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The benefits and costs of flattening the curve for COVID-19

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Abstract:

We examine the net benefits of social distancing to slow the spread of COVID-19 in the United States. Social distancing saves lives but imposes large costs on society due to reduced economic activity. We use an SIR model to perform a benefit-cost analysis of controlling the COVID-19 outbreak. Assuming that social distancing measures can substantially reduce contacts among individuals, we find net benefits of roughly $5 trillion in our benchmark scenario. We examine the magnitude of the critical parameters that would lead to negative net benefits. A key unknown factor is the time to economic recovery with and without social distancing measures in place. Our sensitivity analysis points to a need for effective economic stimulus when the outbreak has passed.

Main Text:

Is the United States overreacting to the new coronavirus or is the current response worth it? Attempts to slow down the rate of COVID-19 infections (“flatten the curve”) have led many governments around the world to issue unprecedented public policies and guidelines to increase social distance within and across countries. The goal is to save lives by reducing the pace and extent of disease spread and avoid overtaxing nations’ medical infrastructure as symptomatic individuals seek medical care. In the U.S., schools, universities, and daycare centers have temporarily ceased operations, cultural events have been canceled, tourist attractions including Broadway and Disney World have closed, and national sports leagues have suspended or canceled their seasons. The U.S. federal government has imposed travel restrictions on Canada, China, Iran, Mexico and 26 European countries to reduce external exposure to the virus, and has issued guidelines urging citizens to avoid gatherings of 10 or more people to help reduce community spread.

These social distancing measures (*1*) save lives, but they also impose significant costs on society. The resulting contraction of economic activity puts vulnerable low-income workers in jeopardy, and recent forecasts suggest that overall economic output in 2020 may decline substantially, despite large fiscal and monetary stimulus. On March 20, Goldman Sachs presented a revised economic forecast for 2020. They predict U.S. GDP will shrink by around 3.8% this year, partly due to social distancing. These economic impacts, along with the public health benefits, should be considered when evaluating any rational risk reduction policy. If many U.S. citizens doubt the wisdom of flattening the curve through self-quarantining and other social distancing policies, then voluntary compliance rates may be reduced, which would undermine the effectiveness of the risk reduction policies (*2*).

Our benefit-cost analysis shows that the extensive social distancing measures currently being adopted in the U.S. likely do not constitute an overreaction. Based on a variety of plausible scenarios, the economic benefits of lives saved substantially outweigh the value of the projected losses of GDP. Our analysis is necessarily preliminary, but we believe it is important to provide a rapid assessment based on what has been learned so far about the public health risks of the coronavirus and what can be reasonably assumed about the economic costs of controlling it.

We use a model with central values of key parameters, and we examine a range of plausible estimates of the health risks of COVID-19 to account for uncertainty about the spread, severity, and duration of the disease, and the severity and duration of the impact on the U.S. economy. We model the spread of COVID-19 using a standard SIR framework, which tracks the numbers of susceptible, infected, and recovered individuals over the course of an infectious disease outbreak (*3*,*4*). We assume a basic reproduction number (R_0) of 2.4, which is a central value among estimates from several epidemiological studies based on early rates of spread in China and elsewhere (*5*,*6*). We use an average infectious period of 6.5 days, which is consistent with reported cases of COVID-19 from early January to early February 2020 (*5*,*7*). These assumptions appear to roughly match those used by the Centers for Disease Control and Prevention (CDC), based on reporting of their modeling results in popular media. We set the initial number of infections to 4,165, which was the CDC official estimate of infected individuals in the U.S. on March 17, 2020. Based on estimates of the influence of similar social distancing measures taken in Australia to combat the spread of the 1918 Spanish flu, and assuming these measures are adopted widely and maintained for the duration of the outbreak, we assume that social distancing will reduce the average contact rate among individuals by 38% (*8*). The value of statistical life (VSL) is taken to be $10 million, which is consistent with U.S. federal agency guidelines (*9*,*10*) and recent syntheses of the mortality risk valuation literature (*11*). We discount future costs and benefits at a rate of 5% per year, which is between the 3% and 7% values recommended for economic analyses conducted by U.S. federal government agencies (*12*).

To account for the possibility of overwhelming the U.S. health care system, we make a critical assumption that the system has sufficient resources to provide adequate treatment for about one half of the maximum number of individuals who would be infected at any one time in an uncontrolled scenario, with no social distancing to slow down the virus. We assume that the mortality rate for infected individuals who are treated when the threshold is not exceeded (i.e., when the health care system is not overwhelmed) would be 0.5%, and the mortality rate above the threshold would be 1.5%. While these assumptions were made independently, the first assumption appears to be in line with initial findings by the Harvard Global Health Institute (*13*) and reporting in the New York Times on U.S. hospital bed capacity in the face of COVID-19 (*14*), and the assumed mortality rates appear to lie within the range employed by the CDC modeling, as reported in popular media.

In the absence of the pandemic, we assume GDP would have grown at a constant rate of 2% per year ("baseline projected"), closely in line with the United States Congressional Budget Office's estimate of potential GDP growth in the U.S. The economic consequences of the pandemic are felt in an immediate decline of GDP and in the subsequent time periods as the path of GDP recovers by approaching its counterfactual (without-pandemic) projected path (see Figure 1 below). In what follows, we refer to the "time to recovery" as the number of months required for the GDP gap to be reduced by 95% of the original decline due to the outbreak.

In the uncontrolled scenario (without social distancing), we assume an immediate shock in GDP of -2.0%, due to the large number of excess deaths, loss of productivity due to sick days, and the inordinate strain on the health care system during the span of the outbreak. Recent estimates of the immediate economic impact from the COVID-19 pandemic when social distancing is not implemented range from a decline in GDP of 1.5% to 8.4% (*15*). For our benchmark scenario, we choose a value from that range that is relatively optimistic, namely -2.0% (as we show below, less optimistic assumptions would strengthen our main result). We assume that a much larger immediate GDP shock of -3.8% will occur in the controlled scenario (with social distancing) because the social distancing measures themselves will significantly curtail economic activity. This value is based on a recent economic forecast by Goldman Sachs, which accounts for the economic effects from social distancing (*16*).

In both the controlled and uncontrolled scenarios, we assume a slow ("U-shaped") recovery, in line with the economic impact of the Spanish flu in the U.S. (*17*). Despite recent forecasts that are more optimistic about the speed of the economic recovery with the implementation of social distancing (*16*), we maintain the assumption of a "U-shaped" recovery for both the uncontrolled and controlled scenarios. Whether recovery will be slow or fast ("V-shaped") with social distancing depends largely on the extent to which the virus can be slowed down and how effective any additional economic stimulus will be at boosting the economy in the short and medium term. While the roughly 36 month return-to-trend after the 1918 Spanish flu (*17*) provides one estimate of the duration of a slow recovery, we employ the more conservative 60 month duration for a U-shaped recovery, based on the average historical recovery of all bear markets since 1835 (*18*). We consider the implications of the speed of recovery in a sensitivity analysis.

The resulting projections of infections over time in our benchmark uncontrolled and controlled scenarios are shown in Panel (A) of Figure 1, and the associated projections of GDP are shown in Panel (B). Panel (A) indicates that social distancing measures sufficient to decrease the average contact rate among individuals by 38% can reduce the peak of the infection curve by more than half. This would avoid overwhelming the health care system and therefore keep the average mortality rate at the lower level of 0.5%.

[Insert Figure 1 here.]

The resulting projections of the number and value of deaths due to COVID-19 and lost GDP under both scenarios are shown in Table 1. The main result of this paper is in the bottom row: under the assumptions laid out above, social distancing generates net social benefits of more than $5 trillion.

[Insert Table 1 here.]

We examine the sensitivity of our results first by considering several alternative assumptions about the speed of economic recovery. We consider a fast, V-shaped, recovery for both the uncontrolled and controlled scenarios. We assume that a fast recovery lasts for 15 months, which is in line with the average of historical recoveries of “event-driven” (one-off shock) bear markets (*18*). We also consider different recovery times for the two scenarios. Table 2 shows the results of this sensitivity analysis.

[Insert Table 2 here.]

We note that our key result—net benefits of social distancing measures are positive—holds in these cases unless the uncontrolled recovery is fast and the controlled recovery is slow. In this case the pace of economic growth after social distancing is not fast enough to make the present value of lost GDP lower than the monetized value of the reduced mortality rates during the outbreak. The roughly 36 month recovery rate of U.S. GDP in the wake of the 1918 Spanish Flu pandemic suggests this may be an unlikely scenario, but it nevertheless highlights the importance of well-calibrated economic stimulus to avoid an unnecessarily prolonged recession. If we assume that the economy can recover in 36 months, instead of 60, net benefits would also be positive in this scenario. The largest net benefits from social distancing are generated if those measures facilitate a fast recovery, while the economy would recover more slowly in the absence of social distancing.

To further examine the robustness of our results, we calculated break-even values for each of the key model parameters in turn, holding all other parameters at their benchmark levels, for all four cases shown in Table 2. These break-even values are reported in Table 3.

[Insert Table 3 here.]

For instance, Table 3 shows that in our benchmark case (with slow recovery for both the uncontrolled and controlled scenarios), net benefits would be negative if the time to recovery is a year or more shorter without social distancing than with, or if the GDP shock with social distancing is 5.2% or more. For the same scenario, if the mortality rate when the capacity of the health care system has been exceeded were 0.76% or lower would the net benefits be negative. The flip side is that all mortality rates higher than this level still result in a positive net benefit. The "none" entries in Table 3 indicate that no alternative values of the corresponding parameter, holding all other parameters fixed, would change the sign of net benefits. We view most of the break-even parameter levels for our benchmark case as safely outside of reasonable ranges, with the possible exception of the average VSL. This is important because the death rate due to COVID-19 is substantially higher for elderly individuals (*19*). Some economic models suggest that individuals' willingness-to-pay for mortality risk reductions declines with age (*20*) and some empirical studies have estimated lower VSL values for older cohorts (*21*) but other studies point to different conclusions (*22*,*23*). We use an average VSL of $10 million because this is close to the value used for many U.S. federal government regulatory impact analyses (*9*,*10*) and is consistent with the hedonic wage literature (*11*). If a substantially lower VSL is appropriate for older individuals, then our main result could change. Another way to view the break-even VSL is that, in our benchmark case, the extensive social distancing measures currently underway amount to spending an average of $5.62 million per life saved.

Our analysis has several limitations. First, we analyze only a single policy package, which is intended to represent the full and varied suite of self-quarantine and other social distancing measures currently being adopted or recommended in the U.S. Our finding of positive net benefits does not mean that this particular package of measures is the socially optimal one; it almost certainly is not. A more detailed analysis of various constituent social distancing measures and different levels of stringency thereof will be needed to find the optimal portfolio of responses to this and similar future pandemics. Second, we focus exclusively on estimating the overall net benefits of social distancing, which means we ignore the likely distributional impacts of such measures. It stands to reason that the most vulnerable groups in society will be the hardest hit. For example, the labor-intensive service industry will be disproportionately affected by these policies, which will lead to mass layoffs of low-income workers. It also is likely that economically disadvantaged groups will suffer the most severe adverse health consequences from COVID-19. In principle, the asymmetric impact of the pandemic and burden of the policy responses can be addressed with appropriate redistributions of resources. A detailed analysis of the distribution of benefits and costs among income, age, rural versus urban regions, and other relevant individual or community characteristics could help to refine the control measures adopted in future pandemics. Third, we do not consider how current social distancing measures might affect the probability of a second wave of COVID-19 infections in the future by preventing the development of herd immunity (*24*). Instead, we implicitly assume that aggressive social distancing measures buy enough time to develop and distribute cost-effective COVID-19 treatments or vaccines, should a second wave occur.

Our analysis suggests that the aggressive social distancing policies currently promoted in the U.S. probably are justified given that no good contingency plans were in place for an epidemic of this magnitude. Our analysis assumes that the large-scale coordination game underlying social distancing is successful in “flattening the curve” of the outbreak. But the economic impacts will be severe, and as they become more salient the wisdom of social distancing might be put into question. If so, an important policy challenge will be to ensure that people are willing and able to sustain effective social distancing measures even in the face of a prolonged economic contraction.

Figures and tables

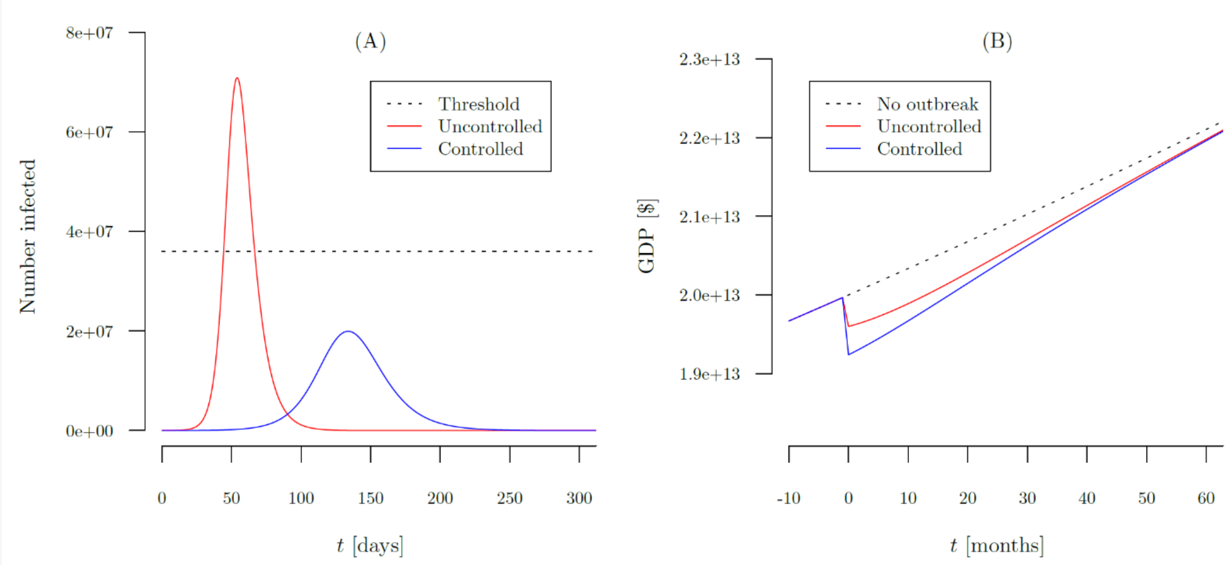

Figure 1. Projections of coronavirus infections (A) and GDP losses (B) for uncontrolled and controlled outbreak scenarios.

Table 1. Projected outcomes for uncontrolled scenario (without social distancing) and controlled scenario (with social distancing).

	Uncontrolled	Controlled
Infections [million]	287	188
Deaths [million]	2.16	0.941
Present value of GDP loss [trillion US$]	19.4	26.2
Value of lives lost [trillion US$]	21.6	9.41
Net benefits [trillion US$]		5.35

Parameter values: $R_0 = 2.4$, infectious period = 6.5 days, low mortality rate = 0.5%, high mortality rate = 1.5%, reduction in contact rate = 38%, VSL = $10 million, uncontrolled GDP shock = −2.0%, controlled GDP shock = −3.8%, uncontrolled recovery time = 60 months, controlled recovery time = 60 months.

Table 2. Projected outcomes under alternative economic recovery assumptions for uncontrolled (without social distancing) and controlled (with social distancing) scenarios.

	Slow controlled and uncontrolled recovery	Fast controlled and uncontrolled recovery	Fast controlled, slow uncontrolled recovery	Slow controlled, fast uncontrolled recovery
Avoided deaths [million]	1.22	1.22	1.22	1.22
Value of avoided deaths [trillion US$]	12.2	12.2	12.2	12.2
Present value of GDP loss [trillion US$]	-6.84	-1.95	14.4	-23.2
Net benefits [trillion US$]	5.35	10.2	26.6	-11.0

Parameter values: R_0 = 2.4, infectious period = 6.5 days, low mortality rate = 0.5%, high mortality rate = 1.5%, reduction in contact rate = 38%, VSL = $10 million, uncontrolled GDP shock = −2.0%, controlled GDP shock = −3.8%, slow recovery time = 60 months, fast recovery time = 15 months.

Table 3. Break-even values for key parameters under alternative economic recovery assumptions for uncontrolled (without social distancing) and controlled (with social distancing) scenarios.

Parameter	Slow controlled and uncontrolled recovery	Fast controlled and uncontrolled recovery	Fast controlled, slow uncontrolled recovery	Slow controlled, fast uncontrolled recovery
R_0	1.30 , 4.62	1.15 , 8.26	none	none
Low mortality rate [%]	none	none	none	none
High mortality rate [%]	0.76	0.10	none	3.13
Reduction in contact rate [%]	18.7	6.10	none	none
VSL [million US$]	5.62	1.61	none	19.0
Uncontrolled Shock [%]	0.60	none	none	none
Controlled Shock [%]	5.2	13.2	28.3	0.89
Uncontrolled recovery time [months]	48.2	none	none	48.2
Controlled recovery time [months]	68.8	39.4	68.8	39.4
Threshold [million infections]	55.9	none	none	none
Discount rate [yr^{-1}]	none	none	none	0.384

Benchmark parameter values: R_0 = 2.4, infectious period = 6.5 days, low mortality rate = 0.5%, high mortality rate = 1.5%, reduction in contact rate = 38%, VSL = $10 million, uncontrolled GDP shock = −2.0%, controlled GDP shock = −3.8%, slow recovery time = 60 months, fast recovery time = 15 months.

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