

Research on the Efficiency measurement of the Lockdown approach based on the Perspective of GDP

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Abstract. Covid-19 has accompanied today's world for almost three years. China has received great success in this protracted fight between us and viruses by adopting a zero-case policy and locking down the measurement. But outside the society still consisting the gossip that China has to adopt this method is because of the too large the population base. The authorities have not confirmed the accuracy of this statement. In this paper, a comparison between China and the United States will be used to compare the advantages and disadvantages of the locking down strategy. The main methods included different ICER tests and multivariable regression analyses. The main finding includes the positive effect of GDP growth, and the advantage outweighs the disadvantage of the approach of locking down. The long-term, in return, is always the one that gets ignored the most.

Keywords: Lockdown, DID, ICER, GDP, Efficiency Measurement.

1. Introduction

1.1 Research background

Switch the time control button and turn time back; in late 2019, the world encountered an unprecedented crisis. Covid-19 shocked the world and brought damage to all countries to a varying degree. The largest economy in this world, the U.S., has suffered an enormous loss, whether from loss of life or the aspect of loss of the economy. From the very first death on January 11, 2020, to today's over a million death cases, all the people in the world express their condolences for this. Other than this, the "side effect" of this pandemic also needs people's attention. A paper analyzed that "Beyond causing sickness and death, the pandemic has triggered education disruptions, job loss, separation from friends and family, food insecurity, financial burden, and an unprecedented mental health crisis [1]". Up to October 2021, 140,000 children lost their parents, which raised to 241,000 by May 2022 [1]. The people are suffering too much deficiency, which can barely be affordable. On May 14, 2022, there were 82.4 million cases received in the U.S., and 998,000 deaths confirmed within the United States [2]. The United States is not alone. The same tragedy is happening all over the world. But the different countries come with different situations.

There are total cases of 1.14 million in China, with a total death case of 5,206 [3]. What makes this huge difference? Why does a country with almost 10 times the permanent resident population even have a much less difficult situation? The mainstream opinion considers this to give credit to two different governments' essence. Compared with the United States, the centralization of authority and single-party system of the Chinese government has built a significant advantage in this race of pandemic treatment in the world. From the very initial case of Wuhan city, the Chinese government has performed professional and high-efficiency methods to against and prevent viral transmission. The achievement is also remarkable, which controlled the Covid spread without preparation. But what exactly happened in that 76 days?

BBC has finished up a timeline of Wuhan pandemic control. On December 30, 2019, the healthcare commission of Wuhan city reported the first unknown pneumonia. The next day December 31, 2019, the same department published an announcement of 27 cases confirmed, and the healthcare department in China suspected unknown pneumonia has the feature of communicability. On January 24, 2020, the government decided to build an extra hospital to accommodate the abnormal high demand for hospital beds and medical instruments. The hospital named "Huo Shan Shen" was completed in 10 days, up to February 3, and the hospital was officially put into use.

After that, the case number was 5,000 due to a lack of experience and processing mode. On February 11, 2020, the government adopted the advanced locking down method. The locking down management continues to be detailed, and all the residents in the city have to stay at home with the injunction of no outing except purchasing daily necessities with a permit. On the same day, the growth of cases reached a peak of 13,436 a day with a total case of 32,994. After this, the growth has significantly decreased, which may benefit from the locking down method. On March 14, the locking down diminished step by step, and the government officially announced the Covid-19 cases were counting to zero at last, with a summary of 67,800 infected, 40,765 cured, and 2,496 deaths [4]. From the perspective of data, the locking down method seems to have done a lot of effective and fruitful work. And some countries in Europe also adopted the same strategy as China, like Italy and Singapore. According to Deb, “Our analysis, based on a global sample, suggests that containment measures, reducing mobility have been very effective in flattening the “pandemic curve.” [5]. For example, the stringent containment measures in New Zealand—restrictions on gatherings and public events implemented when cases were in single digits, followed by school and workplace closings and stay-at-home orders just a few days later. This is likely to have reduced the number of fatalities by over 90 percent relative to a baseline with no containment measures. In other words, the results suggest that, in a country like New Zealand, the number of confirmed COVID-19 deaths would have been at least ten times larger than in the absence of stringent containment measures” [5]. The problem is why some countries still insist on not forcing people to lock down their cities. In this paper, the main point will be the impact of different control measures against the Covid-19 pandemic concerning the gross domestic product.

1.2 Literature Review

Yang (2021) analyzed that when the situation comes with no effective vaccination, city-wide locking down can positively reduce population movement and significantly contain and delay the spread of Covid-19 in the short term [6]. And the authors also concluded that the unprecedented city-wide quarantine in human history in Wuhan provided valuable time for the world to prepare for the fight against the pandemic. In the paper, to evade the selection bias of traditional methods, the authors adopted the synthetic control method (SCM). The authors quoted the analysis of Athey and Imbens to evaluate this method, “SCM method is arguably the most important innovation in the policy evaluation literature in the last 15 years. [6]”. After the detailed modeling and controlling the bias, the authors showed a fluctuating decreasing downward trend at the point of Wuhan locking down. The measure of locking down provided an indelible contribution to decreasing newly confirmed cases.

Normile (2022) analyzed that China is still not equipped with sufficient conditions to coexist with Covid-19. The author quoted the analysis by Airfinity that if the omicron spread in China widely without any successful control measurement, the death cases can easily achieve a million within three months. Despite this statement being partially confirmed valid, this statement also reflects a fact from an indirect perspective that the locking down measurement is strongly effective on the Covid-19 spread control [7].

Fernandes (2020) analyzed a comparison of 30 countries and their economic growth expectations. After using several different scenario estimates to eliminate the difference in countries, the author concluded, “In a mild scenario, GDP growth would take a hit, ranging from 3-6% depending on the country. As a result, in the sample of 30 countries covered, we would see a median decline in GDP in 2020 of -2.8%. In other scenarios, GDP can fall more than 10% and more than 15% in some countries [8]”. In his paper, Table 2 shows the estimated GDP growth in the 2020 (and confidence margin) – 1.5 months scenario. Of all the 30 countries listed in the table, China is the only country that achieved positive growth. And the lockdown strategy contribution cannot be ignored.

1.3 Research Gap

The most paper mainly focuses on the effectiveness of the lockdown strategy in slowing new cases number growth, in other words, the efficiency of the lockdown strategy. Three methods can analyze

the main approach, including the randomized controlled trials (RCTs), the difference in difference (DID), and propensity score matching (PSM). But each of them has its boundedness which impacts the research result. For example, the DID approach has to come with the assumption of the parallel trend as before experimenting. This can result in the bias of the experiment output. After all, researchers can barely find a perfectly balanced model to estimate the effectiveness. Very few researchers experimented with measuring the effectiveness of the lockdown strategy concerning its reflection of it on GDP growth.

1.4 Research framework

This paper firstly will perform an incremental cost-effectiveness ratio (ICER) estimation regarding the effectiveness of the lockdown strategy. Secondly, the DID estimation between China and the United States will be performed to determine the general effectiveness between the two countries with an adopted strategy. Thirdly, the same DID estimation will apply to Wuhan and the city of Philadelphia to excavate the deeper detailed impact of the lockdown strategy. Fourthly, the randomized control treatment will be performed last to verify the validity of the result from the previously DID estimation.

2. Method

2.1 ICER approach

The incremental cost-effectiveness ratio (ICER) is a statistic used in cost-effectiveness analysis to summarize the cost-effectiveness of a health care intervention. It is defined by the difference in cost between two possible interventions, divided by the difference in their effect. This paper will set the loss of GDP by China and the United States as the cost of treatment (numerator) and the Covid-19 cases as the effectiveness of the treatment approach (denominator) to intestate the efficiency of the lockdown strategy.

2.2 DID approach

The difference in differences (DID or D.D.) is a statistical technique used in econometrics and quantitative research in the social sciences that attempts to mimic an experimental research design using observational study data by studying the differential effect of a treatment on a ‘treatment group’ versus a ‘control group’. According to the Solow model, interpretation, and the property of convergency, the countries at a different node of the capital per labor efficiency will all converge to the steady-state at different speeds. The specific speed depends on the different locations of the node. Compared to the GDP growth map, the data is considered valid for this test without an exact parallel trend.

2.3 Fixed Effect Regression/Event Study

In the traditional way of studying the causal effect of a specific event, the researcher usually adopts the fixed effect regression or event study methodologies. But because of the lack of monthly or daily data on GDP, whether city-wide or national-wide, it is not available to capture the true impact of the locking down method on the growth of GDP for the current specific time. So far, there have been three years of people suffering from the Covid-19, and the variable of quarterly data of GDP will not be able to match the variable daily data of patients. But within the future development of detailed statistical data, it is welcome to correct this defect in the future to provide a more precise result to contribute to human welfare.

3. Result

People in this world have fought against the pandemic for almost three years until nowadays. We seem like found our way out of this pandemic. In mid-2021, the terrified Delta variant has swept the

globe, and the United States is the severely afflicted area. Meanwhile, the authorities of the United States were enjoying partial success in fighting the pandemic. The unexpected rebound of the pandemic wasn't mercy at all. Around December 22, 2021, the United States experienced an 800k daily cases, which is the peak back at that time. The authorities of the United States weren't really prepared to adopt the lockdown strategy. The purpose of coexisting with a pandemic is confirmed and adopted. The authorities ordered the vaccine manufacturers to rush out the booster as soon as possible. Until the end of 2021, most people in the United States were forced to inoculate the new booster. And from the perspective of the result, the third shot of booster obtained the achievement of a downward cliff trend of daily cases in the United States (see Figure 1). In March 2022, the daily cases were back to the previous steady normal trend. The contribution of the booster cannot be ignored. But this also expounds an extra problem, what if the authorities of the United States adopt the same locking down strategy as what China did for the first time in Wuhan city? There won't be that many infection cases with uncountable lives that can be saved.



Fig. 1 Daily Trends in COVID-19 Cases in the United States Reported to CDC

4. Discussion

4.1 ICER approach

$$ICER_{CHN,US} = \frac{C_{CHN}-C_{US}}{E_{CHN}-E_{US}} \quad (1)$$

The above equation performs an ICER estimate of cost-effectiveness. From the data of Statista, China has put 4.7% as a share of GDP to the value of Covid-19 fiscal stimulus packages in G20 countries as of May 2021 (see Figure 2), compared with the United States 26.46%, which is way too small a spend. And as the data reported previously, the United States has always been focused on healthcare expenditure. According to Kurani, “Health spending totaled \$74.1 billion in 1970. By 2000, health expenditures had reached about \$1.4 trillion, and in 2020 the amount spent on health tripled to \$4.1 trillion. Health spending increased by 9.7% from 2019 to 2020, much faster than the 4.3% increase from 2018 to 2019. The average annual growth in health spending from 2010-to 2019 was 4.2% [9]”. So as against the covid pandemic, the United States government continued to input more capital into the healthcare system. At the end of 2020, the total national health expenditures as a percent of the gross domestic product are about 19.7% which is one-fifth of total GDP (see Figure 3). But the United States has always had the problem of low efficiency. For example, there has no positive relationship between the two variables of life expectancy and healthcare expenditure. About the variables in the equation represent the value of COVID-19 fiscal stimulus packages in G20 countries as of May 2021 as a share of the GDP of China. This represents the value of COVID-19

fiscal stimulus packages in G20 countries as of May 2021 as a share of the GDP of the United States. In this equation, the total cases of Covid-19 will be considered a factor that reflects the effectiveness of the healthcare system efficiency, representing the efficiency variable of China and the United States, respectively. After analyzing the data obtained from the CDC and WTO, the result has shown that, in the absence of omitted variable bias. From the perspective of the value of COVID-19 fiscal stimulus packages in G20 countries as of May 2021 as a share of GDP, adopting the Chinese method is approximately 0.268 more effective than the approach adopted by the United States.

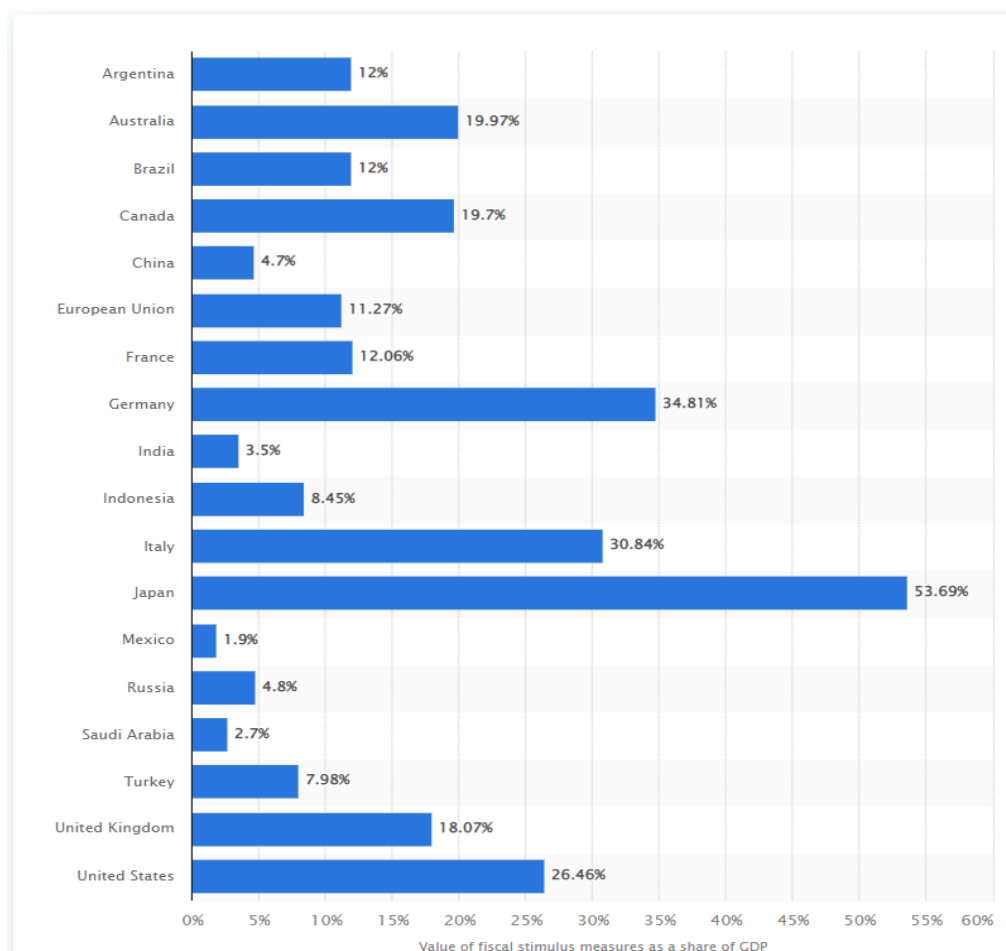


Fig. 2 Value of COVID-19 fiscal stimulus packages in G20 countries as of May 2021, as a share of GDP

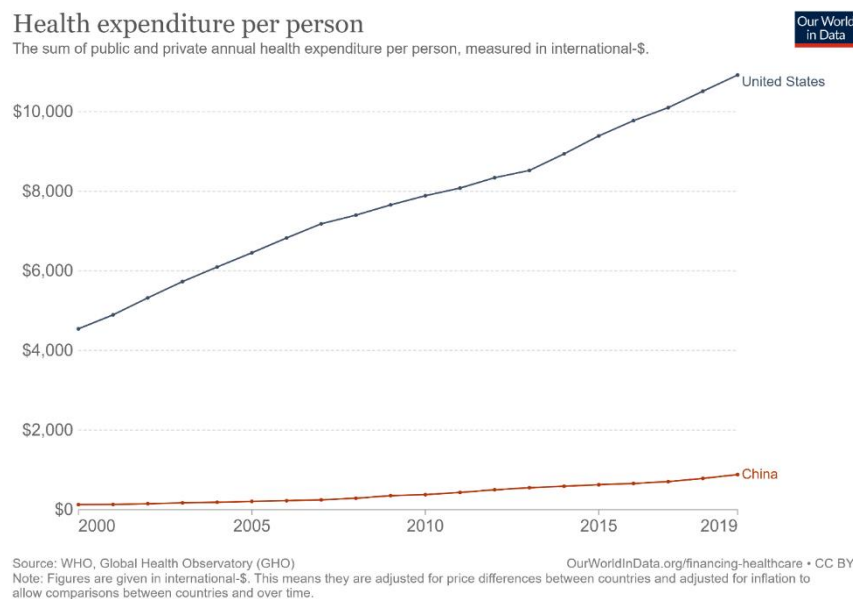


Fig. 3 Health Expenditure per person by Time (the U.S.)

4.2 DID approach

Regression Equation: $GDP_i = \beta_0 + \beta_1 X_i + \beta_2 Z_i + \beta_3 X_i \cdot Z_i + \varepsilon_i$

Table 1. DID result between China and the U.S. in T1

	2019	2020	Difference
China	138,948.18	147,227.31	8,279.13 (5.9%)
The United States	214,332.25	209,366.00	-4,966.25 (-2.3%)
Difference	-71,532.87 (Omitted)	-62,138.69 (Omitted)	\$13,245.38 (8.2%)

Table 2. DID result between China and the U.S. in T2

	2020	2021	Difference
China	147,227.31	177,271.82	30,044.51 (20%)
The United States	209,366.00	229,934.71	20,568.71 (9%)
Difference	-62,138.69 (Omitted)	-52,662.89 (Omitted)	\$9,475.8 (11%)

The above regression equation shows the basic logic of this difference in difference (D.D.) test. Variable X is a dummy variable that indicates whether the data is from China or the United States (=1 if China, otherwise =0). Variable Z is another dummy variable that indicates whether the data is before or after (nontreated=1, otherwise=0). The third coefficient estimator will be able to contribute to interpreting the result of this test. β_0 captures the average GDP of the United States before treatment. β_1 captures the difference in GDP on average between China and the United States before treatment. β_2 captures the treatment effect of the United States. And at last, what we are concerned about the most β_3 captures the difference in value between China and the United States before and after the treatment.

The two tables above show the D.D. test between China and The United States concerning two different periods. The first shown Covid-19 (2019-2020), and after adopting the different responses, the following period GDP reflection (2020-2021). All the data shown in the table are in one hundred million U.S. dollars. According to the test result above in the table, at the first stage of the test, the immediate responses of China by locking down Wuhan city seemed like taking advantage of the United States' positive growth of GDP at that time and overall achieving \$13,245.38 hundred million U.S. dollars advantage in this test. And as for the second period, the United States has caught up a little bit. However, there is still a \$9,475.8 hundred million U.S. dollars difference in the growth of

GDP. There may still be an omitted variable bias, but this experiment is meant to look at the system generally. We can differ in the difference-in-difference (DDD) test from the above two numbers. There is a \$3,769.58 hundred million U.S. dollars advantage of GDP growth in general created by the gap of different reactions to the treatment of Covid-19 by two countries. Again, the result is in the absence of eliminating omitted variable bias.

4.3 DID approach (Cont.)

From the previous estimation, to remove the selection bias, the survey area can be narrowed down to Wuhan City and its counterfactual city in the U.S., Philadelphia. Wuhan city is ranked 40th worldwide. If compared with the level of GDP, it should be benchmarked to the town of Boston. But considering the outstanding industrial engineering property of these two cities, it would be better to put these two together. In addition, the starting of locking down of Wuhan city is embiggened at 2019 with maintaining of 76 days. The assumption would be that the effect of locking down should reflect immediately on the GDP of next year. With the data from Wuhan Statistical Bureau and U.S. Bureau of Economic Analysis [11] [12], and adopting the same model built above, we have:

Table 3. DID result between Wuhan and Philadelphia in T1

	2019	2020	Difference
Wuhan	16223.21	15616.10	-607.11 (-3.7%)
Philadelphia	450742.192	439055.118	-11687.07 (-2.6%)
Difference	2277.47 (Omitted)	2,191.92 (Omitted)	-1.1%

Table 4. DID result between Wuhan and Philadelphia in T2

	2020	2021	Difference
Wuhan	15616.10	17716.76	2100.66 (13.5%)
Philadelphia	*	*	(7.5%) Predicted by Oxford Economics
Difference	*	*	5.5%

The coefficient here indicates that Wuhan has suffered more than Philadelphia by 1.1% of the total GDP growth in the first period. The reason can divide into various, mainly because the locking down a city is similar to pushing the stop button. One thing has to mention here is that the unit of Wuhan GDP is Hundred Million RMB, but Philadelphia is Million of Dollars. But the calculation by percentage will eliminate the bias. All the activities will be suspended in the specified location. But as to the prediction of Chinese authorities, if the policy of zero cases worked out, people will no longer be constrained by the pandemic, which will boost economic growth. Hence, the data from the second table just provided the data support for this conclusion. According to Oxford Economics, "GDP in Philadelphia remains 1.3% below the peak Q4 2019. These ranks 36th of the top 51 metros. GDP is expected to grow 7.9% in 2021, 4.5% in 2022, and 1.5%, annually in 2023 to 2025 [10]". The theory here is similar to the principle of the Solow model. Today's sacrifice will eventually bring the economy to a higher steady-state and allow the economy to develop at a higher speed. Thus, from the comparison of the second part, Wuhan city has led Philadelphia city with a 5.5% growth rate. Today's giveaway will benefit a better tomorrow eventually. And from the International Monetary Fund (IMF) projections, it is also proof of the above statement of result [13]

Year ▲	Nominal GDP (billions \$)		PPP GDP (billions Int. \$)		Nominal GDP capita (\$)		PPP GDP capita (Int. \$)		Growth (%)	
	US ▲	China ▲	US ▲	China ▲	US ▲	China ▲	US ▲	China ▲	US ▲	China ▲
2020	20,932.75	14,722.84	20,932.75	24,142.83	63,416	10,484	63,416	17,192	-3.505	2.270
2021	22,675.27	16,642.32	22,675.27	26,656.77	68,309	11,819	68,309	18,931	6.386	8.437
2022	24,003.70	18,013.40	24,003.70	28,779.53	71,896	12,763	71,896	20,392	3.515	5.574
2023	24,892.61	19,423.48	24,892.61	31,031.00	74,130	13,736	74,130	21,945	1.410	5.439
2024	25,790.12	20,910.47	25,790.12	33,351.27	76,362	14,765	76,362	23,549	1.481	5.273
2025	26,719.63	22,481.43	26,719.63	35,748.12	78,660	15,855	78,660	25,212	1.607	5.121
2026	27,659.15	24,127.83	27,659.15	38,189.88	80,959	17,003	80,959	26,913	1.610	4.863

Fig. 4 Projections of GDP by IMF of China V.S. the U.S.

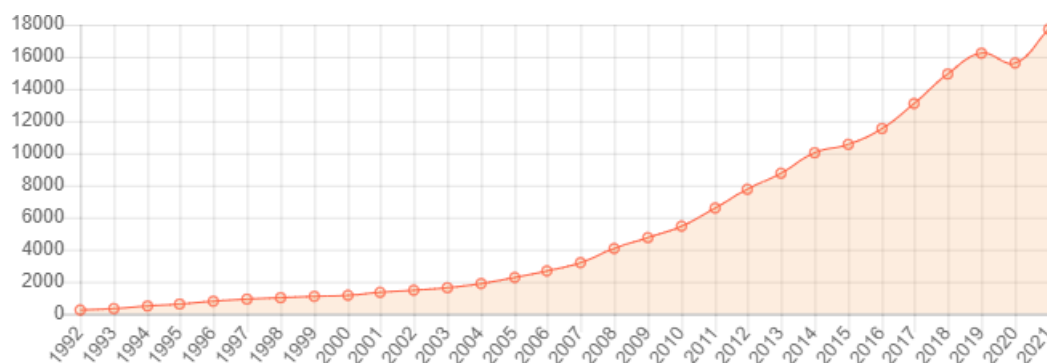


Fig. 5 GDP of Wuhan by Time (Unit: 100M Yuan)

5. Conclusion

To conclude, the locking down method to restrain the spread of pandemics is the correct method to adopt during the fight against the pandemic. Whether from the aspect of benefiting the public health or the aspect benefiting the economic growth, this method will let ordinary people and the economy be benefited permanently. In addition, the people in this world are getting used to living in a world with an unknown tomorrow. Perhaps there will be a “Gamma Mutation” showing up. As the commonly acknowledged theory in project management, people have to leave enough contingency plans and contingency reserve funds for the unknown risks. The same principle can be applied to today’s world, and people have to get ready. From the success of Wuhan, Changchun, Shanghai, and Beijing, we can tell to add the locking down approach to step one in the contingency plan is extremely urgent.

Nevertheless, some world places are still considering this approach violates human rights of infringement of freedom. But it is the same thing as “yesterday’s story”, some authorities in this world had already suffered resistance when they tried to popularize the use of masks. Even though there are predicted difficulties in implementing the plan, the authorities still would be better implemented as much as possible. The evidence and data in this paper will confirm that damage mitigation will be obvious.

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