension to the official intervention. By implementing multivariate OLS and regression on government contingency rate against COVID-19 fatality, we can interpret the impact of governmental intervention in COVID-19. Also, we extracted vital health and economic indicators to understand the variation among death caused by the disease. Finally, this paper aims to help researchers and government officials understand the economic recovery and growth in this global pandemic.

2. METHOD

This study selected total deaths per million as the outcome variable to understand deaths caused by COVID. The chosen primary explanatory variable is the stringency index, developed by Oxford University to launch the score of government responses toward the pandemic [17]. The Oxford COVID-19 Government Response Tracker, known as the "Stringency Index" does not evaluate a country's response's effectiveness but provides a perspective to help researchers and officials compare responses and improve policymaking. Policy indices collected by Oxford University are the average of the individual component indicators, explained by equation 1. As described in equation (1) below, k is the number of component indicators in an index and I_j is the sub-index score for an individual indicator j. Oxford University chose nine indicators to calculate the stringency index. A detailed description of the component's indicators can be found in Table 1.

$$Index = \frac{1}{k}\sum_{j=1}^{k} I_j \qquad (1)$$

This study also acquired other controlled explanatory variables, including reproduction rate, new cases smoothed per million, total tests per thousand, population, population density, median age, population with age 70 and older, GDP per capita, extreme poverty, cardiovasc death rate, diabetes prevalence, female smokers, male smokers, hospital beds per thousand, life expectancy, human development index. Table 2 displays the explanation of all selected variables. The equation can be found in equation (2).

$$Y = \beta_0 + \beta_1 Stringency\ Index + \beta_2 Reproduction\ rate + \beta_3 New\ cases\ smoothed\ per\ million + \cdots + e$$
(2)

This study will use the panel regression model to get the coefficients of explanatory variables. Panel data is a combination of time series data (TSD) and cross-sectional data. The main advantage of panel regression compared with simple linear regression is that it can decrease the endogeneity caused by omitted variables to some extent and get a more valid regression result.

Table 1. Stringency index indicators

Indicator Name	Description	Measurement
School closing	Record closings of schools and universities	Ordinal scale + binary for geographic scope
Workplace closing	Record closings of workplaces	Ordinal scale + binary for geographic scope
Cancel public events	Record cancelling public events	Ordinal scale + binary for geographic scope
Restrictions on gatherings	Record the cut-off size for bans on gatherings	Ordinal scale + binary for geographic scope
Close public transport	Record closing of public transport	Ordinal scale + binary for geographic scope
Stay at home requirements	Record orders to "shelter-in- place" and otherwise confine to home	Ordinal scale + binary for geographic scope
Restrictions on internal movement	Record restrictions on internal movement	Ordinal scale + binary for geographic scope
International travel controls	Record restrictions on international travel	Ordinal scale
Public info campaigns	Record presence of public info campaigns	Ordinal scale + binary for geographic scope

Table 2. Description of variables

Variable	Description
reproduction rate	Real-time estimate of the effective reproduction rate (R) of COVID-19
new cases smoothed per million	New confirmed cases of COVID-19 (7-day smoothed) per 1,000,000 people
total tests per thousand	Total tests for COVID-19 per 1,000 people
population	Population in 2020
population density	Number of people divided by land area, measured in square kilometers in most recent available year
median age	Median age of the population, UN projection for 2020
population with age 70 and older	Share of the population that is 70 years and older in 2015
GDP per capita	Gross domestic product at purchasing power parity in most recent available year
extreme poverty	Share of the population living in extreme poverty in the most recent available year since 2010

cardiovasc death rate	Death rate from cardiovascular disease in 2017 (annual number of deaths per 100,000 people)
diabetes prevalence	Diabetes prevalence (% of population aged 20 to 79) in 2017
total smokers	Share of population who smoke, most recent available year
hospital beds per thousand	Hospital beds per 1,000 people in the most recent available year since 2010
life expectancy	Life expectancy at birth in 2019
human development index	A composite index measuring average achievement in three basic dimensions of human development—a long and healthy life, knowledge and a decent standard of living

3. RESULT

Table 3 presents the result. The regression result explains 36.5 per cent of the variation among the dataset and reaches a Chi-square goodness of fit of 755. Other findings show vital factors correlated with COVID-19 fatality cases, including reproduction rate, the share of smokers, and population density.

Another process this study implemented is checking a core assumption of multivariate regression: non or little multicollinearity among explanatory variables. A perfect linear relationship among the regressors will result in unstable standard errors for the coefficients and biased regression estimates. There are various ways to test multicollinearity. This study chose variance inflation factor (VIF) estimates for the advantage to perform well on a large number of independent variables. It tests how much the variance of a regression coefficient is inflated due to multicollinearity in the model. As shown in Table 4, the VIF diagnosis result is acceptable (VIF<5), indicating our regression does not suffer from a severe multicollinearity issue.

Table 3. Regression result

Total deaths per million	Coef.	St.Err	t-value	p-value	Sig.
Stringency index	-13.506	3.277	-4.12	0.000	***
Reproduction rate	-528.465	118.462	-4.46	0.000	***
New cases smoothed per million	0.816	0.175	4.67	0.000	***
Total tests per thousand	0.128	0.089	1.45	0.148	
Population	0.000	0.000	1.04	0.298	
Population density	2.242	0.600	3.74	0.000	***
Aged 70 older	53.923	17.485	3.08	0.002	***
Gdp per capita	-0.001	0.002	-0.56	0.576	
Extreme poverty	189.145	56.491	3.35	0.001	***
Diabetes prevalence	23.369	31.130	0.75	0.453	
total smoker	27.664	6.454	4.29	0.000	***
Hospital beds per thousand	-146.732	37.070	-3.96	0.000	***
Life expectancy	-29.889	29.433	-1.01	0.310	
cons	3116.001	2302.954	1.35	0.176	

Mean dependent var	720.822	SD dependent var	663.222
Overall r-squared	0.365	Number of obs	9211.000
Chi-square	755.617	Prob > chi2	0.000

R-squared within	0.252	R-squared between	0.631
*** p<0.01, ** p<0.05, * p<0.1			

Table 4. Variance inflation factor estimation result

Variable	VIF	1/VIF
diabetes prevalence	3.22	0.310249
GDP per capita	2.86	0.349253
hospital beds per thousand	2.64	0.379031
population with age 70 and older	2.50	0.399847
life expectancy	2.19	0.457389
population density	2.08	0.479802
extreme poverty	2.04	0.491311
Population	2.00	0.500413
Total smoker	1.83	0.545244
Stringency index	1.48	0.676200

4. DISCUSSION

The coefficient of the stringency index is significantly negative on the outcome variable. This result is consistent with the expectation that the stringency index significantly impacts the decrease of fatality related to COVID-19. Current researches show that the virus is mainly transmitted by air droplets, while the virus can survive in the environment for more than 48 hours under suitable conditions [12]. There are many cases reported in different regions that people are infected just by exposure in the infecting environment, such as public facilities. Facing this cunning virus, wearing a facemask, keeping social distance and washing hands with disinfectant frequently are practical applications to cut down the spread ways of the virus. Research also indicates that the overall death rate of COVID-19 infected persons is down to 2.2% if the patients can get timely treatment. This number is relatively low compared with SARS and MERS [12].

However, empirical study has shown that if the patients cannot get timely treatment, then the symptom of them will deteriorate to severe very quickly, under this condition, the death rate will be as high as 60%-80% [12]. However, twice transmissible as the original SARS-CoV-2 train, the new Delta variant may cause a surging number of infectors rushing to hospitals to seek treatment in a short time. Since the medical resources of a country are not infinite, especially in many developing countries, the consequence of medical supply shortage can be very dangerous. Hospital per bed is an additional key regressor to explain the death variation. While holding all else constant, it has a negative 146.732 coefficient toward COVID-19 death per million. If so many infectors exceed the maximum carrying capacity of the medical system, then "medical resources panic squeeze" will emerge [10]. The situation will exacerbate as patients cannot get proper treatment and suffer from severe symptoms. A similar situation happened in India in 2021 and caused millions of casualties [10].

According to the most updated data, there are 163,569 reported new cases and 3,364 death cases on September 9, 2021. Facing the COVID-19 disaster, each country's government has invested enormous resources to fight the virus, but the result is mainly varied among different countries. China was the first country to report a COVID-19 infected case in the winter of 2019. Now it has been reported with successful results in terms of controlling the disease. However, recent data shows that newly reported cases in China mainly come from overseas travelers [11]. Whereas some other regions with the more advanced public medical system still found themselves trapped in the pandemic. This study aims to elaborate on the potential reasons behind such discrepancies. In China, when the first case was detected and reported in Wuhan, the whole city was under lockdown for 76 days. With authority announced public emergency and strict anti-virus stringency, the nation reacted quickly and effectively. After initial surging cases, the number of reported new cases decreased sharply three months later, and the infection curve was flatted in mid-2020 [11].

The overall anti-virus performance of the western countries was unsatisfactory. Wu, Dong, et al. used data on medical resource inputs and deaths rate from COVID-19 outbreaks in 14 countries to analyze the anti-epidemic effects of 14 countries based on the DEA (Input and Output) model. The study found that China's anti-pandemic result is even better than some developed countries. Furthermore, the allocation efficiency of medical resources in Asian countries was relatively more successful, which shows the public might demand a strong authority when quick decisions are needed in the pandemic [10].

Furthermore, the number of people in a population who an individual can infect at any specific time is timely dynamic. The index can be quantified as the effective reproduction rate of COVID-19. As more patients are vaccinated, infected, or died from the pandemic, the total population is overall less vulnerable, leading to a lower reproduction rate value. Our finding estimates that one unit increase in the reproduction rate would decrease death number smoothed per million by 528.465, holding all else constant. Table 5 shows that all countries started with high reproduction rates but continue to reduce the value. This is consistent with the gradually increasing number of fatality cases throughout the outbreak. Individual behaviour, such as social distancing, can also affect the rate. More and more people voluntarily self-quarantine and maintain social distancing, leads to a lower reproduction rate [18].

Another vital result from the result is the population density. The analysis research by Wong et al. shows that although population density was insignificant in the U.S. during the early stage of the COVID-19 outbreak, it became a pregnant explanatory variable to explain the total infected cases as the disease engulfs across the country [19]. Our result indicates an additional resident in one square kilometer would increase an estimated 2.24 deaths cases per million, holding all else constant. In addition, places with more people result in a shorter average distance between each other and contribute to the spread of the virus. Therefore, population density may appear to be insignificant at the early stage but, in fact, essential to consider when measuring a location's vulnerability during the outbreaks.

This study also confirmed the research by Gülsen et al. about the impact of smoking on a higher risk of severe COVID‐19. Based on 32,849 in-hospital covid patients, Gülsen et al. reported that patients with a smoking history had a significantly increased risk of severe and critical COVID‐19 symptoms and in‐hospital mortality [20]. Similarly, WHO reported smoking tobacco would harm lung capacity and leads to more severe respiratory infections disease. Since the main symptom of COVID-19 is lung dysfunction, people with a smoking history would face more serious results if the virus infected them. Our study found one per cent increase in the share of the smoking population would have an estimated 27.664 increase in the number of COVID 19 deaths smoothed per million.

5. CONCLUSION

This research uses a panel data regression model to study the relationship between death rate and stringency index in the COVID-19 pandemic. The research finds a significant negative relationship between stringency index and fatality caused by COVID-19, which means it is safe to say strict stringency measures are an effective way to reduce the number of death cases in this global pandemic. The research also finds a significant positive relationship existed between the death rate and the proportion of smoking people, which indicates smoking can harm the lungs of patients, making them more vulnerable to the virus. Besides, the research comfirmed a significant negative relationship between the death rate and the number of hospital beds per thousand people, which means the scarcity of medical resources can increase the death rate of COVID-19. However, strict stringency could cause a slow recovery in economy. Therefore, besides strict stringency measures, investing more resources in the medical system such as training more doctors and nurses and building more hospitals is another important way to control the death rate of COVID-19. Alongside this, the "medical resources panic squeeze" is a real story. If the number of infectors covered the maximum carrying capacity of the medical system, it would lead to very severe casualties. For further research, it is necessary to investigate whether there are regional differences as for the effect of the same stringency measures and the reasons behind these differences. It is also necessary to find out among different stringency measures which one has the best result. It is essential to reduce the cost of stringency measures as much as possible. What's more, with the widespread injection of the COVID-19 vaccine on the global scale, it is vital to investigate the true effect of the vaccine on reducing the infection and death rate of the virus, especially for new variant.

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