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The Dilemma of Balancing Public Health and Economic Concerns: Benefit and Cost Analysis on China's COVID-19 Policy Under Monte Carlo Simulation

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Abstract

This study explores the dilemma of balancing public health and economic concerns during a pandemic through a cost-benefit analysis approach in public economics. To estimate the impact of public health policies during an epidemic, this research innovatively applies the Monte Carlo simulation algorithm, using both top-down and bottom-up methods to avoid double counting. The study focuses on zero-clearance public health policy, analyzing the value of lives saved and the economic output decline of the society as a whole during the pandemic as the benefit and cost of preserving lives, respectively. Additionally, the study examines the decreased infected population and medical expenses gained through reductions in mortality due to public health policies, estimating the costs and expenses associated with COVID-19 infection and unemployment using a bottom-to-up method. The study concludes with a discussion of the limitations in data comprehensiveness and authenticity, as well as the particularities of public health policies based on political attributes.

Keywords: Benefit-Cost Analysis, COVID-19, Monte Carlo Simulation, public economic, public health policy

1. Introduction

China has adopted a rigorous COVID-19 containment policy, known as "dynamic zero" (Reuters, 2022), nearly three years into the pandemic. This policy mandates the regular administration of PCR tests for early detection, with a negative test result obtained within two to three days required for entry into businesses and public facilities. Those without a negative test result are legally prohibited from accessing such facilities. Another policy employed is lockdown, which can be implemented at various levels, including building, residential compound, or broader areas. A single case can trigger a lockdown, effectively restricting mobility and movement within affected areas for potentially prolonged periods. Entire cities, such as Shanghai, Xian, Chengdu, Tianjin, and Shenzhen, as well as entire provinces and regions, such as Xinjiang, Tibet, and Jilin, have been subject to lockdowns, some lasting for months. Since March 2020, China's borders have remained largely closed to visitors of all nationalities, with arrivals required to undergo seven days of quarantine at a facility, followed by three days of home isolation.

Over the past three years, the COVID-19 pandemic and the accompanying public health policies have had profound effects on China's economy, as well as the economies of other countries globally. As depicted in Figure 1, China's GDP growth rate in 2020 was the lowest it has been in three decades, at 2.2%. While it rebounded in 2021, with a projected growth rate of 8.1%, experts from the World Bank and the International Monetary Fund have forecast a growth rate of 2.8% to 3.2% for 2022. (The World Bank in China, 2022)

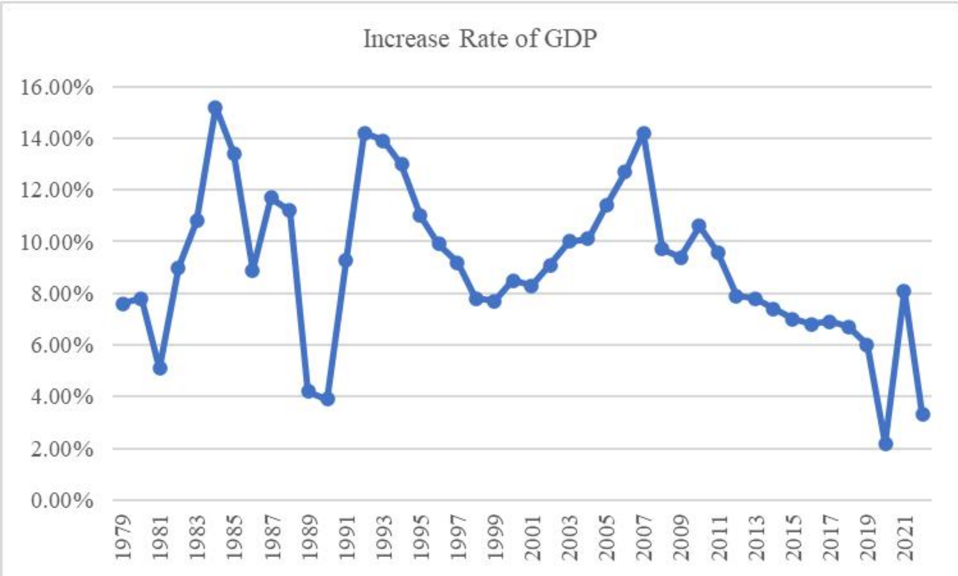

Figure 1. The Increase Rate of GDP, China (1979-2022)

According to Robinson's (2021) recent research publication, there is a potential for the costs of implementing lockdowns to exceed the benefits. This is based on a comparison of the possibility of deaths resulting from economic damages or underfunding and the lives saved through the imposition of lockdown measures, with the significant financial expenses associated with such actions. (Robinson, Oliver, 2021) Economist and Chinese entrepreneur, Liang, suggests that as the virus continues to mutate from Alpha to Omicron, the expenses of implementing the "anti-infection strategy" may rise substantially. In the event that Omicron's case fatality rate approaches that of influenza, a change in strategy may be necessary to better balance the costs and benefits of these measures. (Jiangzhang Liang, 2022)

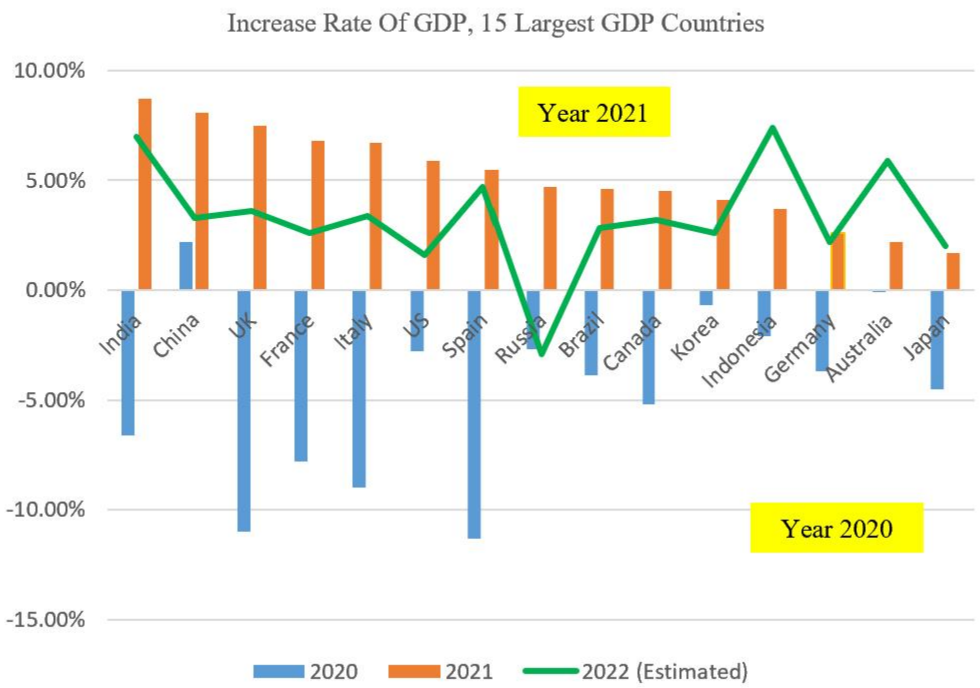

Figure 2. Increase rate of 15 Largest GDP Countries

2. Theoretical Model

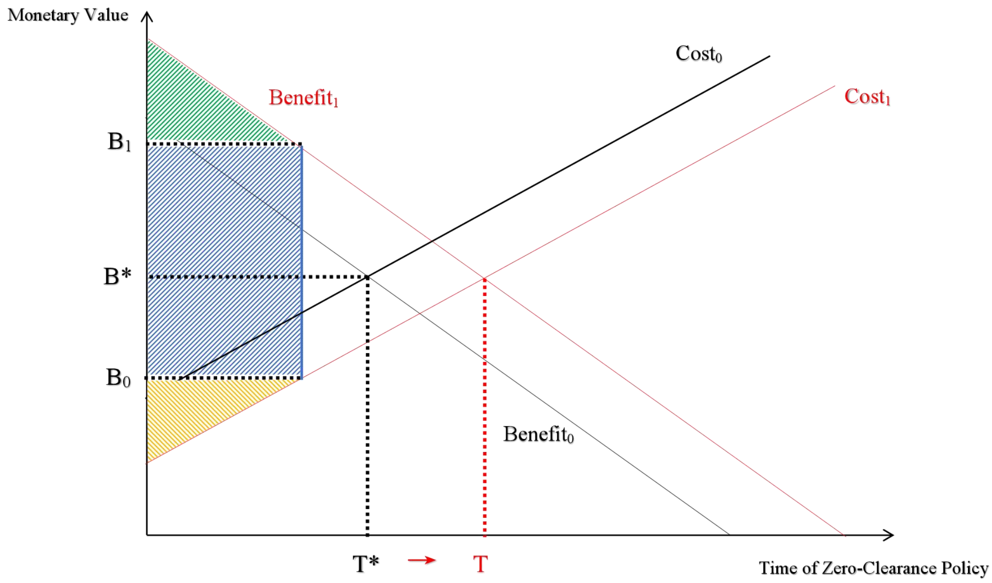

Figure 3. Benefits and Costs of Policy Intervention

In the down-to-top method, the benefit of policy intervention refers to the decreased infected population related health care fees and possible loss of wages due to Covid-19, as shown in the above figure by the shift from Benefit_0 to Benefit_1. Much stricter policy, fewer people get infected, and less loss happen. The cost from policy intervention is possible unemployment and cost associated with lay-off, which are most likely solutions when companies faced long-term zero-clearance policy, especially the small and middle-sized companies. The longer the lockdown lasts, the more businesses will run into difficulties, resulting in more job losses and layoffs, shown as the shift from Cost_0 to Cost_1.

In the top-to-down method, the cost of policy intervention refers to the decrease of GDP from 2020 to 2023 due to the zero-clearance policy, as shown in the above figure by the shift from Cost_0 to Cost_1. The cost from policy intervention is depicted graphically in Figure 3, where the upward shifting, pointing to an positive relationship between time of zero-clearance policy and the increase of the cost, where the cost measures the quantity decreasing in terms of GDP. The benefit of policy intervention refers to the value of saved life due to the zero-clearance policy, that is, minimizing exposure as much as possible keeps infection rates close to zero in most areas, as shown in the above figure by the shift from $\mathrm{Benefit}_0$ to $\mathrm{Benefit}_1$. The benefit from policy intervention is depicted graphically in Figure 3, where the upward sloping, pointing to a positive relationship between time of zero-clearance policy and death case due to infection of COVID-19, where the cost measures the quantity decreasing in terms of GDP.

3. Methods

This study endeavors to evaluate the net benefits of China's zero-clearance policy, which aims to curb the spread of COVID-19, through two distinct approaches: the up-to-down method and the down-to-up method. The former assesses the aggregate costs and benefits to society at large, taking into account the effects on total economic production and the value of statistical life. The latter, on the other hand, analyzes the net benefits at the individual level, considering factors such as healthcare utilization, wage reduction, and loss arising from unemployment. This approach is particularly valuable in avoiding the error of double counting, which is a common pitfall in benefit-cost analyses.

The primary objective of COVID-19 policies is to mitigate the mortality rate. In the up-to-bottom method, the value of lives saved through the strictest health policy is the focus of this research for the benefit analysis. From a macro-level perspective, the economic output decline of the society as a whole during the pandemic is viewed as the cost of preserving lives. This assertion is supported by the observed sharp decline in GDP across all countries between 2020 and 2022. Therefore, the estimate indicators for the cost of the zero-clearance policy are captured by the GDP.

From an individual perspective, a strict public health policy can provide the benefit of mitigating the risk of contracting a viral infection. This outcome also translates into avoiding missed workdays and potential loss of wages due to sickness. However, a potential negative outcome is an increased likelihood of unemployment resulting from the economic downturn that stems from reduced business activity throughout society. Employers facing poor operations or a significant decline in orders may resort to layoffs as a means of cost reduction. This aspect warrants consideration when conducting a benefit and cost analysis of public health policies.

The adoption of estimation methods in cost and benefit analysis is a critical decision that can significantly affect the accuracy and reliability of the results. Two commonly used approaches in this regard are bottom-up and top-down estimation methods. The bottom-up approach involves the detailed estimation of individual costs and benefits, while the top-down approach involves the aggregation of higher-level data to estimate overall costs and benefits.

In this paper, Monte Carlo algorithm is used to quantify the costs and benefits of the zero-clearance policy. In some instances, utilizing the Monte Carlo simulation algorithm to directly estimate costs and benefits may result in double counting of certain factors. For example, when examining the impact of a zero-clearance policy, the lockdown would likely cause economic stagnation, leading to a decline in GDP and increased unemployment. A direct comparison between the reduction in employment and the increase in unemployment with the decline in GDP may potentially lead to the double-counting of costs, resulting in an overestimation of the economic impact of the policy.

To mitigate the potential for double counting, employing the bottom-up and top-down approaches can provide a more accurate estimation of costs and benefits. The bottom-up approach allows for a detailed examination of individual costs and benefits, ensuring that no expenses are overlooked, while the top-down approach facilitates the aggregation of data to develop a comprehensive overview of the costs and benefits associated with a policy.

The idea of simulation is as follows. Firstly, the estimation value of each benefit or cost elements is randomly selected as input. Some element is not constant, instead a distribution interval needs to be estimated. Secondly, add or subtract value of costs and benefits to get net benefits or costs of the zero-clearance policy. This is the first-time simulation. Thirdly, to repeat the first and the second step, and run this simulation time and time again until thousands of values have been generated. Finally, the probability distribution of the final estimated policy net income is obtained, through statistical analysis of these massive total net benefits or costs values after massive simulation times and times again.

Although the Monte Carlo algorithm is utilized in both the bottom-up and top-down approaches, there are slight differences in their logic. In the top-down analysis method, we use the concept of "counterfactual" in economics to make our estimates. This is because the analysis focus of this paper is not to predict the economic trend of China in the next ten years, but to compare the estimated GDP without the epidemic and the zero policy with the actual GDP under the epidemic and the zero-clearance policy. The rationale behind this approach is that the benefits of reducing the number of infections are based on present value, and it is economically viable to compare values at the same point in time. Practically, this can be interpreted as the trade-off between sacrificing future economic growth and preserving human lives and health in the present, i.e., reducing mortality.

In top-down estimates, both the estimates of unemployment and the reduction of infection-related losses are based on the current time and can be compared using T0 as a reference point. For instance, in order to prevent the spread of infections in the current population, a relatively strict zero-clearance policy was adopted, leading to economic stagnation and an increase in the current unemployment rate.

Overall, it is crucial to carefully consider the estimation method employed in cost and benefit analysis, as the accuracy of the results can significantly impact decision-making processes. Utilizing a combination of estimation approaches can help to mitigate potential issues and provide a more accurate picture of the costs and benefits of a policy or program.

4. Results

4.1 Bottom-to-Up Method

Estimated cost of health-care utilization. The product of decreasing quantity of people infected because of the lockdown, and the cost of hospitalization when infected equals an estimate of the cost of hospitalization saved as a result of the lockdown. According to the white paper "Fighting COVID-19: China in Action" released by State Council Information Office in June 2020, the average medical cost per confirmed patient is about RMB 23,000 yuan. Among them, the average treatment cost for severe patients exceeded RMB 150,000 yuan. (Ministry of Science and Technology of the People´s Republic of China, 2020; State Council Information Office, 2020)

In order to estimate the proportion of ordinary patients and severe cases, there are two authoritative reports for reference. The first was published in the Journal of American Medical Association on the statistics of the Wuhan epidemic period. Among the 138 hospitalized patients diagnosed with NCIP, 26% of the patients were critically ill and received ICU care. (Wang D, Hu B, Hu C, et al., 2020) The second data reference is from a report on the monitoring of patients in Shanghai during the closure of the city in 2022. Among the 9911 infected cases as the sample, firstly, the proportion of severe and critical cases was found to be low (2.76%), and they were mainly seen in the 60-year-old above the elderly population. Among those infected with new crowns in society, including asymptomatic infections, the severe disease rate accounts for about 0.2%. In order to provide a reference for public policy in future outbreaks, this paper will consider the different development stages of the epidemic and the severity ratio of different virus strains in the analysis. According to two reports, the estimated upper limit for the proportion of severe cases is 26%, and the lower limit is 2.76%. (Ziyu Fu, et al., 2022)

Many adults who contract COVID-19 will not be hospitalized but will bear the cost of lost wages. According to the information in the monitoring report during the Wuhan epidemic lockdown, it took 10 days for a non-severe new coronary pneumonia patient to be discharged from the hospital due to COVID-19. (Wang D, Hu B, Hu

C, et al., 2020) In addition, according to the policies promulgated by local governments in China in December 2022 (Ju sheng, 2022), it is believed that people can go to work normally after "7+3" days (10 days) after being diagnosed with new coronary pneumonia. This study will estimate the time when a patient infected with new coronary pneumonia will leave the job according to ten working days. Considering the minimum wage mandatory requirements of sick leave for employers, plus consideration of large differences of average wage levels across China, we will use RMB 2,072 as the minimum and RMB 10,000 as the maximum value for estimating the salary income that will be reduced after contracting COVID-19.

The increased unemployment. Rising unemployment due to COVID-19 is a global trend. As the COVID-19 pandemic grinds on and global labour markets continue to struggle, the 2022 International Labour Organization (ILO) report warns the slow recovery by saying the 2022 level for those without jobs, is estimated at 207 million, compared to 186 million in 2019. (International Labour Organization, n.d.) As Figure 1 shows, China's urban unemployment rate peaked at 6.2 percent in February 2020. The second highest was in April 2022, when the unemployment rate was 6.1 percent. After a brief decline from July to September, the trend has risen again. The minimum value of unemployment is 4.9% and the maximum value is 6.2% since 2020.

Among the unemployment rates during the COVID-19 pandemic, one phenomenon that needs special attention is unemployment among young people aged 16-24. From table 1, we can see in 2022, the unemployment rate increased 23.7% compared to 14.26% in 2021, even increased by 48.5% of the unemployment rate in 2019.

According the official report from China's National Bureau of Statistics, in the first three quarters of 2022, the per capita disposable income of residents nationwide was RMB 27,650 yuan. In terms of urban and rural areas, the per capita disposable income of urban residents was 37,482 yuan, the per capita disposable income of rural residents was 14,600 yuan. In the year of 2021, the per capita disposable income of urban residents was RMB 47,412 yuan and that of rural residents was RMB 18,931 yuan. (National Bureau of Statistics of China, 2022) In the first half of 2022, the per capita disposable income of Chinese residents was RMB 18,463 yuan, including RMB 25,003 yuan for urban residents and RMB 9,787 yuan for rural residents. The median per capita disposable income of national residents was RMB 15,560 yuan, and that of rural residents was RMB 8,410 yuan. (National Bureau of Statistics of China, 2022)

By the end of 2021, 746.52 million people were employed nationwide, including 467.73 million in urban areas. Urban employment accounts for total employment 62.7 percent.

Table 1. 2019-2022 Unemployment Rate in China

	2019-2022 Unemployment Rate			
	2019	2020	2021	2022
Urban Unemployment Rate Between 16- and 24-Years Old	11.88% (0.0117)	14.19% (0.015594)	14.26% (0.010059)	17.64% (0.015474)
Urban Unemployment Rate All-Age Group	5.15% (0.001)	5.62% (0.00338)	5.12% (0.001899)	5.59% (0.002548)
Unemployment Rate in 31 Big Cities and Towns	5.08% (0.001215)	5.56% (0.002843)	5.22% (0.001403)	5.97% (0.005569)

According to China's seventh national census, the country has a population of 1411.78 million. In 2020, 12 million people were born and 880 million people of working age lived in cities and towns, accounting for 63.89 percent of the population. To estimate costs caused by unemployment, the urban and rural working age population will be calculated respectively.

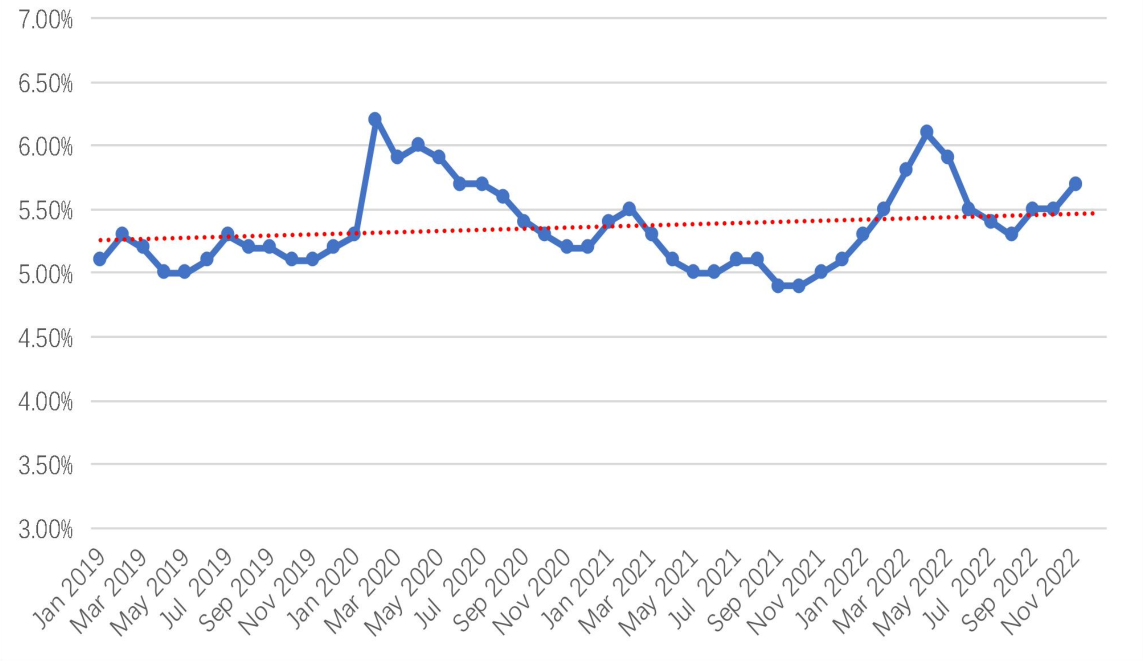

Figure 4. Urban unemployment rate

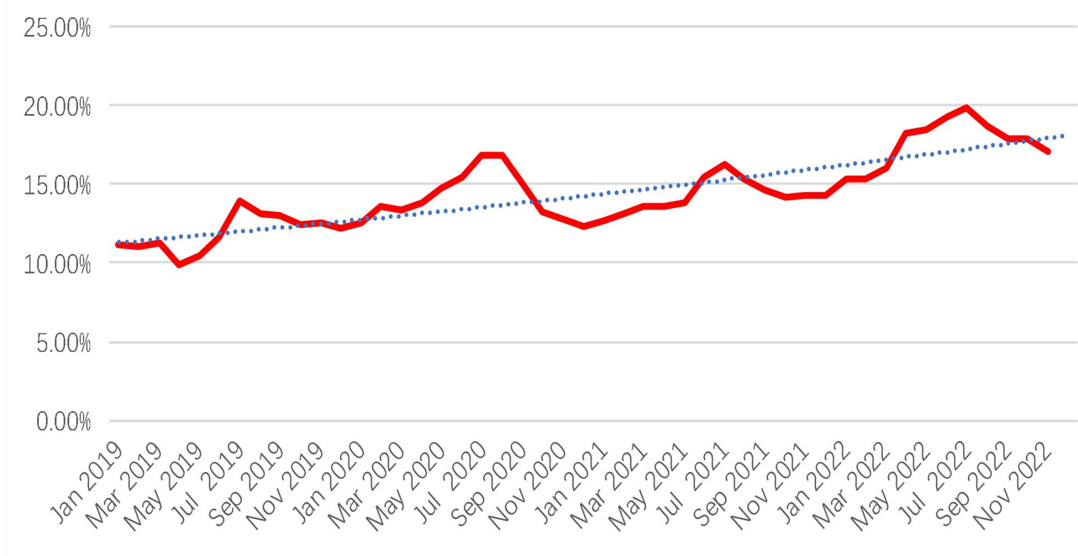

Figure 5. Urban unemployment rate between 16 and 24 years old

According to the statistics from the National Bureau of Statistics and the post-epidemic employment report released by China International Capital Corporation in 2022, the working-age population from 2011 to 2025 is shown in the table below.

Table 2. Projections of the working-age population from 2011 to 2025 (10 thousand)

Year	Age 15-24	Age 25-54	Age 55-64	Age 15-64
2011	22043.6	62996.59	14570.2	99610.4
2012	20987.87	63625.1	15208	99820.98

2013	20072.94	64308.02	15625.49	100006.45
2014	18805.19	65573.03	15504.56	99882.78
2015	17444.03	66860.88	15456.75	99761.67
2016	16710.28	67781.03	15126.07	99617.37
2017	15997.87	67760.4	15431.89	99190.17
2018	15260.57	67077.82	16415	98753.38
2019	14858.85	66554.92	16895.29	98309.07
2020	14526.59	65902.58	17447.94	97877.11
2021	14455.28	65039.14	18074.76	97569.18
2022	14453.53	64369.34	18309.67	97132.54
2023	14470.71	63176.72	19246.23	96893.66
2024	14636.94	62043.96	20316.6	96997.5
2025	14564.18	60735.31	21497.14	96796.63

Drawing on estimations of reduced number of infected people, estimated healthcare costs (ICU and non-ICU), percentage of infected people requiring ICU, potential decrease in wages, and estimated decrease in healthcare costs, we are able to estimate potential benefits. Similarly, using estimations of increased urban and rural unemployment rates, urban and rural labor populations, and urban and rural average wages, we can estimate the total potential costs. By implementing the Monte Carlo Simulation Algorithm, we can obtain a balanced benefit-cost analysis, as presented in the following table.

Table 3. Outcome of Monte Carlo Simulation Algorithm under Bottom-to-Up Method (RMB)★

Model	**Monte Carlo Simulation**
Decreased Infected People	685,219,215
Estimated Cost of Health-Care Utilization (ICU)	151681.9512
Estimated Cost of Health-Care Utilization (not ICU)	23985.51083
The Percentage of Infected People that Needed ICU	0.25
The Cost of Potentially Decreasing Wages	8986.645553
Estimated Decreased cost of health-care utilization	22,816,235,847,865
Benefits	22,816,235,847,865
Increased Urban Unemployment Rate	6.01%
Urban Labor Population	717,082,974
Urban Average Wage	50006
Increased Rural Unemployment Rate	1.32%
Rural Labor Population	289,559,335
Rural Average Wage	19574
Estimated Increased unemployment (Cost)	2,229,449,138,039.49
Balanced benefits after cost considered	20,586,786,709,825.00

Note: The result is randomly generated with N=1000, only one of which is taken as an example here.

Three groups of data generated through 1000 simulations were randomly selected, as shown in Table 3, Table 4 and Table 5. Through comparative analysis, we can see that the estimated costs and benefits of the zero-clearance policy are highly dependent on the estimated number of infections that may be reduced by the policy and the estimated unemployment rate. From the data analysis point of view, the change of the benefit from 7.436 billion yuan to 20.586 billion yuan after considering the cost resulted from the change of the unemployment rate from 5.43% to 6.01% and the estimated reduction of the number of infections from 303 million to 685 million.

In other words, if the calculation overestimates the number of infections that would result from the policy and underestimates the rise in unemployment that would result from the policy, the estimate of the benefits after costs would double, thus creating a huge difference on the assessment of the final economic impact.

Table 4. Outcome of Monte Carlo Simulation Algorithm under Bottom-to-Up Method (RMB)★

Model	Monte Carlo Simulation
Decreased Infected People	302,981,224
Estimated Cost of Health-Care Utilization (ICU)	137843.3188
Estimated Cost of Health-Care Utilization (not ICU)	21355.26876
The Percentage of Infected People that Needed ICU	0.04
The Cost of Potentially Decreasing Wages	9744.706211
Estimated Decreased cost of health-care utilization	9,438,117,291,971
Benefits	9,438,117,291,971
Increased Urban Unemployment Rate	5.43%
Urban Labor Population	717,082,974
Urban Average Wage	50006
Increased Rural Unemployment Rate	0.99%
Rural Labor Population	289,559,335
Rural Average Wage	19574
Estimated Increased unemployment (Cost)	2,001,783,554,414.75
Balanced benefits after cost considered	7,436,333,737,556.72

Note: The result is randomly generated with N=1000, only one of which is taken as an example here.

Table 5. Outcome of Monte Carlo Simulation Algorithm under Bottom-to-Up Method (RMB)★

Model	Monte Carlo Simulation
Decreased Infected People	662,283,743
Estimated Cost of Health-Care Utilization (ICU)	143556.0518
Estimated Cost of Health-Care Utilization (not ICU)	22755.45659
The Percentage of Infected People that Needed ICU	0.21
The Cost of Potentially Decreasing Wages	4994.610958
Estimated Decreased cost of health-care utilization	18,548,252,731,025
Benefits	18,548,252,731,025
Increased Urban Unemployment Rate	5.60%
Urban Labor Population	717,082,974
Urban Average Wage	50006
Increased Rural Unemployment Rate	0.16%

Rural Labor Population	289,559,335
Rural Average Wage	19574
Estimated Increased unemployment (Cost)	2,016,105,866,905
Balanced benefits after cost considered	16,532,146,864,118.60

Note: The result is randomly generated with N=1000, only one of which is taken as an example here.

4.2 Up-to-Bottom Method

Reduced Mortality. To evaluate the potential benefits from reduced mortality caused by COVID-19, we need to have an estimation of possible infection rate, the mortality rate of the infected, and the value of life.

Some scholars in US employed the projected number of prevented deaths to multiply the estimate of expected life production, to get the total benefits of prevention more death. (Broughel J, Kotrous M., 2021) That method doesn't fit for the cases in this study, because of the large population and density of population in China, which country has its own complexity of public health policy in terms of demographic issues and political economic specialty. Some studies in China point out no significant relationship between COVID-19 spreading and population density, because their data was from periods under strictest lockdown policy in China. Just as what they mentioned in their research paper, the unprecedented lockdown policies in China included the prohibition of unnecessary commercial activities in people's daily lives, preventing any types of people gathering by urging people to stay at home, and restrictions on private vehicles and public transportation, which made China the strictest in the world.

From a global perspective, as of January 2023, the United States (1,121,097 cases) topped the list of cumulative death cases, followed by Brazil (694,909 cases), India (530,721 cases), Russia (394,080 cases), Mexico (331,314 cases), Peru (218,387 cases), United Kingdom (201,028 cases), Italy (185,417 cases), Germany (162,688 cases), France (162,643 cases).

Of the 10 countries with the highest cumulative death toll, Peru has the highest number of deaths as a percentage of confirmed cases, followed by Mexico at 4.89% and 4.55%. There is no comparative data for China here, because of the particularity of China's lockdown policy. Considering the large population and complex characteristic of big cities in China, one of the main reasons for locking down is to effectively prevent virus transmission, that is controlling infection rate to the lowest rate. Similar idea to the findings from Pequeno et al. (2020) (Pequeno, P., Mendel, B., Rosa, C., Bosholn, M., Souza, J.L., Baccaro, F., Barbosa, R., Magnusson, W., 2020) and Coccia (2020) (Coccia, M., 2020) the number of confirmed cases was mainly positively related to population density in Brazil and Italy. Population density, as one of the COVID-19 transmission mechanism, cannot be ignored when evaluate the possible outcomes when lockdown policies are not as strict as what China has. For China, a more realistic reference is the death toll from the COVID-19 outbreak in Wuhan in early 2020.

Table 6. Ten countries' data of population, the number of confirmed cases and death cases

Country	Cumulative Confirmed Cases	Population	Cumulative Confirmed Cases/Population	Cumulative Death Cases	Cumulative Death Cases/Confirmed Cases
Globe	668,679,453	8,003,503,000	8.35%	6,713,734	1.0040%
USA	103,086,927	334,230,000	30.84%	1,121,097	1.0875%
Brazil	36,504,006	215,540,000	16.94%	694,909	1.9037%
India	44,681,170	1,417,173,173	3.15%	530,721	1.1878%
Russia	21,826,982	145,100,000	15.04%	394,080	1.8055%
Mexico	7,282,788	130,262,220	5.59%	331,314	4.5493%
Peru	4,469,601	33,359,416	13.40%	218,387	4.8861%

UK	24,210,131	67,026,000	36.12%	201,028	0.8303%
Italy	25,279,682	58,853,000	42.95%	185,417	0.7335%
Germany	37,509,539	84,271,000	44.51%	162,688	0.4337%
France	39,407,727	67,975,000	57.97%	162,643	0.4127%

According to the official reports, during 2020 to 2022, the total cases in Wuhan are 68861 with the total death of 4512. Jiangmei Liu and her colleagues investigated the excess total and cause specific mortality during three months of the covid-19 outbreak (January-March 2020) across different regions of China, based on a nationally representative sample of more than 300 million people. (Liu S, Wu X, Lopez AD, et al., 2016) According to their research, in the three disease surveillance points of Wuhan during the first quarter of 2020, the observed mortality rate was 56% higher than the predicted mortality rate. The main reason was a more than eightfold increase in deaths from pneumonia, including not only covid-19 related pneumonia and other pneumonias. Besides pneumonia, the mortality rates from non-communicable diseases were also increases, including hypertensive heart disease, diabetes, suicides and falls.

In this paper, we employed the data from Wuhan as the maximum estimate of mortality rate, that is 6.55%. Global average mortality rate is used as the minimum estimation and the highest rate of the TOP 10 cumulative death cases countries is considered as the mostly likely number for estimating the mortality rate.

The Value of a statistical life (VSL). To calculate mortality benefits of prevented COVID-19 death, the population average VSL is a useful parameter.

In economics, the value of statistical of life refers to how much a society is willing to spend to reduce mortality. Some people are disgusted with this concept because they believe life is priceless that we can't or needn't calculate its value. This opinion might be right from ethical perspective. However, in order to balance the risk of death caused by potential outputs and input costs, we should find a scientific and rational method to describe one life's statistical value in different areas, like working life, private business operation or public policy making.

Economists from various countries have calculated the value of life in an economic sense based on their own data. According to the research of Chinese scholars, the value of statistical life in China ranges from RMB 1 million to 7.2 million. (Yang Z, Liu P & Xu X., 2016) In this study, these two numbers are used as min and max estimation for VSL. Besides, the average is also considered as a parameter estimate, which is 4.1 million RMB. However, taking the current VSL primarily based on the preferences of current workers into account, VSL for COVID-19 might be adjusted downward for the relatively older population. According to China's National Health Commission, more than eighty percent of the deaths have been among people over 60 years old. In this paper, the probability of 80/100 has been considered in the modeling.

Projection of Decrease in GDP. How to estimate the drop in GDP due to COVID-19 lockdown has been a controversial topic. When examining the decline in GDP brought about by the zero-clearance public health policy, we can borrow the "counterfactual" concept in economics to deduce what the GDP growth rate of China would be if the zero-clearance policy did not exist under the COVID-19 pandemic, and compare it with the real GDP in 2020-2022.It should be noted that this comparative estimate runs the risk of overestimating the cost of liquidation, as the outbreak of COVID-19 may also have contributed to the decline in GDP.

According to the report *China 2030* written by the World Bank in 2013, combined with the analysis of China's economy, they made a summary and forecast of the trend of China's GDP from 2011 to 2030. They projected, China's GDP will grow 7.0% per year in 2016-2020, grow 5.9% per year in 2021-25, and grow 5.0% per year in 2026-2030.

According to the data published on the official website of the World Bank in 2023, China's GDP in the last ten years is shown in the chart below:

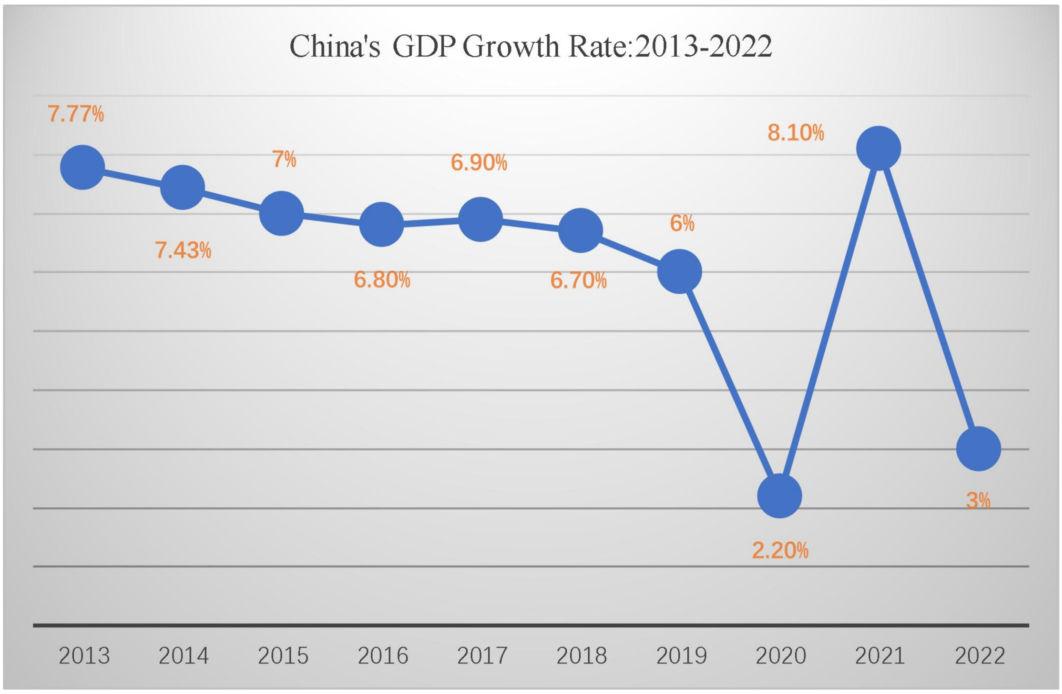

Figure 6. China's GDP Growth Rate: 2013-2022 (World Bank, 2023)

Based on the GDP of China in 2019 and the counterfactual estimates for the three years 2020-2022, the values were substituted into the cost estimation items in the Monte Carlo simulation, and combined with the life value estimation of the people were "saved" due to the reduction of infection due to the epidemic, the benefit estimation under the zero-clearance policy was obtained.

Table 7. Outcome of Monte Carlo Simulation Algorithm under Up-to-Bottom Method (RMB)★

Model	**Monte Carlo Simulation**
Decreased Infected People	179,465,635
The Value of a statistical life (VSL)	5332872.44
Morality Rate	4.69%
Estimated Decreased Value of Lives Because of Policies	44,900,974,397,301
Benefits	44,900,974,397,301
Estimated Decreased GDP (in RMB)	1,621,273,922,992
Balanced benefits after cost considered	43,279,700,474,309.00

Table 8. Outcome of Monte Carlo Simulation Algorithm under Up-to-Bottom Method (RMB)★

Model	**Monte Carlo Simulation**
Decreased Infected People	741,058,829
The Value of a statistical life (VSL)	4528916.01
Morality Rate	2.70%
Estimated Decreased Value of Lives Because of Policies	90,697,449,825,480

Benefits	90,697,449,825,480
Estimated Decreased GDP (in RMB)	1,621,273,922,992
Balanced benefits after cost considered	89,076,175,902,487.50

Three groups of data generated through 1000 simulations were randomly selected, as shown in Table 7, Table 8 and Table 9. Through comparative analysis, we can see that the estimated costs and benefits of the zero-clearance policy are highly dependent on the estimated number of infections that may be reduced by the policy, the value of a statistical value (VSL) and the estimated unemployment rate, among which the estimation on the quantity of possible decrease of infected population plays the most important role.

From the data analysis point of view, the change of the benefit from 43279 billion yuan to 133998 billion yuan after considering the cost resulted from the change of decreased infected number rate from 179 million to 582 million and the estimated morality rate is slightly different with 4.69% and 4.48 respectively. Although the above combination is generated randomly based on our preliminary estimation of each parameter, to analyze them in a comparative way, we can figure out the difference of estimation on decreased infected people and morality rate will influence the judgement of whether a public health policy has huge balancing-cost benefits.

For instance, if we made a hypothesis on that the zero-clearance policy will decrease 582 million people out of infections by Covid-19, which are the 3% of China's population, nearly 134 trillion RMB balanced benefits after costs considered would be generated. And this number is close to the China's GDP in 2022, which is 18.321 trillion US dollars. Is this estimation reasonable? It depends, because it highly depends on the accuracy of estimation of decreased infected people, morality rate, and the value of a statistical life (VSL) as well.

Table 9. Outcome of Monte Carlo Simulation Algorithm under Up-to-Bottom Method (RMB)★

Model	**Monte Carlo Simulation**
Decreased Infected People	582,795,954
The Value of a statistical life (VSL)	5193632.67
Morality Rate	4.48%
Estimated Decreased Value of Lives Because of Policies	135,619,594,369,954
Benefits	135,619,594,369,954
Estimated Decreased GDP (in RMB)	1,621,273,922,992
Balanced benefits after cost considered	133,998,320,446,962

5. Discussion

An important demographic that is not fully accounted for in our analysis is college students in China. As of 2022, there are approximately 10.67 million college students in China, representing an increase of 1.67 million students from 2021. During the three-year period from 2020 to 2022, some universities have implemented online courses while others have resorted to strict lockdown measures, prohibiting teachers and students from leaving campus. The impact of such measures on college students cannot be fully captured by the cost-benefit analysis presented in this paper. The undergraduate program typically spans four years, while postgraduate studies last two to three years, and thus the three-year period under consideration in this analysis represents a significant portion of students' university career. Restrictions on mobility and online courses may negatively affect students' learning outcomes, internships, job prospects, and even their mental well-being. However, it is important to note that the strict lockdown measures have significantly reduced the risk of Covid-19 transmission among college students, protecting their health and effectively curtailing the spread of the virus within this demographic group, which is particularly prone to transmission.

This paper acknowledges the limitations of its analysis in exploring the decision-making processes under different political regimes. The question of the value of a human life is a complex one, and the choices made by politicians under different political systems reflect this complexity. It is not a matter of right or wrong, but rather a matter of rationality in different contexts. States and regimes have an obligation to uphold human rights, including the rights to life, liberty, and property. The decision to implement strict public health policies involves a trade-off between the right to life and the right to liberty. Is it justifiable to sacrifice the right to life of a minority in exchange for greater freedom, or is it more ethical to protect the right to life of all, even at the expense of the freedom of the majority? Both approaches have their own rationality. Similarly, the question of whether the benefits of protecting economic development outweigh the value of reducing the total number of deaths is a matter of debate. Even when using economic methods to evaluate the impact of public health policies, the underlying discussion remains rooted in the value of a human life. This debate is not new and has been heightened in previous events such as the compensation claims for the September 11 attacks. The monetization of life is a sensitive issue for individuals, particularly when it concerns themselves and their loved ones.

It is important to consider the potential for misunderstanding resulting from inconsistent statistical measurement of mortality rates. When making decisions about the accuracy of infection and death data, we must take into account errors that may arise from inconsistencies in data measurement. Since China's data has been subject to criticism since 2020, this article relies on data from Wuhan and Shanghai, which were subjected to city-wide lockdown policies for 2-3 months and received significant attention and resources from both domestic and foreign medical professionals and research teams. While this attention likely resulted in rigorous, authentic, and objective data, we cannot guarantee its 100% accuracy, and we must accept the possibility of errors. This is not unique to China; any country may encounter such potential inconsistencies. Absent evidence to the contrary, we have no reason to doubt the data's integrity. Maintaining a healthy respect for the data and approaching it with rational skepticism can help us avoid over-analyzing it. By summarizing trends and the patterns they reveal, we can gain insights that are more informative for future public health policies than the data itself.

Another aspect that warrants attention is the factors that have not been comprehensively addressed in the valuation of statistical life (VSL). As a relatively recent concept, the academic discourse on VSL is still evolving and gaining clarity. Given the inherent ethical complexities, defining the precise correspondence between a higher health number and VSL remains a challenge.

6. Conclusion

The purpose of this analysis is not to determine whether a specific policy is right or wrong, but rather to provide a unique perspective on the underlying reasons behind public policy decisions. Despite being credited with reducing death rates, the Chinese government's policy has received criticism for its perceived negative impact on the economy. Moreover, the value of human life, which is necessary for Monte Carlo simulation, is a subjective evaluation that remains a highly debated topic in academic circles. As a result, there is no clear consensus on this issue, and it is unlikely to be resolved in the foreseeable future.

Simultaneously, it is crucial to consider the impact of different political systems on public policies. International politics dictates that each country or region has its own sovereignty, and public policy formulation is an essential aspect of a country's political agenda. The type of political system in place ultimately determines the nature of public policies, whether they pertain to healthcare, education, or economics, and serves as a means for political parties to attain power. Hence, the efficacy of public policies is dependent on their compatibility with the country's political ideology, and there is no objective right or wrong, but rather a question of alignment. The rationality of such alignment lies in its coherence.

From a historical analysis standpoint, the COVID-19 outbreak represents an unexpected public health crisis whose ultimate impact remains indeterminate. The assessment of policies implemented in response to this ongoing crisis will require reconsideration in the years, decades, or even centuries to come. In the grand scheme of history, it is important to acknowledge that every individual country or district holds a unique perspective and role in the larger scheme of things. This sentiment holds true in various aspects of life, including academia, politics, and society at large. By recognizing the diversity of perspectives and contributions from each country or district, we can better understand the complexity of issues and work towards achieving more comprehensive solutions. The long-term evolution, whether in the realms of economy, health, education, or law, is inherently contingent with limited correctness by human forecast.

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