Analysis of the Effectiveness of COVID-19 Response Policies

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Abstract

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Objective: To analyze the variations in COVID-19 control outcomes and understand what factors contribute to such disparities in eight different Asian countries/regions: Beijing, Henan Province, Guangdong Province, Zhejiang Province, Hong Kong, Taiwan, South Korea, and Singapore.

Study Design: This study first utilizes a comprehensive literature review to summarize the current sentiments and scholarly comments about the COVID policy response. Then the study proposes five different hypotheses to explain the differences in outcomes. Finally, the study implements both quantitative and qualitative analyses to validate the proposed hypotheses.

Data and Methods: This research relies heavily on both primary and secondary data collection. Primary data centers around the policy collection and secondary data focus on outcome-related variables. Then a correlation analysis and regression models are provided with different variations of the input and output variables.

Results: Strength of the economy, experiences dealing with past pandemics, and timeliness of response are the three most important factors influencing the effectiveness of COVID responses.

Conclusion and Relevance: These findings suggest that to have effective control of infectious disease outbreaks, it’s important to react early. Regions with more experience should be more careful about future disease outbreaks as they may be more susceptible to transmission in general. Future studies should focus on discovering more details about different local-level policies and expand the regions of comparison to a larger context.

Keywords
COVID-19, policy, pandemics, effective control, institutional learnings

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ANALYSIS OF THE EFFECTIVENESS OF COVID-19 RESPONSE POLICIES

By

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1. INTRODUCTION

On the 31st December 2019, the World Health Organization China Country Office was informed of cases of pneumonia of unknown etiology in Wuhan City, Hubei Province, China (Imai et al 2020). On January 30th, 2020, the WHO Director-General declared the novel coronavirus (COVID-19) outbreak a public health emergency of international concern (WHO official website). This is perhaps the most severe public health alert that the world has faced since severe acute respiratory syndrome (SARS). Until November 8th, 2020, there have been a total of 49,578,590 confirmed cases of COVID-19 globally, including 1,245,717 deaths (WHO official website). The sheer number of infected people is significant, let alone the fallout effects of COVID-19 on the world’s economy, countries’ health care systems and capacity, and the normal operations of many nations.

Having immediate and effective policy response is crucial to contain the spread of the diseases and to minimize public health risks. The risk of infectious diseases recurring and spreading is high, especially in today’s interconnected world, and requires national and international public health authorities to take rapid and decisive steps towards containment (Ahmed et al 2009). Every new and unknown infectious disease is challenging, as it questions the ability of relevant agencies to take the most optimal and effective actions to minimize the risks of infection and transmission. Slow reaction to new emerging diseases may lead to devastated consequences as many infectious diseases grow exponentially. In the case of COVID-19, People’s Republic of China (PRC) government has been criticized of its initial slow and chaotic policy responses, which many believed exacerbated the national spread (Mei 2020). Nevertheless, the author recognizes the barriers to provide the most optimal policy responses immediately, given that very little information is known at the beginning phase. There are two potential reasons for
the lack of information. One is the lack of scientific understanding of the disease when the outbreak started. The other is the fact that some governments may try to cover some important information.

This study aims to analyze what factors are correlated with the effectiveness of government response policies in coping with COVID-19 pandemic and provide viable policy recommendations to prepare for any potential future disease outbreaks. Specifically, this study is going to compare and contrast the COVID-19 responses in different regions in Asia, namely Beijing, Henan Province, Guangdong Province, Zhejiang Province, Hong Kong, Taiwan, South Korea, and Singapore.

1.1 Problem Statement

This study aims to analyze the variations of how COVID-19 outbreak is treated in several different countries and regions in Asia. First, the author will establish the criteria to describe and evaluate the effectiveness of the COVID containment. In other words, the author will use metrics to explain whether the government policies were effective at containing the spread of COVID-19 within the region. The metrics include the growth rate of cases in different regions, the population adjusted growth rate of the cases in these regions, and the death rate per case identified. After establishing which regions are more or less effective in their COVID policy responses, this research then explores the key question of what factors contribute to the disparities in outcomes of combatting COVID-19 in these countries and regions. COVID-19 policies include both macro-level and micro-level ones. Macro-level policies refer to the national or state level stay-at-home orders, contact tracing requirements, travel restrictions between different cities/countries, and official quarantine rules. Micro-level policies incorporate specific hospital rules about what types of people could be tested and whether the resident communities have limitations on the number of times each person can go out every day. Beyond looking at what policies were in place, this study
also records when relevant policies were implemented in each area as a measure of the “timeliness” aspect of the research.

Upon understanding the outcomes of the COVID-19 response policies and what kinds of policies were in place during the time, the key question of this study is to find what factors are correlated with the success of failure of an effective outcome. Namely, what are the predictors for whether a country or a region can be relatively successful in containing the spread of COVID-19. 

*Would it merely be what kinds of policies implemented in these regions, or how early the polices were introduced? Or would there be additional factors that can influence the disparities in the outcomes we observed?* To successfully dissect the correlated factors, the author needs to control for many heterogeneity aspects of the policy data. As such, the author chooses to limit the regions and timeframes of the analysis, with rationale explained below.

There are two main reasons to focus on Asia for this analysis. First, most Asian countries’ experiences with COVID-19 were characterized as exogenous shocks because none of regions anticipated what was coming. Comparing to countries on other continents, the first cases in the regions of interests appeared almost two months earlier. During the first two months, very little information was gathered regarding the disease and hence leading to a complete shock for the government institutions. For countries that were affected later on, the local health authorities and policymakers were more aware of the potential challenges and had more time to prepare for it. The reason to not compare with New Zealand, which is deemed to have an extremely effective policy response, comes from similar consideration. Even though New Zealand is recognized to have better outcomes than almost all countries in the world, given that COVID-19 was spread very late to New Zealand and its geographical remoteness from other regions, it does not serve as a good comparator. Second, these regions have some similar characteristics that reduce the overall
confounding heterogeneity. These regions experienced the first imported case of COVID-19 at almost the same time and have mostly approached an end of the first wave of the disease outbreak by mid-May. This makes these places comparable on the time scale and also allows for the outcomes of COVID control to be observed. Additionally, these regions have relatively denser populations compared to the world and are considered to be transportation hubs within Asia. Hence, by limiting the analysis to Beijing, Henan Province, Guangdong Province, Zhejiang Province, Hong Kong, Taiwan, South Korea, and Singapore, the author strives to minimize the confounding heterogeneity between regions in order to maximize the power of analysis.

The timeframe of the study is limited between the start of the first identified cases in these regions to mid-May. The deliberate choice to focus only on the policy responses during the initial wave is based on three considerations. First, COVID-19 came as a shock to the world before the “initial wave”. The governments had much more information about COVID when the second wave came in some regions and their responses were quite different than the initial wave period. Hence, the responses coming from different government back then were more representative of their behaviors for future pandemics. Second, as COVID-19 continues to affect the countries of study and many new policies are being implemented continuously, the later results may incorporate effects from the earlier policies and the later policies. Focusing on the first-wave period ensures that the outcomes of COVID control were of those initial policies. In the regions of study, mid-May is identified as the ending period of the “first wave” because the number of newly identified cases was stabilized, some even went close to zero for these regions. Therefore, using mid-May as the ending point effectively summarizes the policy effects from the first stage of the disease. Lastly, on the practical realm, the data appears to be more readily available for the initial period of the outbreak. Some later policies have yet to demonstrate its effectiveness or lack of. Focusing on the
initial period where the effectiveness can be measured and quantified reliably enhances the validity of this research.

1.2 Motivations

This study provides its value added to the scholarly field of policy analysis and COVID academic research from multiple aspects. It’s important for the government to reflect on their policies after crisis, and few seem to be done in the past. Learning from COVID-19 policy responses and foster institutional changes in the future can provide prolonged benefits. If we understand what worked effectively to contain the spread and transmission of the infectious diseases on the policy level, countries may be able to better prepare and respond to any future disease outbreaks. There are three main underlying motivations.

To start, many related policy analyses have focused on a single area. Most of the studies provide a comprehensive description of what was done in the specific areas and the results of those policies. Specifically, many research articles regarding the contact tracing, quarantine measures, and early detection have been developed in South Korea, Hong Kong, Singapore, and Taiwan. These studies have not taken into account of the counterfactuals (i.e., what would have happened if such policies were not in place) or lateral comparisons to other regions. A lateral comparison of these regions can explain explicitly what policies were unique to these regions and whether those unique policies contribute to the outcomes of COVID control, hence serving as the counterfactuals from regions to regions. Even though the comparison may be challenged by the heterogeneity of the research subjects and lack of counterfactuals in many cases, a comparative study is informative as it can use each region in the study as a counterfactual of another to tell a compelling story. This study, therefore, aims to summarize the different policies in the aforementioned regions and focus
specifically on the unique policies in each region and elucidate whether that has an effect on the overall COVID response.

Second, many scholarly articles treat the effectiveness of COVID response in China as a wholistic entity. However, the author disagrees with this general approach and argues that provincial differentiation existed for both the policy implementation and the effectiveness of COVID response. Beyond national orders, various policies were in place on the provincial level. As Mei (2020) noted in the research, some provinces responded more effectively than others and there could be reasons such as prior experiences dealing with infectious diseases, or the differences in community-based responses. Furthermore, different provinces in China were faced with different conditions at the start and it’s worth exploring whether these differences led to the varying outcomes. Examples of such differences include the distance between and travel frequency to the hotspot Wuhan, Hubei, the level of economic development and health care capacities, and the awareness of infectious diseases and trust in the government.

Additionally, it still appears to be the trend that the focus of COVID-19 research is on the medical and scientific underpinnings, especially in the first few months. While it is undoubtedly important to focus on the treatment and preventions from the scientific perspective, the author argues that more attention should be given to how global health care crisis can be managed at the political and social level. In today’s interconnected world, any infectious disease is destructive, and a successful containment and elimination is only possible through international collaboration. It is important to understand whether the government has taken the right actions, and it is more important to understand it in a prompt manner. Unfortunately, most policy analyses only came out years after the actual crisis, making it difficult for the government to adjust quickly. Taken the examples of SARS and Ebola, most evaluation of government policies only came out more than
five years after the original outbreak, which greatly reduces the ability for the administrative institutions to receive immediate feedback on the effectiveness of the policies or adjust accordingly. By pushing more immediate attentions on the policy responses after disease outbreaks, the author encourages the academic community to respond more quickly for future crisis management policies and provide more immediate assessment to authorities. Especially given that COVID is rapidly evolving, the prompt assessment of current government policies is more crucial.

The author firmly argues that institutional changes need to be in place to minimize the consequences of any infectious disease outbreaks. Unfortunately, there hasn’t been a lot of institutional learnings from past pandemics such as SARS or Ebola. Some countries and regions seemed to repeat the same mistakes this time as the ones they made from dealing with other pandemics. For example, the governments tried to hide the fact of an infectious disease outbreak at the beginning phases. Ahmed et al (2009) criticized the lack of response and the deliberate hiding of information from the public for the SARS outbreak in 2003. Similar issues have been observed by the author that at the beginning of COVID outbreak, the government initially also tried to lower the attention on the disease. The People’s Republic of China (PRC) government seems to have repeated the mistake of initial denial. The initial denial for SARS has been shown by multiple authors, including Ahmed et al (2009), Schwartz & Evans (2007), and Dan et al (2009) to lead to a faster spread of the disease and a worse containment result. The results of the initial denial for COVID-19 have yet to be shown by the academic community, but the general sentiments have been negative as well. Additionally, both pandemics revealed the lack of appropriate health care facilities to isolate and treat infected patients. As a result, the governments have to build the Fangcang hospitals, which will be explained further in the Literature Review section, in order to handle the increasing capacity.
These two repeated actions observed in both SARS and COVID have demonstrated the lack of institutional learnings from past mistakes. The author believes that an effective institutional change should include devising new guidelines in terms of preventing and dealing with disease outbreaks and/or improving the current health care system to better prepare for the worst-case scenario. By conducting a comparative study to thoroughly evaluate the effectiveness of COVID response policies, the author aims to bring attentions to the current COVID policies in multiple regions and foster such institutional changes, which leads to the policy implications of this research.

1.3 Significance and Policy Implications

The primary targeted audiences of this thesis research are the policymakers and health care authorities. In order to foster institutional learnings, it is important that the message from this research can be passed on the government. It’s especially important that this information can be shared with countries and regions that are analyzed in this research. The analyses below provide a direct evaluation of the effectiveness of their COVID-19 policy response and should alert different government bodies about their performances. Given that many of the regions studied in this research are neighboring regions, it can be even more important to learn about what policies were effective for others and try to adapt to future policy changes. For other political entities, even though their policies were not directly evaluated, they should still strive to understand the findings and conclusions of this research to identify similarities and differences in their own policy response. If they see similar mistakes, either by implementing a less effective policy or the lack of an effective policy, they may be able to avoid making similar mistakes by correcting their policy responses. In terms of the health care authorities, it is important that the methods of study and conclusions to be recognized by the academia. Since this research expects to draw more attention
on the policy research about health care crisis, having the academic community access the information and conclusion in this research can be a crucial first step. If the scholarly field identifies the unique value added of a comparative policy study for COVID-19, it is the author’s hope that more researches will be initiated, potentially focusing on different regions of analysis. Additionally, this research can serve as a supplementary material for other published studies that only focus on one region of analysis. The lateral comparisons in this research can draw even further insights in their specific regions. By informing the policymakers and academic community, this research ultimately aims to draw more attention on the prompt analysis of government policies for emerging health care crisis. If countries and regions can pay close attention to their current behaviors and learn from past mistakes, it is expected that they will come up with better coping strategies and be more prepared for future health care emergencies.

However, this research should not be exclusive to the primary audiences. Since COVID-19 affects every individual’s life from multiple aspects, it is important that this research is accessible and understandable to anyone interested in learning about COVID-19 policy responses. After reading this research paper, audiences should have a general grasp of policies in their local areas and make preliminary judgments about the effectiveness of their local policies. The effectiveness of any policy is influenced by the willingness of the general public to comply and their sentiments towards the policy. Most people are probably familiar with their some of their local policies, providing a wholistic picture of the policies can further their understanding and letting them reflect on their sentiments towards the policy responses. Furthermore, learning about policies in other geopolitical areas may even stimulate their thinking about what could have been effective to implement in their region. Under the best-case scenario, this research may ultimately inspire grassroot movements from the general public to request modifications in their local policies,
leading to a collective action from the public and the government to optimize the policy responses for COVID and any future pandemics.

As mentioned before, the promptness of this policy research demonstrates its value added. While most other pandemics response policy are generally produced at least five years after the crisis, this paper aims to provide the analysis within a year. As COVID-19 is still an ongoing threat in the world, a comprehensive understanding of the policy responses during the initial waves of the pandemics can shed light on how to proceed forward. Although more comprehensive and accurate data will only be available years after the crisis, it is critical to provide such interim reports that provide insights into the preliminary effectiveness and can inform changes to be adopted in the current policies. Up to date, most regions of study in this research has faced a much better condition compared to where they started, the author believes that there are places to optimize the responses even further.

Of course, this research may not be the only one addressing the effectiveness of COVID policy responses. Many more similar studies are expected to be published especially in the next few years. It will be worthwhile for the scholarly field to compare and contrast the results from similar research to see if there are common grounds or stark contrast in the conclusions. If some aspects are generally agreed upon in several different research, it might be an important area for the political entities to start reflecting on. On the other hand, if the scholarly field disagrees on some aspects of the effectiveness of response, it will engender further discussions and more academic research to dissect the underlying reasons. As scholarly efforts are built upon one another, this study may be the one to open up the communication in the health care management space about evaluating government performances in COVID-19 response.
A comparative study on the effectiveness of COVID response polices is critical in the realm of COVID academic research. For policymakers, it provides a prompt interim analysis on their performances and helps them to adjust and adapt to new policies if necessary. For the academic filed, it opens up the discussion earlier for policy analyses, with the hope to motivate more similar research in the field. For the general public, it serves as a background overview of their local policies and helps them reflect on their experiences and sentiments. Combining different aspects, this research ultimately hopes to foster the institutional changes in the future, so that the world can be better prepared for future pandemics and any health care crisis.

2. LITERATURE REVIEW

Given that this research is a timely analysis of the COVID policy responses, there hasn’t been much comprehensive literature in the related academic filed at the beginning. As time progresses, more relevant research have been published during the interim of this study and the author has actively incorporated them into the section below. Most of the newly published articles only focus on one country or region for the policy response. Therefore, the author also chose to focus more broadly on the analyses of policy responses for past pandemics such as SARS or MERS. To gain insights from the current field of study and to critically analyze the drawbacks of current academic studies, the literature review section is going to focus on three key areas.

First, the author is going to provide an overview of the past analyses on pandemic responses of the relevant countries and regions of study. There are three main purpose for this section. Firstly, it is worth exploring how were these regions dealing with similar health crisis in the past and how well did they response. This will not only summarize whether these regions have prior experiences of dealing with rapidly evolving health crisis, but also provide some preliminary insights into how
effective these regions used to be in infectious outbreak containment. Second, it will be interesting to compare the effectiveness of past responses to the results from this paper (i.e. effectiveness of current response policies for COVID). Based on whether the results are similar or drastically different, different policy suggestions can be provided to the local governments to better prevent future crisis. By comparing to the policies and effectiveness of policy responses to the past, the author also hopes to understand whether some of these regions learned from their past mistakes dealing with other pandemics and apply the strategic changes to combatting COVID. Third, these past literatures may provide more insights on how to properly choose the metrics to represent the effectiveness of government response policy for pandemics. Even though the author may not directly adopt the entire methodology from any of the past study, these metrics serve as a foundation for the author’s understanding of the academic field and guide the metrics of measurements that is presented later in the paper.

Then, the author is going to explore the newly published articles in the relevant academic field until the end of October. As mentioned before, the newly published articles focus mostly on one single country or region, but they did provide a relatively comprehensive analysis for that region itself. These articles can provide a preliminary summary of the different kinds of policies implemented at these regions and some included analyses of their effectiveness. Furthermore, the authors can also use information from these articles as a validation to her own data collection. In other words, the author can compare whether there was important missing information from the primary data collection by comparing to the existing policies from the published articles. However, it does appear that most of these researches only discuss the relationship between public health prevention-related policies and the effectiveness of policy response, but not other aspects that may be interesting in predicting the results of COVID containment.
Lastly, the author notices that unlike pandemics in the past, COVID is perhaps the most global pandemics since the bursting of digital technologies and social media development. In conjunction with the highest than ever Internet usage rate and the penetration of social media, it makes the nature of the COVID pandemic response interesting. On one hand, it might be easier for the government to publish policies and monitor the results of the policy responses as data are available online and almost in real-time. On the other hand, it’s also easier to collect people’s sentiments towards the government responses. Many countries and regions have taken advantage of the convenience of network to gather information and provide more effective tracing and prevention strategies, although privacy and legal concerns still remain. Furthermore, data on social media platforms can help us grasp into how people felt about the government responses may lead to some preliminary results of the success of government policies. It is expected that the era of social media will be more influential in the upcoming decades. Therefore, an understanding into how the advancements in technology and social media communication affected the current pandemic response may shed light on hot to better prepare for future crisis. In fact, some scholars, such as Gralinski and Menachery (2020), have already sensed the differences in COVID policy responses with SARS responses by noticing the changes in the roles of Internet communication and social media.

2.1 Policy Response Analysis for SARS Pandemics

There have been many past pandemics in recent human history and most of the recent ones have been studied carefully by the academia. Different narratives in terms of the effectiveness of responses and suggestions for better measures have been provided in these researches. After some compare and contrast, the author decides to focus on the study of SARS policy response to achieve
the aforementioned three goals. The choice to compare with SARS is based on the following considerations. First, SARS is perhaps the most comparable infectious disease to COVID-19 given the similarities in the viruses, the initial uncertainties around the scientific underpinnings, including the route of spread, the effective treatment, and prevention methods, and the origin of both viruses in China. Second, SARS is also relatively recent in human history and the government and the health care systems tend to be more similar compared to pandemics in the past. Third, most of the subjects in this study was affected by the SARS outbreak, although to different extent, and hence we may be able to gain some initial insights into the effectiveness of pandemics response policies in the past.

The very first SARS case was identified in Foshan, Guangdong Province, China in November 2002 (Dan et al 2009). It was quickly spread to 8,096 people in 29 different countries in the next 8 months (CDC official website). Most research focused on the effectiveness of policy response in China, the origin of the disease. China was generally criticized for its delayed responses for SARS pandemics when it started and multiple authors speculated that government’s reaction to hide the information at the beginning may have exacerbated the national and international spread of the diseases. Ahmed et al (2009) argued that Chinese government showed an initial reluctance to deal openly with the situation. This could be due to either political considerations that announcing such information earlier may lead to unnecessary panics in the nation or the logistical difficulties to control the spread of the disease. Schwartz & Evans (2007) also described the situation as “unsurprising” when they learned that the government was slow to recognize the seriousness and challenges of SARS and the fact that very little action was taken in the early months of the epidemic. Even though the responses from the earlier months received many criticisms, many scholars agreed that later policy responses in China showed great
improvements and many ended up being effective at containing the further spread of the disease. General strategies included building a Fangcang hospital in Beijing, clear stay-at-home orders and limited traveling options, and active communications with the international community. Fangcang hospitals, which became prevalent in COVID responses this year, refer to the temporary hospitals built to isolate and treat infectious patients, usually using existing public venues such as the sports stadiums or construction sites (Chen et al 2020). Ahmed et al (2009) argued that once Chinese government changed its policy, it developed an impressive control strategy that was followed by billions of people in the country. Starting April 21, China started to trace and track the close contacts of infected patients, providing early isolations and interventions to prevent further spread of SARS effectively (Ahmed et al 2009). Pang et al (2003) also commented on the quarantine strategies in Beijing that they successfully identified 30,000 close contacts and were able to quarantine these people either at home or in a hospital, with 60% of them quarantined individually. Furthermore, with an effort facilitated by the WHO, Beijing also incorporated the traveler-screening strategy as part of its policy response. Beijing government made sure to set up different checkpoints along bus stations, railways, and airports to closely monitoring people entering and leaving the regions to minimize the risks of infection (Ahmed et al 2009, Pang et al 2003). These strategies translated into effective control of the spread of SARS. To sum up, responses of COVID in China, with a focus on the Guangdong Province and Beijing, are characterized by an initial inefficient response for the first four months and followed by an improved efficient strategy starting in late March and early April.

On the other hand, out of the 29 affected countries and regions, Singapore, Hong Kong, and Taiwan have been viewed to have the most effective policy responses. SARS became identifiable in Singapore starting in early March. Opposite to many initial negative feedbacks for
Guangdong Province in China, Singapore and Hong Kong received many positive judgements even from the very beginning in terms of their policies for contact tracing and quarantine measures. Tan (2006) points out that Singapore made intensive efforts to locate contacts within 24 hours of case notification, set up a contact tracing center with up to 140 employees, utilize the armed forces in contact tracing, and set up a contact database accessible to all hospitals. Singapore government also demanded that all hospitals should report the number of cases of SARS every day even though the case number is zero (Ahmed et al 2009). On top of the effective hospital measures, Singapore also made significant efforts to early contact tracing. Tan (2006) argued that Singapore government was able to expand the WHO definition of “cases” and “potential cases” and allowed them to have an expanded network of people to keep track of to identify atypical conditions as early as possible. These strategies were widely appraised by many scholars and government institutions and many of which were adopted later on by other countries (Ahmed et al 2009).

Because Hong Kong was in geographic proximity with Guangdong Province, SARS cases were spread to HK earlier in February. Taiwan observed its first case of SARS in a similar timeline as Singapore in mid-March. Even during the stages of which the PRC government was still reluctant to share more information about the disease, Hong Kong and Taiwan government has taken active and preemptive measures. Similar to Singapore’s response strategy, both places have also taken a precautionary measure to notify the hospitals to be prepared for cases of SARS in early February even before the onset of the first case at February 15th (Ahmed et al 2009). On top of that, Hong Kong has taken special measures to protect the vulnerable groups—elderly residents—who are more likely to be infected (Tsang 2005). Additionally, both Hong Kong and Taiwan have delegated an ample amount of medical resources before the number of cases spiked. As Brudon & Cheng (2006) mentioned, Hong Kong and Taiwan initially assigned specific units
within the hospitals to be used for SARS patients and for quarantine of suspected individuals. Later on, both places decided to assign entire hospitals for isolating and treating the patients, which effectively reduced the transmission route between infected patients and others. Overall, it seems like Hong Kong and Taiwan government have more awareness to prepare for the SARS outbreak and have more medical resources to delegate at hand.

Comparing provinces in China with other Asian countries and regions, Schwartz and Evans (2007) attributed the effective responses in regions such as Hong Kong, Taiwan, and Singapore partly to the closer communications of them with the World Health Organization (WHO), which at the time served as an important mediator between many countries and regions. Another study from Chan et al (2010) supported this argument by saying that prior to the SARS outbreak, PRC gave very little priority to the threat of infectious disease epidemics in the country, adding yet another layer of reasons for the lack of effectiveness of China’s SARS response. On the other hand, Hong Kong, Taiwan, and Singapore had a much longer history to following WHO guidelines and cooperating with WHO to minimize the risks of diseases. However, it has been observed that the SARS outbreak may have triggered China to be more involved with the global health affair and be more cooperative and proactive in international organizations such as the WHO (Chan et al 2010). This political change is therefore interesting, as we can observe whether the changes in government attitudes after SARS have facilitated the maturation of public health response system in China in preparation for future public health emergencies.

In terms of methodologies, SARS scholar articles are generally aligned in what they used to represent the effectiveness of government responses. In general, the authors have used the identified case numbers, mortality rates, and the time to which it takes for the country/region to clear the newly increasing cases to zero as proxies for the effectives of government policy
responses. Since most of the SARS research were conducted after it disappeared, the authors were able to collect those numbers and datasets. In the context of this research, some of the parameters may not be applicable because COVID is an ongoing disease and many of these numbers have not been finalized. Furthermore, none of the research above seem to consider the impacts of population dynamics in different places. The author suspects that more densely populated areas may subject to quicker transmission of the disease and this research will take into account of the different population density levels. For specific analyses, COVID research focused on the qualitative aspect, i.e., describing what happened in different countries at different timelines. The qualitative discussions are very effective in these researches, as it provides comprehensive discussions from multiple aspects and the tones of the discussions remain neutral. While the author is going to mimic the qualitative strategies from relevant literatures, this is also only partially applicable for the purpose of this research. The author hopes to combine the use of qualitative and quantitative data analysis for COVID as the quantitative data analysis can provide further insights into how much each factor may influence the success of COVID containment in each of the country/region. The metrics of measurement chosen for the analysis of this study will be further explained in the “Data and Methods” section.

Even though these studies provide comprehensive summaries on SARS responses and government policies, there remained a few caveats in the research methods and conclusions. First, the scholars don’t seem to consider the fact that SARS was spread to different regions at quite different times, which could confound the results of their findings. For example, the first case appeared in China in November 2002 whereas it didn’t appear in Singapore until March 2003. The time gap between the appearances of the first case may have left different governments with different amount of time to prepare for and devise the policies. It won’t be a surprise that countries
with more time to prepare for the disease outbreak be more effective in their policy responses, so a lack of control on the time of the spread may reduce the credibility of some of the researches. Second, these past studies didn’t recognize other factors that may influence the government’s ability to implement or even propose policies. One such example would be the health care resources available per capita. It could be that fewer hospitals and hospital beds are available in mainland China, and this is why China couldn’t separate out hospital units, or even the entire hospitals, for isolating and treating SARS patients in the beginning. These factors, although seemingly not directly related to the effectiveness of SARS policy response, may have played an important role. Third, most of these studies have focused on qualitative discussions of the different policies in different countries and the results of SARS containment. No connections seem to be drawn about the implementation of the policies and the effectiveness of disease control. Although some authors explained that it was hard to draw any causal influences because there were many policies involved and that there’s no counterfactuals in policy analysis, the author insists that maybe some correlation can be identified by controlling some factors. Note that a further expansion on the drawbacks of current researches will be addressed separately in the section below.

2.2 Newly Published Articles about COVID-19 Policy Responses

At the beginning phase of this research, there was no literature directly related to the field of interest for this research. As time progresses, some scholars have noticed the similar research topics and have been summarizing the quarantine measures and contact tracing strategies in several Asian countries. These articles will provide a background for the author to understand the preliminary results in the field and borrow their methodology if applicable. There are a few characteristics of the following articles that especially provide the value-added to this research.
First, most of these articles provided analyses of different policies in details, serving as a good background for the author to understand more about response policies in these regions. Most of these articles go more in-depth in terms of describing the policies but doesn’t focus that much on analyzing the effects or the outcomes of these policies. Second, these studies focus on a similar timeline as this study, namely from the start of COVID pandemic to approximately May. This is important because as stressed earlier, this research focuses on the policy implemented during the initial stage of the disease and these articles seem to align with it. This makes the result from these literature articles more transferrable to understanding the context for this research. Furthermore, the existence of such literature proves the fact that the data is relatively available in the proposed regions and proposed timelines, adding a layer of confidence for the data collection below. Thirds, these existing researches seem to agree with each other on that conclusions drawn from literatures focusing on the same region are in parallel with each other and no explicit conflicts are identified between authors. Based on these characteristics, it is important to summarize the key takeaways form the current literatures and build the foundation for this research. We will begin by analyzing the specific policies and evaluations of these regions one-by-one (in alphabetic order), and then followed by a critical comparison of some of the important policies/measures mentioned. Note that there wasn’t any article commenting on Beijing’s specific policy response up to the point of the research, so Beijing is excluded from below for this purpose.

2.2.1 Guangdong Province

Recall that Guangdong Province is where the first SARS case was discovered. Many believe that experiences from SARS have helped Guangdong Province to better train their medical staff to prepare for future disease outbreak and for the government to devise a better coping
strategy. Because of its dense population, there were also a lot of people coming back from Wuhan to Guangdong Province for Chinese New Year. It is estimated that around 0.4 million people came back to Guangdong Province, with half of them going to the two main cities Guangzhou and Shenzhen (Zhang et al, 2020). Therefore, the slow reproduction rate of Guangzhou Province is also very impressive (Wang and Tenuis, 2020). Zhang et al (2020) commented on Guangdong Province for following the principles of “early detection, early reporting, early isolation, and early treatment”. It is noticed that Guangdong Province is actually the first province to initiate the highest level of public health emergency response, on the same day that Wuhan announced the citywide lockdown. After the highest order of public health status, Guangdong Province quickly established many measures including checking temperatures, wearing masks, and release public information to the citizens. Scholars have suspected that the cautious attitudes came from the slow reaction to SARS (Zhang et al, 2020), which exacerbated the spread to both China and the world.

Since Guangdong is a relatively developed province in China, it has a higher level of health care provisions and better quality of care in general (Tan 2006). Starting in January, the Guangdong government has disposed 104 hospitals over 17 thousand medical professionals to fight and prevent COVID. Most of these hospitals and medical professionals have experiences dealing with SARS (Zhang et al, 2020). In addition, the government has also urged hospitals to open up free online consultation programs to reduce the need for people to go to the hospital and hence limiting the risks of cross-infection within the hospital (Zhang et al, 2020). Therefore, the combination of government’s and hospital’s experiences of dealing with SARS, plus the effective healthcare provisions in Guangdong Province, have contributed to the relatively slower day-to-day growth rate of cases.
2.2.2 Henan Province

Henan Province has received mostly positive comments about their early actions on traveler screening and active cooperation with the central government in responding to national policies and devising more adaptive local-level policies. Given the geographical proximity of Henan Province to Hubei Province, many people travel frequently between Henan Province and Hubei Province. Furthermore, because of the population structure, that many Henan residents actually work outside of the province, and the time coincidence with Chinese New Year, many people travelled back to Henan Province to celebrate the festival with their families. It is estimated that out of the 5 million people that left Wuhan before January 23rd, 2020, 0.3 million of them arrived in Henan Province (Song et al, 2020). Knowing this large population flow between the two provinces, the Henan Provincial Government was alerted early on to implement strict traveler screening. This traveler screening was made possible with the help of grassroots communities, who also managed to help monitor the behaviors of people in home quarantines (Yang et al, 2020). In addition, the government also tries to close down some travelling routes even before the city lockdown of Wuhan on January 23rd, 2020. This preventative measure is widely praised by different other provinces, saying that it may have reduced the number of imported cases (Wang and Tenuis, 2020).

Second, multiple studies have stressed the importance that the local government has played in responding very cooperatively to national orders. Yang et al (2020) discusses that Henan Provincial Government quickly implemented the guidance from PRC and have raised public awareness of the disease through multiple channels, including TVs, non-commercial advertisement, radio series, and etc. Furthermore, different cities within Henan Province also implemented specific rules to further prevent the spread of the disease. As an example, Zhengzhou,
which is the capital city of Henan Province, opened a special information line that provides 24-hour free consultation for people to get more information and direct suspected people to the correct medical service centers (Yang et al, 2020). Therefore, the cooperative attitudes from both provincial and city governments, and from the grassroots communities have successfully reduced the transmission rate of COVID-19 within Henan Province.

2.2.3 Hong Kong

The COVID pandemic in Hong Kong was characterized by a few waves of imported cases with limited local transmissions (Lam et al, 2020). This is unusual since most countries have experience a high level of community spread after the initial important period (Cohen and Kupferschmidt, 2020). The low community spread of COVID cases in Hong Kong speaks to the relatively effective policy responses. After the initial wave of importation, Lam et al (2020) argued that the government has strengthened the border controls and have prevent flights from landing or connecting in Hong Kong. Furthermore, the government mandated the trace and home quarantine of every close contacts up to 14 days (Lam et al, 2020).

Interestingly, some scholars suggest that the success of Hong Kong’s COVID containment has less to do with effective government policies, but more correlation to the grassroots-level public responses and self-organized activities. Hartley and Jarvis (2020) pointed out that there is an inherent lack of trust from Hong Kong people to the government, especially after what happened in 2019. Therefore, many people didn’t trust the government guidelines. Nevertheless, while people didn’t really trust the government, there is a high rate of voluntary mask-wearing behavior starting in January and that could have contributed to the low local transmission of COVID in Hong Kong. Additionally, Hartley and Jarvis (2020) criticized the lack of government provision
of facemasks for all the residents. Rather, the grassroots activists have actually purchased and distributed the masks to people in need. Cowling et al (2020), although way less extreme than Hartley and Jarvis (2020), also attributed part of the success of Hong Kong’s policy to people’s behavioral changes. Upon an interview with different groups in Hong Kong, they found that people have voluntarily changed their behaviors and adapted to social distancing very well (Cowling et al, 2020). Additionally, many people tried to avoid to go to the hospitals because of the risks of cross-infections. Unlike Hartley and Jarvis (2020), Cowling et al (2020) believe that the social behavior changes followed the initiation of various government policies and extensive public education and awareness on the disease.

However, all authors seem to agree that experiences with SARS has prepared the region better for any future health care crisis. Lam et al (2020) suggested that the government adapted its policy from SARS responses and Cowling et al (2020) also mentioned that the public was more alerted than other regions because of their experiences with SARS. Even Hartley and Jarvis (2020) mentioned that the SARS pandemic had revolutionized the health care system in Hong Kong and making it more prepared for pandemics as such. Hence, whether the success of Hong Kong is due to the effective government policy on border controls, quarantine measures, and public education, or due to the community-level responses, or a combination of both factors remains unknown and requires further evaluation.

### 2.2.4 Singapore

Singapore shows unique response strategies by focusing on hospital resources reallocations. Wong et al (2020) detailed about the strategies across hospitals in Singapore to reallocate their staff, to mobilize their hospital beds and to modify the regular flow of patients within the hospital.
Specifically, they made sure to isolate enough hospital beds and operating rooms for COVID patients, update medical staff about the latest information starting in early January, and start to accumulate personal protective equipment (PPE) and respiratory machines (Wong et al, 2020). These measures ensure that the hospitals have ample resources to deal with the peak of the pandemics. Furthermore, Kuguyo, Kengne, and Dandara (2020) mentioned that Singapore has established 900 Response Public Health Preparedness Clinics (PHPCs) across the country, which served as the intermediary between the community and hospitals. These clinics will track and measure patients with flu-like symptoms, and then classify them as high-risk vs. low-risk for COVID infection. The existence of PHPCs, therefore, reduced the risks of people going into hospitals and also made sure that people with suspected symptoms know the right place to visit. These two measures together, lower the risks of within-hospital transmissions and try to protect both the medical staff and the vulnerable groups.

Singapore also has a unique contact tracing method called TraceTogether, which was developed and implemented later in March. The use of TraceTogether has also been recognized to improve the overall COVID outcomes in the country. The details about TraceTogether will be addressed in the next section below. Researches propose that there are two underlying reasons for Singapore’s early response and early public awareness strategy. One being their experiences from dealing with SARS and MERS outbreak, the other one being the fact that Singapore is an international transportation hub. These factors may have led the country to plan its medical resources early on, establish the emergent PHCPs, and develop a completely new software to use as the contact tracing method for the whole country.

2.2.5 South Korea
South Korea didn’t implement a country-wide lockdown or travel ban that is as stringent as many of the other Asian countries or regions (Park, Choi, and Ko, 2020). However, they still seem to achieve an impressive result by almost flattening the curve in late March. Scholars have attributed this success to mostly the ability of massive testing earlier than many other countries, the public-private partnerships (PPP), and the effective contact tracing mechanism proposed by the South Korean government. Park and Chung (2021) discussed about the availability of Real-Time Polymerase Chain Reaction (RT-PCR) testing in South Korea, which is enabled by their past experiences dealing with MERS outbreak in 2015. With the technology available, the government has also utilized the existence of PPP to help with mass producing the testing kits, hence streamlining the whole process. On top of that, Park, Choi, and Ko (2020) proposed that the use of information technology-based tracing strategies in South Korea has helped the government to track down the close contacts of infected or suspected individuals quickly and effectively. More specific details about the technology-based contact tracing method will be discussed in the section below.

The other interesting aspect noted by a few different scholars is the high obedience of South Korean people during pandemics (Lee and You, 2020). They argue for a concept of “social learning”, which means a stream of effective information sharing, public education, and timely implementation of public health policies. Raising public awareness is important, especially at the beginning of the disease outbreaks so that people can better protect themselves and obey the guidelines from the government (Lee and You, 2020). Furthermore, scholars have attributed the high obedience of people to the collective memory that South Korea has about public health crisis in recent history (Park and Chung, 2021). Since South Korea has been in multiple similar public health crisis including the recent ones like the SARS and MERS, the people have learned to adapt
to the policy changes in pandemics time and react every faster than the official government policies. Therefore, the use of RT-PCT testing, the information technology-based contact tracing method, and the high obedience of citizens together tamed the COVID growth in South Korea effectively.

2.2.6 Taiwan

In fact, the very first few papers about COVID policy responses actually focus on Taiwan, since Taiwan generally have the number of cases stabilized by that point and the world seems to agree that Taiwan has been controlling COVID spread very well. In general, Taiwan is deemed to have leveraged its experiences of dealing with SARS, used their robust public health systems, received supports from multiple health industries, and spread the public awareness early on, which all contributed to their impressive response to COVID-19 (Lin et al, 2020). Specifically, since the SARS pandemics in 2003, Taiwan has established the National Health Command Center (NHCC) that focuses on disaster management and large-scale disease outbreaks (Wang, Ng, and Brook, 2020). During the COVID crisis, NHCC responded immediately and identified the crisis very early on starting January 15th. Taiwan called for alerts of travelers from China in early January, which was before any health emergent status was announced in mainland China. Furthermore, Taiwan was clear about its priority to contain local transmission. To do so, Taiwan government leveraged the strength of their national health database to track the travel history of its residents and to identify the vulnerable populations (Wang, Ng, and Brook, 2020). They even proactively seek out patients with prior respiratory issues and mark them as special groups to look out for.

Taiwan has been more detailed on many aspects in terms of their policy responses. For contact tracing, Taiwan focuses on closes contacts of index cases—people who did not wear appropriate personal protection equipment (PPE) while having face-to-face contact with a
confirmed case for more than 15 minutes during the investigation period. All close contacts are required to quarantine at home for 14 days and will be tested for relevant symptoms regularly (Cheng et al. 2020). In order to better complement their contact tracing, at the meantime, Taiwan also developed and produced the testing kits by adapting from the existing ones (Lin et al., 2020). Beyond the public health measures, the health care system itself in Taiwan seems to be prepared for coping with disease outbreaks. Lin et al. (2020) argues that the National Health Insurance system has facilitated the effective response as well. Not only did it contain specific information about patient history and disease surveillance, it also ensures that checking for potential COVID infection is affordable in many different clinics and hospitals.

Overall, Taiwan has received very positive comments on their COVID response strategies as they quickly mobilized and instituted approaches for case identification, resource allocation, testing development, and utilization of their databased to identify the vulnerable groups. Many authors have attributed this policy response to their experiences of SARS from 2003 and the well-established health care system in the region.

2.2.7 Zhejiang Province

Zhejiang Province is deemed to have one of the best records of containing COVID-19. Authors attribute the success of Zhejiang Province to two main strategies—1) The effectiveness of community-based organizations, and 2) The early adoption of the health code system (Cheng, Yu, Shen, and Huang 2020). Note that Zhejiang Province actually has one of the highest numbers of imported cases from Hubei Province both given its high population density and proximity between the provinces (Wang and Tenuis, 2020). The containment of community spread of COVID-19 is therefore more impressive under this context. Community-based organizations are
those grassroots level organizations either initiated by volunteers in different districts or the existing ones such as the charitable organizations and community service organizations, some even involve private business organizations. They are believed to help with mobilizing the resources quickly throughout the province, voluntarily tracking that people wear proper respiratory equipment when in the public spaces, and even motivated the use of digital tracking systems to better cope with the pandemics. Figure 1 below shows a more detailed description from Cheng, Yu, Shen, and Huang (2020) about the specific roles that each player in the community-based organizations have played in Zhejiang.

Furthermore, since the headquarter of Alibaba is located in Zhejiang Province, the experimental trials with the health code systems actually initiated in China (Cheng, Yu, Shen, and Huang 2020). The similar health code systems are later adopted to almost all provinces in China and it is believed that the early and more stringent use of health code systems in Zhejiang may have contributed to the effective response. Therefore, by utilizing the strength of different public and private organizations in Zhejiang and adapting to the health code systems early, Zhejiang Province is believed to achieve an impressive result regardless the high number of imported cases.
### 2.2.8 Synthesis and Comparison

Drawing from the various literatures on different geographical locations, the author synthesized some preliminary insights and findings. From the descriptions from other scholars in the field, we can already identify some similarities and differences in the different policies and evaluations of policies in these regions.

(Figure 1. The role of different community-based organizations in Zhejiang. Cheng, Yu, Shen, and Huang 2020)
To start with common takeaways, it seems like multiple scholars agreed that many of these places have learned from their past experiences dealing with other infectious disease outbreaks. Out of these regions, South Korea, Hong Kong, Singapore, Taiwan, and Guangdong Province were among the ones having more experiences dealing with similar issues. Second, public education and raising awareness of the disease seems to be a ubiquitous strategy across different places. Third, since most of these regions are either have a large volume of travelers between the place to the hotspot Wuhan (e.g., Henan Province, Zhejiang Province, and Guangdong Province), or are international transportation hubs (e.g., Singapore, Hong Kong, and South Korea), traveler screenings and travel restrictions are mostly observed relatively early on in these places.

However, there are also many unique strategies that are only seen in one or a few places. For example, it seems that Singapore is the only place that stressed about strategies in hospitals and emergent clinics. Second, Hong Kong and Zhejiang Province seem to emphasize the roles of community-based organizations and the help from the grassroot activists in containing COVID. Third, Taiwan and Guangdong Province are the only regions that emphasize that the health care capacity, health care provision, and effect of health insurance on the COVID responses. Fourth, both South Korea and Taiwan have attributed their ability to flatten the curve to their fast development and manufacturing of the testing kits. Both places actually managed to start very early by adapting the testing kits they’ve used from dealing with previous health care crisis. Lastly, South Korea focuses on public-private partnerships (PPP) and how PPP enables the country to manufacture massive testing kits effectively. Similar cooperation between the public and the private sectors is also alluded to in the discussion of Zhejiang Province by Cheng, Yu, Shen, and Huang (2020). One caveat is that it is possible that other places also implemented these unique strategies, but they just haven’t been picked up by the academic field yet.
While these studies provide a good overview of policies on specific Asian countries or areas, there are a few research gaps in the current academic field. Namely, there is a lack of lateral comparisons and relative evaluation of these regions, and the studies focus solely on the public health prevention measures but ignoring other important factors influencing decision-making and policy outcomes, and some articles seem to contain a strong political preference. Additionally, it’s important to note that the literature analyzed above are those published no later than October 2020, meaning that the data many authors used are from the earlier phases and potentially different time periods of study. The author will address these concerns using the described methods below, to control for the time period of analysis and initial imports from the hotspots. The author will also compare and contrast the results from more quantitative data to the more qualitative and descriptive results presented above.

2.3 Emerging Disease in the Age of Digital Technology and Social Media

One interesting aspect of COVID-19 is that with technological advancement and widespread Internet use in the world, innovative methods of contact tracing and monitoring that were only theoretical in the past now becomes viable. Many of these new methods are adopted by various countries to identify the infected people and their close contacts more closely.

For example, South Korea has developed and utilized a special information technology-based tracing approach starting in February. This customized app requires the quarantined individuals to report their health status on a regular basis, and, with aggregated location data, modeling efforts were also made to locate potential sources of community-acquired infections (Park, Choi, and Ko, 2020). Importantly, this method does not only track the currently infected individuals closely, but also monitor early the close contacts of those infected individuals, even
though most of them did not show any symptoms. A further explanation of the flow of the information and the relevant agencies in charge is shown in the Figure 2 below. More interestingly, it was discussed that such approach was invented during the MERS spread in 2015 and was upgraded for COVID use (Park, Choi, and Ko, 2020). This aligns with other literatures from section one that countries with more experiences dealing with past pandemics may have a better coping strategy and will prepare earlier for the potential threats. As a result, amid relatively slack border controls or lockdown policies as many other Asian countries, Park, Choi, and Ko (2020) argued that the use of such IT-based technology has contributed largely to flattening the curve of newly confirmed cases and deaths starting from mid-March. They reached the conclusion by roughly comparing the pre-tracking versus post-tracking period in South Korea. However, the author foresees some issues with the method as other conditions may have changed as well as time progresses, and Park, Choi, and Ko (2020) didn’t provide a good control method.

(Figure 2. COVID-19 tracking system in South Korea. Park, Choi, and Ko, 2020)
Similar use of IT-based strategies has been observed in other areas of study. For example, the use of a Bluetooth tracker called TraceTogether in Singapore and the innovative “health code” in China to record the basic health status of people. To explain further, Singapore Ministry of Health has launched the app TraceTogether on March 20, 2020, to keep track of the proximity data for every app user and alert people if they have been in close contacts within some infected individuals within the last two weeks (Singapore Govt Official Website). The advantage to the technology is that it tracks your relative proximity with every individual that’s been within to you without knowing your exact location in order to protect your privacy. Furthermore, it also records the duration of the contact with others. Many times, people aren’t aware of all the individuals they’ve encountered in the past two weeks, especially when you are just crossing the street or taking a public transportation somewhere, and this app remembers the data for you for up to two weeks. A month after the initial launch, it shows an adoption rate over 20% with 1 million people downloading it. Many authors seem to agree that the adoption of the app contributes to the effective flattening of the curve in Singapore (Baharudin and Wong, 2020). Only a few weeks after the initial launch of the app, Singapore became the imagination of many other countries, such as Australia, and many other governments tried to adopt a similar strategy (Goggin, 2020).

China also took on the benefits of digital technology and came up with the innovation of “health code” in early February. By cooperating with WeChat, the government generates unique QR code for every user and use it to indicate the basic health status of the patients. People have to self-report their body temperatures and the existence of any relevant symptoms. “Green code” means you are healthy and low risk, “yellow code” means you are a close contact of some infected individuals and are classified as medium risk, and “red code” means you are an infected person (Liang, 2020). A visualization of the three different kinds of health code is provided below in
Figure 3 and 4. Starting in late February, the “health code” becomes necessary for almost all aspects of people’s life in China. For example, only people with the “green code” are allowed to take public transportation and enter a commercial building (Smith, 2020). Beyond health code, PRC and many local governments also provide data on the potential places that any infected individuals haven been to in the past two weeks on a publicly available platform. More specifically, there are data on the whereabouts of identified patients, including the public transportation they’ve taken during the past 14 days and even specific regions, streets, and supermarkets they’ve been to (Shevchenko 2020). “Health code” and information-sharing proved its effectiveness by allowing China to reopen very early in the spring and haven’t seen much of a surge ever since.

(Figure 3. Health code system in China. Liang, 2020)
Beyond the use of digital technology, the widespread coverage of Internet throughout the world in the last 20 years has generated incomparable attention on social media channels. The existence of multiple social media platforms enabled the faster distribution of information and the ability for researchers to capture sentiments from the people. After the SARS pandemic, it has already come to the scholar’s attention that the use of social media in the future could help reduce the risks of infectious disease outbreaks and be used as a channel for announcing policy changes (Smith, 2006). To start with information circulation, official national and local governments will post regular updates of confirmed case numbers and patient statuses on social media, so that it is easier for the general public to monitor and discuss the COVID conditions own regions (Galinski and Menachery 2020). Some platforms such as WeChat in China also serve local feeds on newly published policies and case updates depending on the specific geographic locations. Furthermore, platforms such as the John’s Hopkins COVID tracker and many others are publicly accessible to people all around the world, providing people with more sources of cross validation. Many new guidelines from WHO or national governments are also updated almost simultaneously on these platforms, allowing for real-time information transmission to all citizens.

Beyond the convenience of sharing information with people on different social media platforms, these platforms also be used as channels of which people express their opinions and feelings toward the government response policies. Smith (2006) argued that the media representation of the disease is important for people’s perceptions and reactions to changes in government policies. It will be easy for the government to track how local residents responded to a new quarantine policy for example. Since people’s sentiments may indicate how effective the policies can be, it may motivate the government to modify their policies based on people’s
reactions. Not only can people’s sentiments be shown on the social media platforms, people also tend to share their personal experiences and stories within the pandemics. This move may provide first-hand information about the current status in the hospital, mobilize grassroots movements as discussed in the last section, and reflect the “normal life” for people in COVID. Combining all the information can potentially be helpful in gaining additional insights into the qualitative aspect of how effective are the government response policies. Therefore, as Gralinski and Menachery (2020) argued, while far from perfect, the government response to COVID-19 opens up new channels of policy interactions and seemed to have a better outcome comparing to the results from SARS outbreak just 17 years ago.

However, in spite the enthusiasm around the use of innovative digital technologies to combat infectious disease and the power of social media to distribute important information more effectively, there remain a few challenges with the use of such methods. First, as Park, Choi, and Ko (2020) noticed, even though the tracking was very effective, there were many privacy controversies surrounding such detailed recording of the information. As the app will reveal some very sensitive personal information, certain individuals may be disdained once others find out they were infected or have been in close contacts (Park, Choi, and Ko, 2020). For some residents in Singapore, they didn’t download the TraceTogether app because they were worried that their private information might be used for other purposes by the government. Similarly, the health code system and information-sharing strategy has caused many troubles for citizens in China. Some criticized that the type of information published on the public platform (i.e. the whereabouts, the proximal living area, and hospitals they’ve been to) is too detailed and people could easily identify the person even without a published name (Liang, 2020). Additionally, arguments and disdains have been seen that people would blame the infected individuals for spreading the virus etc.
Therefore, to better use the digital technologies in the future, it is very important for the government to consider the privacy issues and unintended consequences for people.

Second, as sentiments from the public become more transparent to the government during the pandemic times, one may suspect that these sentiments may indirectly affect government’s decision-making process. In other words, government may try to issue policies that will align with what most people are hoping for, but not with the best interest of containing the pandemics. However, whether these virtual “interferences” from the public bring positive or negative effects remains unknown and more studies are required in this field. Furthermore, there’s concerns about the validity of the information that people pose on social media. Without a comprehensive checking system, it’s likely that people will be spreading fake news about government policies on the Internet, which may hinder the effectiveness of policy responses. Therefore, even though the advancements in technology can provide potentially more effective response measures, we have to be cautious about the privacy issues and the unintended consequences from using social media overflow.

2.4 What’s Lacking in the Current Literature?

Although the aforementioned literature has provided solid context to analyze pandemics response policy, there are a few considerations lacking from these authors and will be addresses in this research study.

To start with past pandemics response literatures, even though they serve as good proxies for COVID analysis, the fact that every infectious disease outbreak is different and that the world faces with different social, political, and economic considerations may complicate the factor. Beyond the problems with the methods of study discussed in the section above (i.e. lack of timeline...
control, lack of considerations for other influencing factors, and lack of quantitative analysis), there are two additional considerations with regard to the past pandemic response literatures. First, the world has not been that connected compared to 20 years ago, we should be able to address the new challenges coming from the more than ever interconnected globe. As people’s travel pattern and societies’ normal operations change, there may be a new focus of the pandemics study and best practices for the political institutions. Second, the advancement of technologies and medical studies may have changed the dynamics of dealing with pandemics. To take a few examples, the changes in the social media usage and making the relevant data more publicly available is different from what we observed in the past. Additionally, the advancement in telemedicine, for instance, may have lowered the likelihood of people going to hospitals during pandemics time, and hence reducing the risk of transmissions in hospitals. These changes in societal structures, should caution the author that some preliminary results from SARS pandemics responses may not be applicable under current situations. SARS policy responses seem to suggest that there is a lack of communication methods to spread the risks of SARS to residents in the country early on, but this may not be true in the context of COVID in the era of Internet and social media.

Then onto the newly published COVID literatures, even though they analyzed rather comprehensively on their selected area of interests, there are a few things lacking according to the author’s opinion. First, there is a lack of lateral comparisons between regions. For example, papers that praised the policy measures in Zhejiang Province and Henan Province never compared itself to other provinces. Or rather, the comparison is limited to a small area. The authors mainly looked at whether other provinces in China were doing the similar things, but no comprehensive comparisons were given. This could cause trouble because a lack of a comparative study makes it harder to judge on a relative scale whether the policy responses were effective. Additionally, the
author noticed that most of the recent COVID policy researches emphasize solely on the public health prevention measures, such as contact tracing and quarantine measures. Though public health measures may be arguably the most important influencers of the effectiveness of the pandemic response, there are other factors that can’t be ignored in order to grasp the full picture of the effectiveness of pandemic response. More potential factors will be addressed in the Hypotheses section below. Thirdly, some of the papers seem to be written with a strong political bias towards certain government agencies. For example, the Hartley and Jarvis (2020) paper seems to have a strong objection to the measures taken by mainland Chinese government and attributed the distrust to the Hong Kong government by local people to earlier events. These political biases may have led the authors to bias their opinions in the COVID policy response analyses.

Nevertheless, these current literatures provided a good overview of the current conditions. The consensus from the scholars have generally been positive, meaning that many are focused on analyzing the positive aspects of the COVID control outcomes. However, since most of the evidence is descriptive, it’s hard to make preliminary comparisons at this point. Although it does seem like Zhejiang Province and Henan Province are the best amongst these regions due to their fast to actions and the cooperative attitudes from the public.

On common problem among all literatures so far is the lack of direct policy suggestions to the countries or regions of study. As stressed in the previous section, this paper truly aims to foster the institutional changes so that the government can better prepare for future disease outbreaks. While the current literature provides good summary of the policies and even evaluations of policies, most of them didn’t provide explicit policy suggestions. For those that did provide policy suggestions, not enough information is given on how to measure the success of those policy suggestions in the future, nor did they advocate for the importance that different national
governments need to be aware of their mistakes in the past. Therefore, this study is going to address the problem by providing explicit policy suggestions based on the data analyses results and is going to advocate, along with similar researches, that such information should be shared with policymakers and health care providers. To address these challenges and fill in the academic area, the author proposes the following hypotheses and methods of analysis to proceed with the research study.

3. HYPOTHESES

Based on motivation of the study and insights from the current literatures, the author proposes several hypotheses to answer the questions of what leads to the disparities of COVID-19 outcomes. There are five proposed hypotheses, which are broken into two primary hypotheses and three secondary ones, that could explain the differences in COVID policy outcomes. These hypotheses were formulated from observations from past literatures and a comprehensive understanding of the problem statement itself. Due to the time constraints and the difficulty to control for other confounding variables, this research will prioritize the two primary hypotheses on 1) the public health prevention measures that were in place in different regions, and 2) the preparedness of the health care systems. The three secondary hypotheses—economic development level, demographics, and past experiences dealing with infectious disease outbreaks—will also be incorporated in the data analysis model to test for their significance. A more in-depth explanation of the five hypotheses is provided below.

3.1 Preparedness of the Public Health System
The first and perhaps the most important hypothesis is what public health prevention measures were actually in place in these regions and when were these measures ordered. The influences of these public health measures are expected to be two-fold. On one hand, whether those prevention measures were enforced, suggested, or not in place will play an important role into understanding the effectiveness of policy response. On top of that, how early were those public health prevention guidelines published by the government might also have an impact. The most important public health measures in the context of COVID-19 are contact tracing and quarantine measures. While some measures may be common across the board, such as the 14-day quarantine requirement for close contacts with infected individuals, many unique prevention measures were observed in these regions. To take Singapore as an example, Singapore’s Ministry of Health has mandated the use of a Bluetooth tracker called TraceTogether to record proximity and duration of an encounter between two users starting in late March and early April. This information is then used to identify close contacts when a person is found to be COVID-19 positive (Singapore Government Official Website). Another unique public health response measure is observed in Zhejiang Province. Cheng et al (2020) noted in their case study in Zhejiang Province that the appearances of community-based grassroot organizations may have contributed to the effective containment of COVID in their province, making Zhejiang having one of the best COVID record in China.

It is hypothesized that different public health measures may have different levels of impacts. Some measures may be more effective than others or the combinations of some measures may outperform the single measures. For example, it is reasonable to speculate that the contact tracing works more effectively in conjunction with the strict quarantine measures of infected individuals. Each of the widely used public health prevention measures will be recorded and transform into a
categorical variable for analysis. Furthermore, it is also expected that the earlier those measures were in place, the better the effectiveness of the response. This projection is based off the logistic growth nature of the infectious disease, such that the number of cases may grow very significantly in the lack of an early intervention.

In order to test for this hypothesis, a qualitative discussion of what public health prevention measures were in place in different regions, and a quantitative assessment of each prevention measures, along with a categorization of early, intermediate, and late for the timing of those measures, will be carefully documented and analyzed in the sections below.

3.2 Health Care Systems and Available Resources

The second primary hypothesis is how prepared is the local health care systems for such a big-scale global health care crisis. The preparedness of the health care systems refer, in general, to the amount of available medical resources and the ability for the local government to deploy those resources as needed. More specifically, it incorporates the following aspects. First, the amount of medical available resources per capita, including the physician-patient ratios, number of hospital beds, and the capacity of each hospital, is important. It predicts the total and average amount of resources each government has and the ability for the government to mobilize those resources as soon as possible. Second, where are the health care facilities located within the region may also affect the effectiveness of policy response. If a region has an unbalanced distribution of health facilities, it may be harder for some patients to access than the other, leading to a less effective result. Third, the process that patients have to do though in order to be treated as a COVID patient is essential. Starting from how can a potential patient be tested and reported, which departments
within the hospitals that patients need to visit, and leading to how should patients pay for the services to get treated, can all be influential of how well COVID spread can be controlled.

It is hypothesized that regions with more available health resources per capita and more accessible health care facilities will have a better policy response. Although some areas of studies are close in geographic proximity and some are under the same national government (i.e., PRC), disparities in their health systems exist. For example, Hong Kong and mainland China, though close in proximity, have different levels of primary care access and qualities (Wei et al 2015). Furthermore, it also depends on the resource allocation within the regions. Some regions may have more preemptive measures to reserve the hospital beds for potential COVID patients even before the spike of the diseases, and this is hypothesized to contribute to the effective COVID response policies. Hospitals in Singapore, Taiwan, and Hong Kong have been observed to take early actions to reallocate their medical resources starting in early January (Wong et al 2020 & Wang et al 2020), which was before the appearance of first COVID cases in these regions. In previous infectious disease outbreaks, scholars have also found similar patterns that a timely response to reallocate medical resources can be crucial to the success of disease containment (Schwartz and Evans 2007).

In order to test for this hypothesis, both qualitative description of different health care systems and people’s experiences within the systems, and the quantitative data analysis of whether the amount of medical resources per capital is correlated with the outcome metrics of this study, will be carefully documented and analyzed below.

### 3.3 Secondary Hypotheses

Beyond the two primary hypotheses, there are three secondary hypotheses that need to be addressed in this research. The overall strength of the economy, the demographics data, and the
different levels of experiences of dealing with past pandemics may be correlated with the effectiveness of response policies. These considerations may serve as additional variations in the models to be described below and by controlling some of these variables, we may be able to better project the relationships between the effectiveness of government response policies and the two primary hypotheses mentioned above.

To explain each of the hypotheses further, the economic development level of each of the country/region is shown to have correlation with the available medical resources and the awareness of the local government to prepare for the pandemics (Lam et al 2020). Many researches have concluded that the economic development of a country is predictive of the strength of the health care systems in that country, and hence correlated with the medical resources a place can deploy during a pandemic. The economic development of a region may also be correlated with the awareness of the government and the general public to follow the guidelines of the public health prevention measures. Therefore, it is worth analyzing whether the variations of the economic development contribute to the disparities we observe in outcomes.

Demographics data include age and gender structures, the population density, and the level of urbanization. Because the demographics of this study may be hard to control due to the heterogeneity of the regions, it is therefore critical to take a snapshot of the overall demographics to either there’s not much of a difference in these metrics, or we can evaluate whether these differences in demographics contribute to the differences in outcomes that we observed. If, for example, two regions have similar population density and age structures, but one place has a better outcome than the other, it may indicate that some other factors are predictive of the effectiveness of policy response. On the other hand, if two places have similar health care systems and public health prevention measures, but different demographics and different COVID control outcomes,
we may be able to draw inferences between the demographics and the effectiveness of the response policy.

The last hypothesis builds upon the experiences that different government bodies have regarding past health care crisis, especially the most recent ones such as SARS, MERS, and Ebola. It has come to the attention of many scholars, including Hartley & Jarvis (2020), Zhang et al (2020), Wang et al (2020), and Mei (2020), that regions that were more affected by SARS and MERS in the past seem to have a quicker and more accurate response of COVID. They concluded multiple reasons for this phenomenon. First, the scholarly field seems to agree that regions that were hit by past pandemics were more alerted of the potential threats, and that’s why regions such as Taiwan and Guangdong Province started preparing their medical staff even before the first case was identified (Mei 2020 & Zhang et al 2020). Second, regions with past pandemics experiences have some spare space in the hospitals and have remained training guidelines about how to prevent cross infections in the hospitals, leading to a more immediate response (Wong 2020). Additionally, past experiences dealing with pandemics may make these regions ahead of others in terms of developing innovative measures for contact tracing and quick identification of susceptible populations, hence better protecting its population. All these proposed reasons could be valid, although subjective to further analysis by this research. To understand exactly how much experiences each of these regions have, the author is going to categorize each region into “Low”, “Medium”, and “High” in terms of its experience, using data such as the ones Ahmed et al (2009) proposed. Hence, by understanding the level of experiences these regions have about coping with pandemics may further shed light on the effectiveness of the COVID response policies.

4. DATA AND METHODS
This section will start with an explanation of how the author collected both primary and secondary data, and potential biases by using these datasets. Then the author is going to show in detail about the collected data for the metrics of measurements, i.e., the output variables, and the independent variables, i.e., the input variables. A preliminary analysis of the output and input variables will be analyzed to show preliminary insights. Lastly, the author is going to describe a detailed analysis plan that will help us connect the output variable with the input variables. All of the models have been experimented by the author and the results and discussion of such is included in the next section.

4.1 Data Collection

This research relies heavily on both primary data and secondary data collections. The author recognizes the risk that some of the related data may not be as accurate at the start of the pandemics, as it is usual the case that these data are adjusted even years after the pandemics. Nevertheless, the author tries to avoid this issue by collecting some primary sources by herself and validate certain sources across different platforms. The primary data collection focuses on the actual public health prevention measures that were in place for these regions, namely the contact tracing, quarantine requirements, and health codes from government policies. These resources are mostly collected through primary channels, including following and searching different official government websites to extract the policies and the dates of the policy implementation. Since there are many detailed policies in place from January through mid-May, the author chose to record those that are deemed most important and impactful by judgement. The focus of the public health measures is also on the policies that are unique to these regions and focus less on the ones that are common across the board. Most of the primary data collection is validated by comparing with the
data used in other COVID policy research paper that focuses on a specific area. Primary data is presented in the Figure 5 below. Note that this is only a preliminary representation of the data collection and more details are added later in the data analysis and in the qualitative evidence section below. More information on the sources and explanation of the data is in Appendix A.

(Figure 5. Primary data collection examples, changes were made later on)

Secondary data collection relies on sources that have already been published. The output metrics will be collected mostly through the secondary channels as no primary collection of large-scale COVID data is possible for the author. These data (i.e., the number of identified cases and deaths, the dates of the first identified case, and etc.) will be collected through multiple platforms including World Health Organizations (WHO), Our World in Data, and the John’s Hopkins
COVID tracker, to ensure consensus. Although there may be discrepancies in how each region categorize the cases and collected their data, since we are looking over a period of few months, the biases should remain constant in the data collection methods and hence have a lesser effect on the accuracy of the overall data.

For the input variables, the secondary resources will be important for both qualitative and quantitative data. For the qualitative data, the author is going to use literatures that describe the different health care systems as the supporting evidence for the first hypothesis. Furthermore, a special kind of qualitative data, namely people’s sentiments towards the health systems and the public health prevention measures, is going to be collected through multiple news channels and websites. As mentioned before, a broader view of the story of the people is important as it potentially speaks to the effectiveness of the response policy, and people’s willingness to cooperate with the government under the emergent scenarios. Such data will be collected through news outlets such as BBC, CNN, local news channels, and various social media platforms such as Facebook and WeChat. For the quantitative data, the author is mainly going to collect the demographics data and past experiences of these countries dealing with SARS. The demographics data is going to be collected through the publicly available census website. The past experiences of dealing with pandemics will be collected mostly through previous researches, as most of them present a relatively comprehensive summary of the past pandemics. The author is then going to translate the level of experiences each country has into a categorical variable with 3 levels: “Low”, “Medium”, and “High”.

Both the primary and secondary data collection is dated at mid-May to ensure consistency across the regions and to limit the scope of the analysis on the outcomes of COVID control in the initial wave of COVID outbreak. The choice of the analysis period is explained in more detail in
the “Problem Statement” section above. However, the author does recognize the limitation that there are only a few observations and it may be hard to establish statistical significance. The small number of variables is due to the fact that most of the policy-related data are hand-collected and the analysis period is rather early. Therefore, the main goal with the amount of available data is to factor out the most important factors influencing the disparities of COVID containment results.

4.2 Metrics of Measurements

It is not immediately clear what would be the most appropriate proxies to represent the effectiveness of the government response policies. The author decides to try three kinds of variables as the dependent variable in the model. The first option is using the growth rate of cases in different regions, i.e., the average number of new cases per day. More specifics about how to calculate this growth rate is provided below. The decision to focus on the growth rate is based off the consideration to account for the different tracking methods for number of cases and deaths, which may introduce different margins of errors (Leung et al 2020). Even though regions may have different ways to count the number of cases, as long as the discrepancy is consistent within the region, looking at the growth rate of the cases can minimize the disparities in counting methods.

To calculate the growth rate, the author decides to adjust for the initial number of imported cases from the hotspot Wuhan. This is because the initial imported cases appeared in those regions without the government knowing a lot about the pandemics and hence no policy was practically possible to prevent the spread initially. Comparing the cases and growth rate with or without the adjustment can be used as a test for the hypothesis that the initial imported cases were out of the control by most local governments. By subtracting the initial imported cases, the author believes that the data is more representative of how well the local government contains the virus locally.
and how policy responses help prevent the spread. There were more than 5 million people travelled from Wuhan to other cities before the city lockdown order on January 23rd, 2020 (Song et al 2020) and where those people went could have a significant impact on the initial number of imported cases in different regions. To account for the fact that many of the initial cases were imported from Wuhan, Hubei during the Chinese New Year travel upsurge, the author is going to calculate the growth rate of the number of cases using the cumulative cases minus the imported number and then divide by the time period in days. For example, it is estimated that Henan Province has an initial of 398 import of cases from Wuhan (Song et al 2020, Health Commission of Henan Province). Up to mid-May, there has been a total of 1276 cases identified. The growth rate of COVID cases in Henan is going to be calculated using 1276 minus 398, and then divided by the number of days elapsed between the first case and May 11th. This method is justified because after the city lockdown in Hubei Province since January 23rd, nearly no people could leave the province and enter other places and hence we can attribute future growth within these regions to be the consequences of within-region policy responses. Furthermore, using this method also addresses the concern about varying distances to the hot spot. Even though these regions are of different distances to Wuhan, since no travel between the hotspots and other places were possible until April, by accounting for the initial number of imported cases from Wuhan, we have controlled for the variability of different distances to Wuhan.

However, the first option remains the bias that different regions have different demographic structures, which could lead to different population density, age structure, an etc. These concerns are addressed by the second option proposed. The second option is going to be the growth rate of cases adjusted by the population to reach the average number of new cases per 100,000 people in the region. All else equal as the first option, the author is going to use all the statistics adjusted by
the total populations in the region. Note that the direct data of population adjusted cases is unavailable in some regions of studies. Given this constraint, the author decided to work from the number of cases and the total population of the regions to calculate the per 100,000 people case numbers manually.

The third option that the author is going to attempt is the number of cumulative deaths in those regions, divided by the total number of cases identified. This decision is based off the concern that the number of deaths may be representative of how well the health care system deals with public health crisis and what care was provided to the COVID patients. Figure 6 highlights all three metrics of measurements variables from primary data collection. It’s not hard to notice that the number of deaths in all these regions seem to be fairly low. Even adjusted by the total number of cases, the percentages of death rate in the regions remain extremely low. Hence, the author preliminarily concludes that using the death rates in these regions may not be the best representative of the effectiveness.

(Figure 6. Metrics of Measurements/Dependent Variables Summary)
Considering the different scales of the numbers and the large variations observed, the author also decides to transform the dependent variables to categorical variables. The categorical variable might also be helpful because there are only 8 observations and predicting a linear model based on very few numbers of observations may be difficult. Therefore, the author provides cut-offs to categorize all three different dependent variables. More information on how the cut-off points are chosen is described in the Appendix C. Note that the in the actual regression model, the categories are transformed in the following way——Low: 1; Medium: 2; High: 3.

<table>
<thead>
<tr>
<th>Countries &amp; Regions</th>
<th>Beijing</th>
<th>Guangdong</th>
<th>Henan</th>
<th>Zhejiang</th>
<th>Hong Kong</th>
<th>Taiwan</th>
<th>South Korea</th>
<th>Singapore</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Identified Case</td>
<td>29-Jan</td>
<td>19-Jan</td>
<td>22-Jan</td>
<td>25-Jan</td>
<td>23-Jan</td>
<td>21-Jan</td>
<td>20-Jan</td>
<td>23-Jan</td>
</tr>
<tr>
<td>Days Until May 11</td>
<td>103</td>
<td>111</td>
<td>110</td>
<td>107</td>
<td>109</td>
<td>111</td>
<td>112</td>
<td>109</td>
</tr>
<tr>
<td>Cumulative Case So Far</td>
<td>593</td>
<td>1,589</td>
<td>1,276</td>
<td>1,268</td>
<td>1,047</td>
<td>440</td>
<td>10,009</td>
<td>23,336</td>
</tr>
<tr>
<td>Cumulative Case Per 100,000</td>
<td>2.753</td>
<td>11.947</td>
<td>1.357</td>
<td>2.210</td>
<td>14.054</td>
<td>1.850</td>
<td>21.125</td>
<td>413.759</td>
</tr>
<tr>
<td>Initial Imported Cases</td>
<td>100</td>
<td>228</td>
<td>398</td>
<td>271</td>
<td>9</td>
<td>10</td>
<td>13</td>
<td>24</td>
</tr>
<tr>
<td>Initial Imported Cases Per 100,000</td>
<td>0.464</td>
<td>1.714</td>
<td>0.423</td>
<td>0.472</td>
<td>0.121</td>
<td>0.042</td>
<td>0.025</td>
<td>0.426</td>
</tr>
<tr>
<td>Cumulative Death So Far</td>
<td>9</td>
<td>8</td>
<td>22</td>
<td>1</td>
<td>4</td>
<td>6</td>
<td>256</td>
<td>20</td>
</tr>
<tr>
<td>Cumulative Death/Total Case</td>
<td>1.52%</td>
<td>0.50%</td>
<td>1.72%</td>
<td>0.08%</td>
<td>0.38%</td>
<td>1.36%</td>
<td>2.35%</td>
<td>0.69%</td>
</tr>
<tr>
<td>Demographics</td>
<td>Population</td>
<td>21.54</td>
<td>13.3</td>
<td>94</td>
<td>57.37</td>
<td>7.45</td>
<td>23.78</td>
<td>51.64</td>
</tr>
<tr>
<td>GDP Per Capita (2019)</td>
<td>$23,151</td>
<td>$12,198</td>
<td>$7,080</td>
<td>$13,925</td>
<td>$49,334</td>
<td>$24,828</td>
<td>$31,431</td>
<td>$63,987</td>
</tr>
</tbody>
</table>

(Figure 7. Categorical Metrics of Measurements/Dependent Variable Summary)

It is helpful to provide some preliminary data visualization of the metrics of measurements to observe any abnormalities. Overall, it seems like Singapore is the outlier among all the regions. In the analysis below, the author tested the data with and without the Singapore observations. Figure 8 shows the population adjusted cumulative cases of all regions and Figure 9 contains the same information without Singapore. Figure 10 and 11 shows the growth rate (adjusted by population), with and without Singapore respectively. From Figure 8 and 10, it can be observed that Singapore has a very high number of cumulative cases (adjusted by population) and growth
rate (adjusted by population). When excluding Singapore from other observations, we can see that other places are on a more comparable scale of the output variables. This may indicate that Singapore has the worst effectiveness of containing the spread of the virus from our metrics of measurements. Additionally, the four provinces in China seem to achieve relatively similar statistics despite their differences in demographic structures and local policies. This shows that even though we wanted to separate out different provinces in China and expected these different regions to have different levels of effectiveness, the preliminary results did indicate that these regions tend to have similar outcomes.

(Figure 8. Cumulative Case Per 100,000 People)
(Figure 9. Cumulative Case Per 100,000 People without Singapore Observation)

(Figure 10. Population Adjusted Growth Rate)
Conversely, the death rate adjusted by number of cases seem to be relatively similar among these regions and Singapore even have one of the lowest estimates regarding the death rate. Figure 12 indicates the death rate by number of cases in different regions. Do note that the absolute value of the death cases is extremely low, as we can see from the data collection above in Figure 6. The extremely low number of cases for deaths may make it less useful as an outcome variable. A more commonly used metrics to compare the actual COVID death rate is looking at the “excess mortality,” which is defined as the addition in mortality rates when compared to a normal year. However, the author ultimately chose not to use the “excess mortality” because the provincial-level data was not available for the provinces in China. This is the only dependent statistics that Singapore doesn’t seem to stand out as an outlier. However, as mentioned in the previous section, since the actual death cases are extremely low and the statistics are very similar, it may not be the most appropriate metrics.
One important message, however, is that we only have a total of 8 observations, which may be the reason why Singapore stood out as an outlier from many other places. The small number of observations we have may make it unsuitable to build a strong and indicative statistical model. This point is further addressed below in the Limitation section.

**4.3 Independent Variables**

For the independent variables, the author has transformed the five hypotheses above into quantifiable variables to represent the data. The first three variables are continuous variables. GDP per capita is directly taken from the 2019 data from secondary source. The level of medical resources is proxied by the number of hospital beds per capital within the region. Number of unique local level polices was summarized from the primary data collection and related literatures to see whether the government has done something differently. Next, we have a categorical variable to represent how early or late the government responds to the crisis. The timeliness of the response was categorized into “Early”, “Medium”, and “Late” by combining the enacted dates of the policies.
and compared to each other on a relative scale. The last variable was transformed from the past literatures into a numeric variable from the range of 0 to 3, with 0 being almost no experience to 3 being very familiar with the protocols. The information of the data came from Ahmed et al (2009) and other newly published literatures that commented on the SARS and MERS control experience of these regions. Figure 13 below provides a summary of the different independent variables explored in this research.

(Figure 13. Independent Variables Summary)

Similar to the metrics of measurements, the author has considered the need to transform some of the independent variables into categorical ones. Specifically, the GDP per capita data and the available medical resources are transformed based on threshold cut-offs. Note that the in the actual regression model, the categories are transformed in the following way —— *Low*: 1; *Medium*: 2; *High*: 3 —— for GDP per capita and medical resources. The categories are transformed —— *Early*: 1; *Medium*: 2; *Late*: 3 —— for the timeliness of policy response. More information on how the cut-off points is chosen is described in the Appendix C below. The other two variables stay as
continuous variables, because all these variables are within a relatively small range and the author decides that no transformation is needed. Figure 14 below provides a summary of the transformed categorical variables.

<table>
<thead>
<tr>
<th>Data</th>
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<tr>
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<td>Medium</td>
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<tr>
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<td>Number of Unique Local Level Policies</td>
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<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
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<td>Medium</td>
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<tr>
<td></td>
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<td>Early</td>
<td>Early</td>
<td>Medium</td>
<td>Medium</td>
<td>Early</td>
<td>Medium</td>
<td>Late</td>
</tr>
<tr>
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<td>1</td>
<td>3</td>
<td>2</td>
<td>3</td>
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</tr>
</tbody>
</table>

(Figure 14. Categorical Independent Variables Summary)

The author has plotted all five of the independent variables for some visualizations. Figure 15-20 below represents the data for each one respectively, the blue charts represent continuous variables whereas the orange charts represent categorical variables. Note that the experiences dealing with SARS was originally thought to be a categorical variable, however, after consideration, since the experiences are counted from the region’s recent encounters with pandemics, it is actually additive and should be treated as a continuous variable.
Taking a closer look at Figure 17, it’s interesting to see that South Korea has almost doubled the hospital beds per capita compared to many other regions whereas Singapore has almost only half of the medical resources compared to the majority of these regions.
(Figure 17. Hospital Beds Per Capita (2019))

(Figure 18. Unique Local Level Policies)
Overall, it’s interesting to observe that unlike the dependent variables, the independent variables are not that different from each other except the large variable in GDP levels. Recall from the last section that most of the outcome variables are very similar to each other, so perhaps the similarity in some of the input variables can explain that. However, since the output variable for Singapore is quite different from that of the others while the explanatory variables are very
similar, it may indicate that there are other factors influencing the outcomes of the COVID control in Singapore that is not captured in our data. Nevertheless, a more accurate conclusion can only be given after we have fit our model for quantitative data analysis below.

4.4 Data Analysis Plans

To test the validity and soundness of each of the proposed hypotheses above, the author is going to use a combination of qualitative and quantitative data analysis methods to provide evidence. The author will start with qualitative data analysis by describing the different policies and gathering sentiments from news articles and official press releases about how the general public and the government officials felt about their COVID response policies. This will be combined with some of the observations from other relevant papers that are discussed in the Literature Review section. The quantitative data analysis will then focus on transforming each of the proposed hypotheses into a quantitative representation and use regression to analyze whether the input metrics can predict the outcome metrics.

Since there are two sets of data for both the dependent and independent variables. There will be essentially four kinds of quantitative analysis approaches that the author is attempting with. First, the author will start with continuous dependent variables and continuous independent variables. Then, the author will use continuous dependent variables with categorical independent variables. After that, the author will use both kinds of independent variables with categorical dependent variables. Within each approach, the author experimented with three different metrics of measurements (i.e., the dependent variables) separately to see how well the model is doing. For all the models, the author will try to look at the two-by-two correlations (i.e., fitting each explanatory variable to the output variable and see how significant the result is). The choice is
based on the fact that with such a few numbers of observations, it is hard to establish a valid multiple regression model. Hence, we want to look separately at how each variable is correlated with the output variable and out of the ones that are statistically significant, which one can explain the largest variation in the data. Figure 21-24 represents the four kinds of models respectively.

There are two caveats in our data analysis approach here. One is that for the “Medical Resource” variable is that when it is transformed to categorical variable, it has a very small variation among all data and hence is not useful in the model. Therefore, in the actual regressions, only the GDP is transformed in the independent variables and medical resource is constantly kept as the continuous variable. The other is that as mentioned before, because the outcome variables for Singapore is very different from those of other regions, the author also tried fitting the model without the observation of Singapore to see whether we can obtain a more powerful and accurate model.

(Figure 21a. Growth Rate)
### Regression 2

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Independent Variable</th>
<th>GDP Per Capita (2019)</th>
<th>Medical Resources</th>
<th>Number of Unique Local Level Policies</th>
<th>Timeliness of the Response</th>
<th>Experiences Dealing with Past Pandemics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Growth Rate Adjust by Population Density</td>
<td>Beijing</td>
<td>0.02</td>
<td>23151</td>
<td>5.74</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Guangdong</td>
<td>0.01</td>
<td>12198</td>
<td>4.56</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Henan</td>
<td>0.01</td>
<td>7080</td>
<td>6.34</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Zhejiang</td>
<td>0.02</td>
<td>13925</td>
<td>5.79</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Hong Kong</td>
<td>0.13</td>
<td>49334</td>
<td>5.40</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Taiwan</td>
<td>0.02</td>
<td>24828</td>
<td>6.98</td>
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<td>1</td>
</tr>
<tr>
<td></td>
<td>South Korea</td>
<td>0.19</td>
<td>31431</td>
<td>12.43</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Singapore</td>
<td>3.79</td>
<td>63987</td>
<td>2.40</td>
<td>2</td>
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</table>

(Figure 21b. Population Adjusted Growth Rate)

### Regression 3

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Independent Variable</th>
<th>GDP Per Capita (2019)</th>
<th>Medical Resources</th>
<th>Number of Unique Local Level Policies</th>
<th>Timeliness of the Response</th>
<th>Experiences Dealing with Past Pandemics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Death Rate by Number of Cases</td>
<td>Beijing</td>
<td>1.52%</td>
<td>23151</td>
<td>5.74</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Guangdong</td>
<td>0.50%</td>
<td>12198</td>
<td>4.56</td>
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<td>1</td>
</tr>
<tr>
<td></td>
<td>Henan</td>
<td>1.72%</td>
<td>7080</td>
<td>6.34</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Zhejiang</td>
<td>0.08%</td>
<td>13925</td>
<td>5.79</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Hong Kong</td>
<td>0.38%</td>
<td>49334</td>
<td>5.40</td>
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<td>2</td>
</tr>
<tr>
<td></td>
<td>Taiwan</td>
<td>1.36%</td>
<td>24828</td>
<td>6.98</td>
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<td>1</td>
</tr>
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<td></td>
<td>South Korea</td>
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<td>12.43</td>
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<tr>
<td></td>
<td>Singapore</td>
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<td>2.40</td>
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</table>

(Figure 21c. Death Rate by Number of Cases)

(Figure 21. Continuous dependent variable with continuous independent variable)

### Regression 4

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Independent Variable</th>
<th>GDP Per Capita (2019)</th>
<th>Medical Resources</th>
<th>Number of Unique Local Level Policies</th>
<th>Timeliness of the Response</th>
<th>Experiences Dealing with Past Pandemics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Growth Rate (Avg # of New Cases/Day)</td>
<td>Beijing</td>
<td>4.79</td>
<td>2</td>
<td>5.74</td>
<td>1</td>
<td>3</td>
</tr>
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<td></td>
<td>Guangdong</td>
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(Figure 22a. Growth Rate)
### Regression 5

<table>
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<th>Dependent Variable</th>
<th>Independent Variable</th>
<th>GDP Per Capita (2019)</th>
<th>Medical Resources</th>
<th>Number of Unique Local Level Policies</th>
<th>Timeliness of the Response</th>
<th>Experiences Dealing with Past Pandemics</th>
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</thead>
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</table>

(Figure 22b. Population Adjusted Growth Rate)

### Regression 6

<table>
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<th>Dependent Variable</th>
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<th>GDP Per Capita (2019)</th>
<th>Medical Resources</th>
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<th>Timeliness of the Response</th>
<th>Experiences Dealing with Past Pandemics</th>
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<tr>
<td>Beijing</td>
<td>1.52%</td>
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<td>5.74</td>
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<td>3</td>
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</tr>
<tr>
<td>Guangdong</td>
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<td>4.56</td>
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<td>2</td>
</tr>
<tr>
<td>Henan</td>
<td>1.72%</td>
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<td>6.34</td>
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<td>1</td>
</tr>
<tr>
<td>Zhejiang</td>
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<td>5.79</td>
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</tr>
<tr>
<td>Hong Kong</td>
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<td>5.40</td>
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<td>3</td>
</tr>
<tr>
<td>Taiwan</td>
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<td>1</td>
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</tr>
<tr>
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<td>Singapore</td>
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<td>2.40</td>
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</table>

(Figure 22c. Death Rate by Number of Cases)

(Figure 22. Continuous dependent variable with categorical independent variable)

### Regression 7

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<th>Dependent Variable</th>
<th>Independent Variable</th>
<th>GDP Per Capita (2019)</th>
<th>Medical Resources</th>
<th>Number of Unique Local Level Policies</th>
<th>Timeliness of the Response</th>
<th>Experiences Dealing with Past Pandemics</th>
</tr>
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</tr>
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</tr>
<tr>
<td>Henan</td>
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</tr>
<tr>
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<td>13925</td>
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</tr>
<tr>
<td>Hong Kong</td>
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<td>3</td>
</tr>
<tr>
<td>Taiwan</td>
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<td>1</td>
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</tr>
<tr>
<td>South Korea</td>
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<td>12.43</td>
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<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Singapore</td>
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<td>63987</td>
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</tbody>
</table>

(Figure 23a. Growth Rate)
### Regression 8

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<th>Dependent Variable</th>
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</thead>
<tbody>
<tr>
<td>Growth Rate Adjust by Population Density</td>
<td>GDP Per Capita (2019)</td>
</tr>
<tr>
<td>Beijing</td>
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</tr>
<tr>
<td>Guangdong</td>
<td>1</td>
</tr>
<tr>
<td>Henan</td>
<td>1</td>
</tr>
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<td>Zhejiang</td>
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</tr>
<tr>
<td>Taiwan</td>
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<td>South Korea</td>
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<td>Singapore</td>
<td>3</td>
</tr>
</tbody>
</table>

Late-3 Medium-2 Early-1
High-3 Medium-2 Low-1

(Figure 23b. Population Adjusted Growth Rate)

### Regression 9

<table>
<thead>
<tr>
<th>Dependent Variable</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Death Rate by Number of Cases</td>
<td>GDP Per Capita (2019)</td>
</tr>
<tr>
<td>Beijing</td>
<td>1</td>
</tr>
<tr>
<td>Guangdong</td>
<td>1</td>
</tr>
<tr>
<td>Henan</td>
<td>1</td>
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<td>Zhejiang</td>
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<td>South Korea</td>
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</tr>
<tr>
<td>Singapore</td>
<td>0</td>
</tr>
</tbody>
</table>

Late-3 Medium-2 Early-1
High-3 Medium-2 Low-1

(Figure 23c. Death Rate by Number of Cases)

(Figure 23. Categorical dependent variable with continuous independent variable)

### Regression 10

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Independent Variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Growth Rate (Avg # of New Cases/Day)</td>
<td>GDP Per Capita (2019)</td>
</tr>
<tr>
<td>Beijing</td>
<td>2</td>
</tr>
<tr>
<td>Guangdong</td>
<td>1</td>
</tr>
<tr>
<td>Henan</td>
<td>1</td>
</tr>
<tr>
<td>Zhejiang</td>
<td>1</td>
</tr>
<tr>
<td>Hong Kong</td>
<td>3</td>
</tr>
<tr>
<td>Taiwan</td>
<td>2</td>
</tr>
<tr>
<td>South Korea</td>
<td>2</td>
</tr>
<tr>
<td>Singapore</td>
<td>3</td>
</tr>
</tbody>
</table>

Late-3 Medium-2 Early-1
High-3 Medium-2 Low-1

(Figure 24a. Growth Rate)
For each of the model, the author starts looking at the correlation of the output variable with the explanatory variable separately. Then the author tries to fit single regression models when appropriate. By observing the correlations between the output variable and explanatory variable and the significance of the independent variables (i.e., the p-value) from the models, the author then decides which are the variables that can explain the most variations in the data. Additionally, the author also tries to compare out of the four approaches of using continuous vs. categorical variables, which one will be most suitable within the context of this research. Even though there
are many models involved in the process, the author hopes to either find some similarities between the models (i.e., variable X predicts the outcome variable in different models) or find out which model performs much better than the other and explains the potential underlying reasons. Following these steps, the author hopes to identify the most important independent variable that predicts the outcome of government response policies and answer the proposed hypotheses.

5. EVIDENCE AND DISCUSSIONS

After experimenting with the four different approaches, the author has concluded that using the categorical outcome variable and continuous input variable shows the greatest statistical power (i.e., the Model 8 as shown above). This is likely because the large variation in continuous dependent variable is smoothed by the categorical variable while the variations in the input variables are maintained. Especially given the fact that there are only very few observations with relatively abundant number of variables, scaling them to a few numbers are more reasonable. Additionally, models without the observation of Singapore are generally better than the one including Singapore. This may be due to the previous suggestion that Singapore varies very much in the dependent variables and without Singapore observation, the input variables can better explain the outcome. This section is going to begin with a detailed analysis of the quantitative evidence, followed by the qualitative evidence to see whether it agrees or disagrees with the results from the quantitative part. Lastly, the author will summarize the most important insights from the data.

5.1 Quantitative Evidence
Across all the models, we find that the model is strongest (i.e., has the highest statistical significance and best explanation power) when we use the population adjusted growth rate as the dependent variable. This is almost true for all of the four approaches that we proposed, and it is consistent with our previous assumption. The author thinks it is because the differences in demographics may bias the data for Option 1 and that the death rate data is too low to show the power of the model for Option 3. Therefore, the models that we choose to discuss below all have the Option 2 (i.e., the population adjusted growth rate) as our dependent variable. Across four types of models, using the categorical dependent variable and continuous independent variables seem to fit the data the most. We will focus on discussing the results from Approach 3 (i.e., using categorical outcome variable and continuous explanatory variables). The explanation will be centered around the results with all 8 observations involved, with a slight discussion on the model when excluding Singapore. The result of the models tested will be included in the Appendix D to show why those approaches are not as appropriate as the one we select as our final model.

5.3 Approach 3—Categorical Dependent Variable and Continuous Independent Variables

We started finding the correlations between all the explanatory variables and the output variable (i.e., population adjusted growth rate). Out of the five variables, the GDP per capita seems to have the highest correlation (0.925) with population adjusted growth rate, followed by experiences dealing with SARS (0.793), and timeliness of response (0.566). The amount of available medical resources and number of unique local-level policies don’t seem to be that correlated with the outcome variable with only a -0.144 and -0.147 correlation respectively. Figure 24 below shows the detail of the five correlation matrices. It does seem like from the initial analysis,
GDP per capita and experiences dealing with SARS are the most correlated and significant variables to explain the output variable.

(Figure 25a. Correlation between GDP per capita and the population adjusted growth rate)

(Figure 25b. Correlation between available medical resources with the population adjusted growth rate)

(Figure 25c. Correlation between number of unique local level polices and the population adjusted growth rate)

(Figure 25d. Correlation between timeliness of response and the population adjusted growth rate)

(Figure 25e. Correlation between experience dealing and past pandemics with the population adjusted growth rate)

As mentioned before, we subjected that the correlations may be stronger when we take out the Singapore observation because it seems to be an outlier on the output variable end. After experimenting, there are two correlations that are improved after dropping the Singapore
observation. The correlation for medical resources changed from -0.144 to 0.566 and the correlation for experience dealing with SARS has increased from 0.793 to 0.837. The other variables either doesn’t show significant changes in the correlations or have decreased associations (i.e., the correlation for timeliness of response has decreased from 0.566 to 0.258).

<table>
<thead>
<tr>
<th></th>
<th>Growth Rate Adjust by Population Density</th>
<th>Medical Resources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Growth Rate Adjust by Population Density</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Medical Resources</td>
<td>0.565848558</td>
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</tbody>
</table>

(Figure 26a. Correlation between available medical resources and the population adjusted growth rate without Singapore observation)

<table>
<thead>
<tr>
<th></th>
<th>Growth Rate Adjust by Population Density</th>
<th>Experiences Dealing with Past Pandemics</th>
</tr>
</thead>
<tbody>
<tr>
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</tr>
<tr>
<td>Experiences Dealing with Past Pandemics</td>
<td>0.836660027</td>
<td>1</td>
</tr>
</tbody>
</table>

(Figure 26b. Correlation between experience dealing with past pandemics and the population adjusted growth rate without Singapore observation)

Overall, from the correlation analysis, the data concludes that the GDP per capita and the experiences dealing with the past pandemics are most correlated with the output variable. The timeliness of response is somewhat related to the outcome while the medical resource is only somewhat related when we remove the Singapore observation. However, the number of unique local level policies doesn’t seem to be correlated with the outcome metrics with or without the Singapore observation.

We then confirmed our finding by looking at the single regression model with each of the variables above to see whether these variables are significant and whether they can explain the variations in the data. We found that variable that explains most of the variation is using GDP per capita to predict the outcome, with an R squared value of 0.86 and a P-value of 0.00999. This means that the GDP per capita value alone is able to explain 86% of the variation in the data and
that the GDP per capita variable is highly significant. Since the coefficient for GDP per capita is positive, this means that with more GDP per capita, we expect the regions to have a higher population adjusted growth rate, meaning a less effective response. This is counterintuitive but could be explained by the fact that countries with higher GDP per capita may be more connected to other places and hence have a higher possibility of disease transmission. More explanations will be provided in the Discussion section below.

(Figure 27. GDP per capita to predict the population adjusted growth rate)

Similarly, we find that experiences dealing with past pandemics also seems to be correlated with the output variable with an R square of 0.628 and is statistically significant at 0.02 level. This means that experiences dealing with past pandemics alone can explain 62.8% of the variations in the data. On the other hand, timeliness of response doesn’t seem to explain a lot of variations on its own, with an R square of 0.321 and the model is barely statistically significant at 0.15 level. The results of the statistics models are shown in the Figure 28 and Figure 29 below respectively.
Overall, our regression models confirm that these three variables seem to the most important one in predicting the categorical outcomes. Similar results are achieved (i.e., these three variables are the most significant ones in predicting the outcome variable) when excluding the Singapore observation using the same model. The only major difference is that medical resources went from being very insignificant (i.e., with a p-value of 0.733) to barely significant at 0.2 level. However, the R square value is low, meaning that medical resources alone cannot explain much of the variations in the data.

(Figure 28. Experience with past pandemics to predict the population adjusted growth rate)

(Figure 29. Timeliness of Response to predict the population adjusted growth rate)
Figure 30. Available medical resources to predict the population adjusted growth rate without Singapore observation

### 5.2 Qualitative Evidence

Many of the qualitative evidence is already presented in the Literature Review and Data and Method sections above as the secondary evidence showing what policies were in place for each of these regions and what’s the general sentiments regarding those policies. The author summarizes the important unique local level policies and when were these policies implemented in Table 1 below to emphasize the policies that were taken into consideration for the context of this research. Note that the data below comes from a combination of primary data collection and secondary data collection from other articles. There will be no separate analysis on the qualitative evidence as most of the sentiments and highlights are emphasized in the Literature Review sections as the secondary resources. The qualitative evidence of the unique policies will be analyzed together in the Discussion, Conclusions and Future Research Direction sections below.

#### Table 1: Important Policies

<table>
<thead>
<tr>
<th>Regions</th>
<th>Policies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beijing</td>
<td>No entry to other residence areas (i.e., cannot visit family or friends).</td>
</tr>
<tr>
<td>Province</td>
<td>Measures</td>
</tr>
<tr>
<td>----------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Henan Province</td>
<td>Returners from other provinces must be quarantined for 14 days in a hotel</td>
</tr>
<tr>
<td></td>
<td>Public announcements and education on local cables and channels about the information and updates about the disease</td>
</tr>
<tr>
<td>Guangdong Province</td>
<td>First highest-level of emergency response status, with measures including checking temperatures, mask requirements, and building entry monitoring quickly established (Zhang et al, 2020)</td>
</tr>
<tr>
<td></td>
<td>Hospital provides free online consultation hotlines 24/7 to reduce the need for people with minor illness going into the hospital (Zhang et al, 2020)</td>
</tr>
<tr>
<td>Zhejiang Province</td>
<td>First implementation of Health Code and Zhejiang Health Code</td>
</tr>
<tr>
<td></td>
<td>Multiple city-wise lockdown following the lockdown of Wuhan</td>
</tr>
<tr>
<td></td>
<td>Government-encouraged community-based organizations to help with checking quarantined individuals and demographics follow-up</td>
</tr>
<tr>
<td>Hong Kong</td>
<td>Early travel restrictions and no-entry permitted to non-citizens (Lam et al, 2020)</td>
</tr>
<tr>
<td></td>
<td>StayHomeSafe App to catch violators who broke the social distancing requirements</td>
</tr>
<tr>
<td>Taiwan</td>
<td>Using big data and digital health records to identify susceptible individuals and notify them in advance</td>
</tr>
<tr>
<td>Singapore</td>
<td>Hospital resources re-allocations to segment the areas within the hospitals and ensure enough operating rooms are reserved for COVID patients (Wong et al, 2020)</td>
</tr>
<tr>
<td></td>
<td>Using TraceTogether to share information about new COVID alert using the proximity data collected by Bluetooth</td>
</tr>
<tr>
<td>South Korea</td>
<td>Mass testing requirements from the government (Park and Chung, 2021)</td>
</tr>
</tbody>
</table>
### 5.3 Discussions

By observing the four different approaches above, we can compare and contrast to reach some important insights. Overall, the model with categorical output variable and continuous input variables shows the best significance and power. This is likely due to the fact that lack of adequate observations makes continuous output variable harder to fit. Additionally, because Singapore differs very much by the outcome variable, it may bias the linear regression to a large extent. This can be proven by the fact that when we remove the observation of Singapore from both Approach 1 and Approach 2, the power and significance of the models improved drastically (can be seen in the Appendix D below). The continuous input variable retains the variability in the data, especially for the GDP per capita which varies quite a bit across these regions.

Across different models, it seems to be consistent that GDP per capita and experiences dealing with past pandemics are the most significant variables to explain the variations in the model. The timeliness of policy response is somewhat statistically significant. The other two variables—medical resources and unique local-level policies—don’t seem to be correlated with the output variable. Recall that the research has five proposed hypotheses, and we want to discuss what our results imply about these hypotheses below.

#### 5.3.1 Hypothesis 1—Preparedness of the Public Health System
The preparedness of the public health system is measured together by the number of unique local level policies and the timeliness of response. Overall, while the number of unique local level policies is not indicative of the outcome, the timeliness of response seems to be a relatively important factor. The results for the timeliness of response are somewhat expected, because in the context of a worldwide pandemic, the regions that are more alerted and are able to respond earlier can contain the spread better. This conclusion confirms the theory that early response and early action is important, especially in this more and more interconnected world.

However, it is unexpected that number of unique local level policies are not important for models both including and excluding Singapore. This may be due to the lack of variations and a small range of numeric numbers for this variable. Additionally, one thing that this research didn’t take into account in the quantitative model is exactly what policies are in place in these regions. Considering that what policies are in place may be more important than how many policies are in place, our approach may be biased because it failed to understand this factor. Luckily, this is somewhat addressed in the literature review and qualitative sections where the author summarizes the exact policies in these different regions. However, it’s hard to draw correlations or even causations just by looking at the qualitative evidence that we have, and hence the current description of the policies lacks a lateral comparison power. This may be a good future direction of research as to look into if adding a specific policy has a positive or negative impact on the overall performance of the region in combating pandemics.

5.3.2 Hypothesis 2—Health Care System and Available Medical Resources

The health care system and available medical resources is modeled using the hospital beds per capita. Out of all our approaches, the available medical resources itself don’t seem to correlate
with the outcome variable. This is surprising to us because many would hypothesize that the medical resources can be important in determining how much resources a country or a region has and how much they can deploy at hand when the pandemics happen.

There may be two explanations for this result. First, these countries and regions seem to have relatively adequate medical resources compared to many other countries and regions in the world, and hence the available medical resources may not be the actual constraining factor in dealing with the pandemics, at least in what we’ve seen in these 8 observations so far. Second, in the context of a pandemic, the government may be willing to give more resources compared to a usual time to cope with the response and there may even be cross-national collaborations to help combat the crisis. Therefore, even though there are differences in the medical resources, this difference is minimized by the resource flux from other regions and non-government organizations. For example, some provinces in China have sent over doctors to provinces with more severe conditions of COVID to help even out the differences in medical resources.

Additionally, we only use the hospital beds per capita as a very rough proxy for the available medical resources. There may be other proxies that are more representative for the available medical resources. A good example maybe the number of doctors in the regions and the easiness to access the hospital settings. Especially during the special context of COVID, more places may be used as hospital beds and other medical resources to help with the pandemics and hence our current proxy may not be as appropriate.

5.3.3 Hypothesis 3—Overall Strength of the Economy

The overall strength of the economy is measured by the GDP per capita level. Out of all the variables, the GDP is the most significant and most important variable in predicting the
outcome. This means that the overall performance level of a country’s or a region’s GDP is very correlated with how well the place can handle the hit of a pandemic from the point of view of containing the spread of the case. Surprisingly, however, is that the coefficient for GDP per capita is positive, meaning that the higher the GDP level, the higher the population adjusted growth rate of cases. This is interesting because it seems to be counterintuitively of what one would expect (i.e., it’s normally assumed that countries and regions with a higher GDP level will have a better response because they have more resources and etc.)

The author came up with two explanations for the unexpected results for GDP per capita. For one, the higher the GDP, the region may have more interconnectedness within the region and with other places. Hence, there may be a consistently higher levels of travel frequency in these regions. The higher the traveling frequencies may continue to be the trend even during pandemics times, and hence increasing the probability of spreading the virus within the regions especially at the beginning phase of the outbreak. Second, there may just be different reporting counting methods for the number of cases. It may be that countries and regions with higher levels of economy strength have a more comprehensive method in censoring the cases and deaths, especially at the beginning of the pandemic phase. Nevertheless, regardless of the surprising direction of the GDP per capita variable, it is the most important significant variable in the model and can explain the most variations.

5.3.4 Hypothesis 4—Experience Dealing with Past Pandemics

Experience dealing with past pandemics is also statistically significant and very correlated with the outcome of the COVID containment. The coefficient for the experience dealing with past pandemics is also positive, meaning that the more experiences a region has dealing with past
pandemics, the higher the population adjusted growth rate of cases (i.e., the worse the outcome). This may also seem counterintuitive at the first place. However, the explanation could be provided that the regions with more experiences may be the regions more susceptible to disease outbreaks. Therefore, the fact that some regions have more past experience may not necessarily be a good thing, because it indicates the susceptibility of these places to worldwide pandemics. The statistical significance of the variable means that experience dealing with past pandemics is an important factor influencing the difference in the effectiveness of government response policies. More experiences lead to higher levels of growth rate, and the underlying reason may be due to the innate differences in the susceptibility of these regions.

5.3.5—Hypothesis 5: Demographics

In the quantitative model, the author didn’t specifically model the demographics data (i.e., the demographics data is not taken into account in the input variables). Instead, the demographics consideration, and specifically the population data, is incorporated in the output variable calculation. Since we use the population adjusted growth rate as the output variable (i.e., looking at the growth rate per 100,000 people), we have considered how the differences in population may have biased the absolute number of cases. As we can see from the differences in the actual growth rate vs. the population adjusted growth rate, the demographics adjusted data actually change the scope of the output and make the models more applicable in the context of this research.

Additionally, the demographics may influence many other aspects of the model. For example, the demographics may be related with the strength of the economy in the country and the available medical resources. The author tries un-bias the model by using variables that take into account this consideration. For example, the author used the medical resources per capita
instead of total medical resources for these regions. However, there still remains the possibility that more influences of the demographics data on other variables are not discovered or that the demographics may be the confounding factor in some of the conclusions that we draw earlier.

Therefore, the preliminary message is that the demographics of these regions are important to predict the outcome of pandemics control, just like the demographics data is generally important in many infectious disease contexts. Although this research does show that the demographics, and especially the population density, may indeed be correlated with the outcome and may contribute to the differences in the effectiveness of government response policies, more detailed research needs to be conducted. Specifically, future research could look at the correlations between how exactly the demographic data influences the outcome variables.

5.4 Synthesis

To conclude, the data analysis suggests that the strength of the economy, timeliness of response, and experiences dealing with past pandemics are the best candidates to explain the differences in the effectiveness of government response policies. It’s an interesting result because two of the three most important variables were initially categorized under the secondary hypotheses and only one out of three variables was from the primary category. Out of the three variables, the GDP per capita can explain the most variation in the outcome variable with the highest statistical significance. The strength of the economy is expected to have a significantly positive effect on the population adjusted growth rate. This means that the higher the GDP level, the faster the spread of the cases within the region. The most likely explanation is the fact that regions with higher GDP levels are more interconnected and have more traveling frequencies to other places, hence it is more likely to have a higher rate of spread. Additionally, places with higher
GDP levels tend to have a higher population density as we can see from the Figure 5 in the previous section, the higher population density may lead to an unbalanced growth of cases in more densely populated regions.

The experience dealing with past pandemics is also very statistically significant and can explain an adequate number of variations in the effectiveness of government response policies. Unlike what one would expect, the regions with more experiences dealing with past pandemics actually have a worse outcome in terms of effectiveness in containing COVID. The author thinks that it is more likely that these places are more susceptible to infectious disease outbreaks. For example, these places could be the transportation centers or are exposed in areas where viruses can generally live longer. Even though some government may have more experiences than others, as indicated by Park, Choi, and Ko (2020) that South Korea was able to develop the COVID testing kits very quickly from the ones they had for MERS, these experiences can now be easily shared across countries and regions and hence may not be a huge advantage to the countries with more experiences.

The timeliness of response is barely statistically significant with a relatively low R value. Nevertheless, these three variables translated to three out of the five proposed hypotheses being tested. It indicates that regardless of what situations the countries are in, acting earlier seems to be better than acting later. Even though the government may change the policies later due to new circumstances, it is essential to have some measures in place earlier than later.

The other two variables—unique number of local level policies and the available medical resources—are not very correlated with the outcome variable. These two variables were initially from the primary hypotheses category, but the research result doesn’t suggest that these two factors are not related to the effectiveness of government response policies. It could be that the author
didn’t have the best proxy for these two variables, and it could also be that the author wasn’t able to model more details about the policies instead of just the number of policies. More research is needed to explore whether these two variables are just not correlated with how effective the government response policy is at all, or there are actual correlations that were not explored in this research.

Additionally, there are two caveats to be aware of when thinking about the conclusion for this research. One is that there are only 8 observations in total and there aren’t many variations within the data, especially for the input variables. This makes the dataset not a perfect setup for correlation and regression analysis, as generally more data and more variation are preferred. This also makes Singapore an outlier from the data because the other outcome variables have much lower numbers. The second caveat is that these regions of studies all have relatively good containment of COVID when compared to the word averages, so the results may be biased because we are looking at one end of the story. It may be worthwhile to include countries that have relatively different levels of COVID controls to see whether the same conclusions can be draw. Therefore, due to these caveats, it’s important to note that the conclusions drawn below should only be interpreted in the context of these regions.

### 6. Limitations

Given the nature and data collection of this research, there are three main limitations of the research. First, as discussed in the Data and Methods section above, we only have a total of 8 observations. This is an extremely small number to build a good correlation or regression model as the correlations in a small number of datasets are more likely to be due to random chances. The two most significant effects of only have 8 observations are: 1) lack of variations in the input data;
2) it makes Singapore an extreme outlier in the output metrics. Additionally, all these regions have a relatively effective policy response judging from the overall sentiments coming from the world, so this research may only be capturing part of the story for the effectiveness. The author justifies the choice of these countries and regions as explained in the Introduction section before because these regions experienced COVID more as a shock and have data more readily available in the earlier months. However, the author does recognize the unpreventable bias introduced by only focusing on these regions and argue that the results of this research should not be interpreted outside of the context provided.

Second, the variables used in this research may not be the best and only ones important in the context of a policy response study. There may be a two-fold problem with the variables of choice in this research. First, some of the variables chosen for the quantitative analysis may not be the best proxies for the questions of interest. There may be other more appropriate variables in the context as explained in the Evidence and Discussion section above. The author chose the variables deliberately due to the ability to collect those real-time data remotely and accurately. Second, there may be other confounding factors that are either not fully explored or not considered at all in this research but could be correlated with the disparities in the effectiveness of government policy responses. Such an example could be the political structure of a country or a region, as the policymakers are often bounded by the political structures to react to crisis in certain ways. Another instance is the demographics data. More research is needed in order to fully understand the direct relationships between some of the demographic metrics to the outcome variable. Therefore, the author recognizes the limitations in the variables that are considered and analyzed in this research.

Third, common to all kinds of policy research, the lack of counterfactual makes it impossible to draw causal relationships and may have bias the study of how strong the correlation
Even though we are using the regions as a comparison for each other, we cannot entail the specific effects of a variable on the outcome. For example, we cannot predict whether country/region X will have a more effective policy response results if country/region X have had more experiences dealing with past pandemics due to the lack of counterfactuals. The author tries to minimize the impact of this limitation by focusing on the regions that identified the first COVID cases at around relatively the same time and have experienced COVID more as a shock to their society (i.e., These regions are relatively close to the hotspots and didn’t have much time to prepare for it compared to many other countries and regions in the world.) These two factors ensure that these 8 regions are more comparable and hence minimizing the impact of heterogeneity. However, the author still recognizes the lack of counterfactual being an important factor for the lack of a stronger relationship to be identified between the effectiveness of policy responses and the hypotheses.

7. Conclusions and Future Research Directions

To understand what influences the outcome disparities in COVID-19 response policies, the author explored both the current literatures and establish primary models for analysis. First the study focuses on the current sentiments from literatures and reports, then it shows the collection of primary and secondary data to establish the model, and finally quantitative and qualitative data analysis are provided to explain the most important variables affecting the differences in outcomes. In this section, the author summarizes the most important insights gained from this thesis research, provides actionable recommendations to policymakers, and sheds light on future research considerations.
7.1 Insights and Takeaways

Out of the five proposed hypotheses, three of them are shown to be correlated with the effectiveness of COVID policy responses and they provide actionable insights. First, the strength of the economy shows that higher the GDP per capita level, the lower the effectiveness. Countries with higher levels of GDPs may tend to think that they have more medical resources to be deployed when dealing with health care emergencies and hence should be less concerned about the crisis. However, this research suggests the opposite. It may be because countries with higher GDP level have a much higher level of population density and more frequent travels between other places. Hence, these countries should actually be more careful under the context of infectious disease outbreaks. A good strategy will be early implementation of travel restrictions and close monitoring of travelers to minimize the number of imported cases (Lam et al, 2020). Additionally, people living in these high-income and densely populated areas should be more alerted and willingly avoid going to crowded places as early as possible. The travel restrictions and voluntary social distancing may have a significant impact on slowing down the growth rate of infectious diseases transmission (Lam et al, 2020). In order to achieve these goals, the government needs to be prepared early on and provide adequate public education to its residents.

Second, the timeliness of response in any pandemic is crucial. Note that in the models discussed above, the author didn’t specify the details of which policies were implemented. The models simply take into account the number of unique local level policies and evaluates the timeliness of response by looking at the average implementation dates of these policies. The significant correlations indicate that regardless of what kinds of policies will be in place in the context of infectious disease outbreaks, it is important that these policies will be published and implemented as early as possible. It is understandable that some governments may choose a more
cautious attitude when it comes to disease outbreaks (i.e., not announcing any policies until more information is gathered and known). However, from the results of this research, it is better to act earlier even though it’s not the best policy, but it may be the most optimal policy at the time given the limited knowledge. Acting early can be beneficial to the local citizens and even citizens residing in other regions. Additionally, since the policies often change with the progress of the disease transmission, the tolerability of not-so-accurate policies at the beginning of the outbreak is generally higher. For countries and regions that chose to be more conservative in responding to COVID, they should be more alerted and willing to announce their policies earlier even when there are still many unknown factors around the crisis.

Lastly, past experienced dealing with the pandemics indicates that regions with more experiences actually have a lower effectiveness. This doesn’t mean that having experiences doesn’t help at all with future pandemics. What this may really suggest is that some regions may be more susceptible to infectious disease outbreaks than others and these regions should be especially alerted. Potential reasons behind the high susceptibility could be that these regions are transportation hubs (i.e., frequent travels from and to other places) or the climate and weather in these places facilitate the disease transmission more easily. Regardless of the reasons, these regions should reflect on their past experiences and be even more careful whenever the next disease outbreak may be threatening. Some qualitative evidence does suggest that regions with more experiences can come up with a plan more quickly or design and manufacture the testing kits more easily (Park and Chung, 2021). However, this advantage may be offset by the fact that these regions are more susceptible, and the viruses usually hit the areas faster.

It’s actually interesting to observe what variables influence the outcomes of COVID policy responses. Overall, the message is clear—the outcome of COVID control could be affected by
multiple variables in different ways. Given that infectious disease outbreak is unpredictable and unstable, countries and regions should all be prepared for the worst-case scenarios. All three hypotheses above together re-emphasized the importance of institutional learnings. Especially worth noting is the unexpected results from the relationships with GDP and experiences dealing with past pandemics. Countries and regions with more advanced economic development and more experiences with past pandemics should actually be more alerted in case of health care crisis. If the government can learn from the experiences of COVID and reflect on what factors influenced the outcomes, they should be able to come up with emergency plans based on their local situations. The more prepared the government, the better the chance to contain the spread of infectious disease at an earlier stage.

7.2 Future Considerations

Even though it is crucial to provide prompt analysis of the COVID response policies in order to provide real-time feedback and actionable plans, there remain some unsolved questions. The author believes that the research fields still require the following three aspects of additional studies in order to advance the field of COVID-19 policy analysis further.

First, more research is needed in providing lateral comparisons on more regions. As mentioned in the previous sections, only 8 observations in the quantitative data model have weakened the explanatory power of our models. It’s important to include more countries or regions for comparison and to establish a stronger relationship. Even though the methods of this research are replicable to many other regions, it is suggested that future studies should focus on more regions for comparison in general. Additionally, because these 8 regions are on the spectrum of relative effective outcomes compared to the world, it’s important to also include more variations
in the model in the future. By introducing regions with even more disparate outcomes, the research may identify different factors contributing to the large disparities observed.

Second, future research should explore different variables than the ones included in this study. Due to the availability of many data at early stages of COVID outbreak and the author’s constraint to collect abundant data, some of the variables do not incorporate all the levels of details that the author expected. For example, a more detailed explorations into different kinds of local level policies and whether a particular policy has an impact on the overall effectiveness of response can be worth exploring. Additionally, many variables that are not mentioned in this study can be valuable to study as well. The author encourages the field to explore more broadly and test out different hypotheses. In the end, a research effort to compare and contrast the important contributing factors is required to have a significant impact in the field of COVID policy responses.

Third, there is a need for the long-term monitoring of the effectiveness of COVID response policies. As COVID continues to threat the health of the world, there seems to be different impacts at different stages of the disease outbreak. This research focuses solely on the beginning period of the outbreak and in regions that are affected relatively early on and experienced COVID as an exogenous shock. More studies on different countries which encounter COVID at relatively different time frames can provide insights into whether the influencing factors change over time. Additionally, a long-term follow-up on the regions of studies is important as authors can compare and contrast across the academic field whether the same regions experience different outcomes over a longer period of time.

It takes a great amount of collective efforts to understand the variations in COVID-19 containment outcomes. It is even more difficult to dissect what are the most important contributing factors to such disparities. An interpretation into this field can have significant impact on how the
governments can best prepare for future health care crisis. It is the author’s hope that this thesis research contributes to the scholarly field by summarizing the status quo and provides a detailed comparison of the regions of interest.

_Last but not the least, a special thanks to Professor Mark V. Pauly on his suggestions and mentoring throughout this thesis research, without whom I would definitely not be able to complete such a project. Another special thanks to Dr. Utsav Schurmans for providing and organizing the Wharton Research Scholars opportunity for me to start thinking about a research topic of great importance to me._


"Singapore's COVID-19 Contact Tracing App Now Freely Available To Developers."

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APPENDIX A

Data sources for the preliminary policy results attached above:

2. 1 Point 3 Acres: https://coronavirus.1point3acres.com/zh/world
5. World GDP per capita data (2019):
   https://en.wikipedia.org/wiki/List_of_countries_by_GDP_(nominal)_per_capita
8. Contact tracing for Hong Kong: Huang, Sun, and Sui (2020, April 15).
9. Contact tracing for Taiwan: Cheng, Jian, Liu, Ng, Huang, and Lin (2020).
11. HK quarantine measures: Zhang, Chung, and Wong (2020, March 27).
12. Singapore quarantine measures: Ng et al (2020)
APPENDIX B

Data sources for the calculations of dependent and independent variables:

1. Number of COVID cases in China (Live updates): http://2019ncov.chinacdc.cn/2019-nCoV/

2. Number of hospital beds per capita for different provinces in mainland China:
   This statistic shows the number for 1,000 inhabitants in Beijing.

   In 2018, Hong Kong's hospital density is 5.4 beds per thousand inhabitants.

4. Number of hospital beds per capita for TW:
   Hospital bed density in Taiwan 2007-2017 shows there are 0.2 beds per ten thousand inhabitants.

5. Number of hospital beds per capita for South Korea:

6. Number of hospital beds per capita for Singapore:
   https://data.worldbank.org/indicator/SH.MED.BEDS.ZS
APPENDIX C

Explanation for the cutoff points for the quantitative models:

1. Cutoff points for dependent variables:

<table>
<thead>
<tr>
<th>Dependent Variables</th>
<th>Growth Rate (Avg # of New Cases/Day)</th>
<th>Growth Rate Adjust by Population Density</th>
<th>Death Rate by Number of Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4.79</td>
<td>12.04</td>
<td>7.98</td>
</tr>
<tr>
<td></td>
<td>0.02</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>1.52%</td>
<td>0.50%</td>
<td>1.72%</td>
</tr>
</tbody>
</table>

(Figure 31. Dependent Variables explanations)

a. Growth Rate: cut-off points for “Low” is anything below 5; cut-off points for “Medium” is anything in between 5 and 20; cut-off points for “High” is anything higher than 20.

b. Population Adjusted Growth Rate: cut-off points for “Low” is anything below 0.1; cut-off points for “Medium” is anything in between 0.1 and 0.5; cut-off points for “High” is anything higher than 0.5.

c. Death Rate by Number of Cases: cut-off points for “Very low” is anything below 1%; cut-off points for “Low” is anything in between 1% and 5%, no higher ranges were observed.

2. Cutoff points for independent variables:
(Figure 32. Independent Variables explanations)

a. GDP per capita: cut-off points for “Low” is anything below 15000; cut-off points for “Medium” is anything in between 15000 and 40000; cut-off points for “High” is anything higher than 40000.

b. Medical Resources: cut-off points for “Low” is anything below 4; cut-off points for “Medium” is anything in between 4 and 8; cut-off points for “High” is anything higher than 8.
APPENDIX D

Additional quantitative models are provided below:

1. The best model for continuous outcome and input variables:

<table>
<thead>
<tr>
<th>Growth Rate Adjust by Population Density</th>
<th>GDP Per Capita (2019)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Growth Rate Adjust</td>
<td>1</td>
</tr>
<tr>
<td>GDP Per Capita (2019)</td>
<td>0.761789809</td>
</tr>
</tbody>
</table>

**SUMMARY OUTPUT**

Regression Statistics

- Multiple R: 0.761789809
- R Square: 0.580323713
- Adjusted R Square: 0.510377665
- Standard Error: 0.924983385
- Observations: 8

**ANOVA**

<table>
<thead>
<tr>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>Significance F</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7.0986375</td>
<td>7.098637505</td>
<td>8.2967334</td>
<td>0.028042885</td>
</tr>
<tr>
<td>6</td>
<td>5.1335656</td>
<td>0.855394262</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>12.232203</td>
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<td></td>
<td></td>
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</tbody>
</table>

**Coefficients**

<table>
<thead>
<tr>
<th></th>
<th>Standard Error</th>
<th>t Stat</th>
<th>P-value</th>
<th>Lower 95%</th>
<th>Upper 95%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-0.928823156</td>
<td>0.6012754</td>
<td>-1.544754864</td>
<td>0.1733577</td>
<td>-2.400091149</td>
</tr>
<tr>
<td>GDP Per Capita (2019)</td>
<td>5.14608E-05</td>
<td>1.787E-05</td>
<td>2.880405078</td>
<td>0.0280429</td>
<td>7.74471E-06</td>
</tr>
</tbody>
</table>

(Figure 33. Continuous outcome variables and continuous input variables)

2. The best model for continuous outcome variables and categorical input variables:

<table>
<thead>
<tr>
<th>Growth Rate Adjust by Population Density</th>
<th>GDP Per Capita (2019)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Growth Rate Adjust by Population Density</td>
<td>1</td>
</tr>
<tr>
<td>GDP Per Capita (2019)</td>
<td>0.569909586</td>
</tr>
</tbody>
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105
3. The best model for categorical outcome and input variables:

(Figure 34. Continuous outcome variables and categorical input variables)

(Figure 35. Categorical outcome variables and categorical input variables)