Microsoft

COVID-19 Economic Impact and Recovery Framework (working paper)

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Rolf Harms, Greg Detwiler, David Morrell, Diana Wang, Jenny Ye

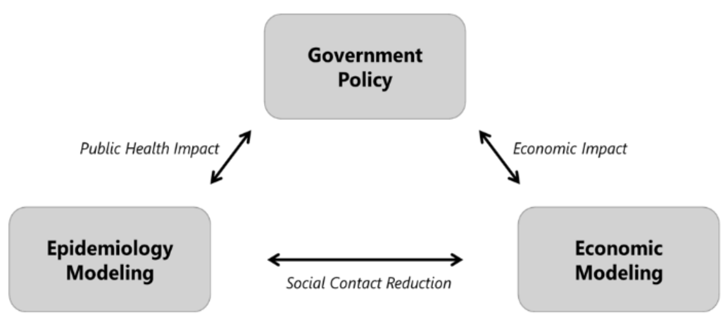
Correspondence: rolf.harms@microsoft.com

In this paper we outline an economic model that quantifies the impact of government and self-initiated responses to COVID-19. We also created an app that shows regularly updated estimates and allows a user to define custom scenarios and then calculates GDP impact. Policymakers are focused on shaping GDP outcomes, not merely predicting them. Based on our work with epidemiology teams and policymakers (as well as our own economic modeling), we outline a policy framework to help governments think through recovery and reopening strategy.

1. CONTEXT AND APPROACH

COVID-19 requires policymakers to strike a careful balance between managing infection curves and economic recovery. The former is informed by current data on infections as well as modelled projections of infection and disease transmission rates. The latter is informed by estimates of the economic impact of government mitigation measures as well as the impact of self-initiated changes in human behavior (e.g., fear of going to stores). Keeping the economy closed for a long time will cause significant economic damage. Insufficient social distancing may cause a resurgence that will cause more deaths *and* more economic damage. This is a unique dilemma that requires a combined perspective from epidemiology models *and* economic models.

FIGURE 1 : Our Approach



At Microsoft and GitHub, we are not epidemiology experts, but we do understand the power of software, the ability of the cloud to solve complex problems, and the value in platforms that empower others. In an effort to help, we have been assisting some of the leading epidemiology teams with open sourcing their code, running and calibrating their models in the cloud, and building out User Interfaces.

This work has given us a better appreciation of the epidemiology aspects. Separately we have been building an economic model to estimate GDP impact by industry, using our understanding of the disease models to layer in different scenarios. Given the unusual nature of this economic disruption, we have applied some of the same techniques we used in assessing past technological disruptions such as our "economics of the cloud" work.[1]

In talking to policymakers in the U.S. and U.K., it is clear the lines between the epidemiology and economic impact work are blurring. Today the epidemiology models and economic models tend to live in isolation. This has led to a debate between healthcare outcomes and economic impact. We do not take a position in this debate. We argue that to some degree this is a false trade-off: There are many opportunities to improve the outcome for one without compromising the other.

[1] *This modeling work helped create the case for Microsoft's investment in cloud computing about a decade ago.*

In this paper, we bridge the experience gained from working with epidemiology teams as well as our own economic modeling to outline a policy framework (and data) to support policymakers in this difficult time. In Section 2 we provide an overview of our economic impact model. In Section 3 we introduce the notion of social contact as a new scarce economic resource. In Section 4 we discuss the notion of a "Social Contact Budget." Section 5 outlines a data-driven approach on how to best spend it and achieve the highest "Return on Social Contact." Finally, in Section 6 we frame up how the budget can be expanded over time and show data that quantifies the recovery.

2. ECONOMIC IMPACT MODEL

This section will provide a summary of the economic model we have developed that quantifies the impact to U.S. GDP under several scenarios. Although this paper focuses on U.S. numbers, our model covers the 15 largest economies in the world representing ~75% of global GDP, all of which will eventually be made available in our Power BI Dashboard (U.S., Canada, U.K., Italy, and Australia currently available). We will briefly highlight our approach below with more details provided in the appendix.

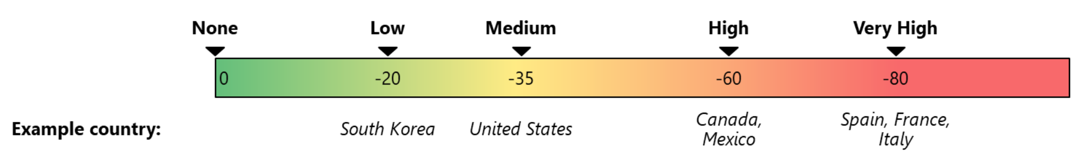
The model has three key modules:

1) The magnitude of response as measured by changes in people's mobility/social contact, whether driven by government mitigation measures or by self-initiated behavior change
2) The degree to which industries are susceptible to disruption from government intervention and self-initiated behavior change
3) The duration over which we expect government interventions and behavior change to last

2.1 Magnitude of Response

For our model we use a continuous scale for magnitude of response. A country's current and historical level of response is determined using Google's publicly released cell phone mobility data[2], which shows the amount of foot traffic in key areas (e.g., stores, transit, work) relative to normal over time and by geography. We initially used the Oxford Stringency Index data[3] but found mobility data to be a better fit for our use case as it captures the impact of government interventions as well as compliance and voluntary measures taken by individuals. In general, we see five levels of response based on the variation in interventions seen worldwide (Fig. 2).

FIGURE 2: Magnitude of Response



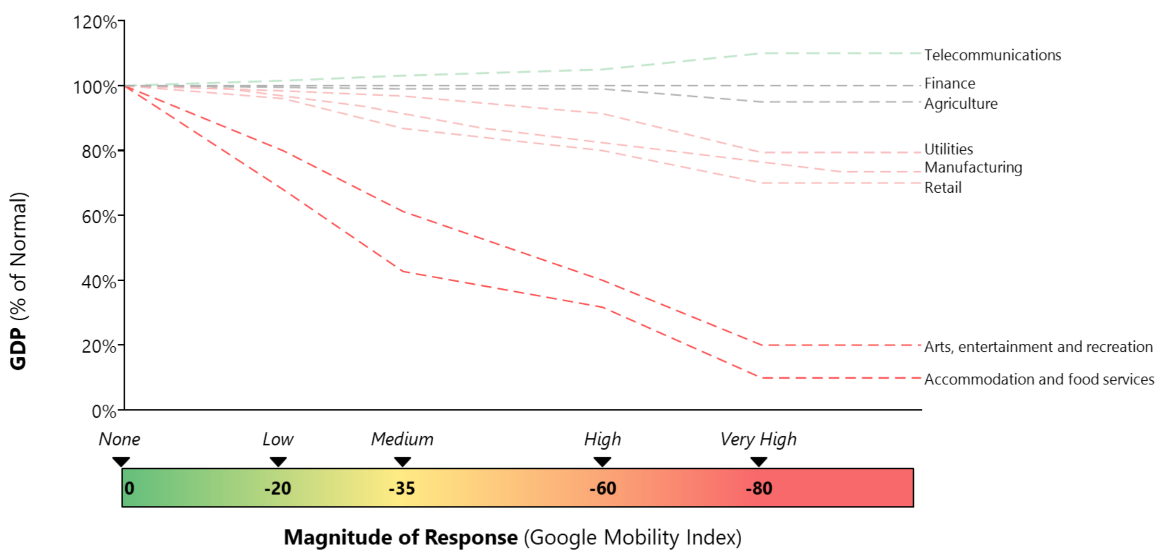
[2] Google LLC "Google COVID-19 Community Mobility Reports". *https://www.google.com/covid19/mobility/ Accessed: Jun 8, 2020.*

[3] *Hale, Thomas, Sam Webster, Anna Petherick, Toby Phillips, and Beatriz Kira (2020). Oxford COVID-19 Government Response Tracker, Blavatnik School of Government.*

2.2 Industry Susceptibility

We have assessed industries based on their susceptibility to social distancing and lockdown. To do this, we have studied data from 15 countries and used it to build a data cube of over 1,000 individual economic impact datapoints[4] that cross references economic impact in 30+ industries with the magnitude of response in place at the time. To the extent possible we rely on official economic reporting data but have also incorporated more real-time or high-frequency data sources (e.g., consumer spending, shipping volumes). Using this data, we determine the degree of impact for each industry under different degrees response. Figure 3 shows a sample of industries.

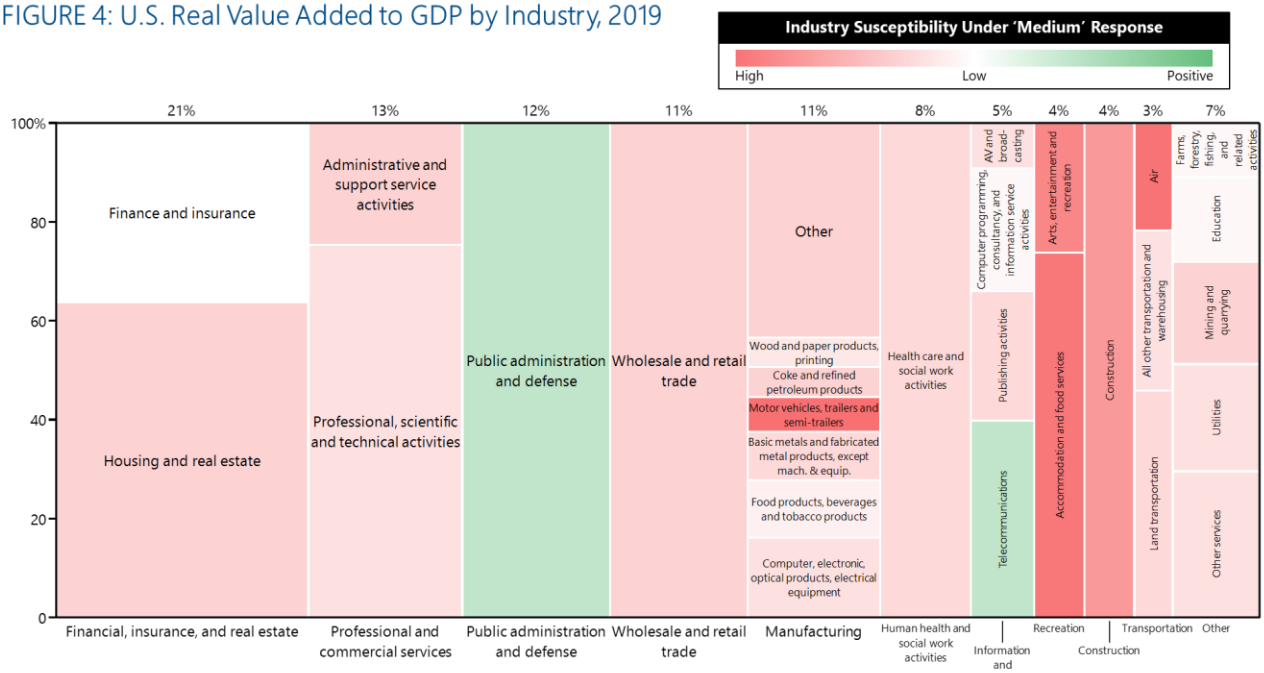
FIGURE 3: Example Industry Susceptibility by Magnitude of Response



We then aggregate the economic impact across industries based on each industry's contribution to U.S. GDP. Figure 4 shows the high-level breakdown of U.S. GDP by industry (value added) that we used for weighting purposes in this rollup, with rough color coding to indicate the relative impact to industries under a 'medium' level of response (i.e., what U.S. mobility looked like on average in May).

[4] *Sources: U.S. Bureau of Economic Analysis; U.S. Census Bureau; U.S. Department of Agriculture; U.S. Department of Education; Board of Governors of the Federal Reserve System (US), Industrial Production Index [INDPRO], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/INDPRO, May 5, 2020; Ministry of Trade, Industry and Energy (Korea); Statistics Korea; El Ministerio de Trabajo y Economía Social (Spain); Instituto Nacional de Estadística (Spain) Own compilation with data taken from the INE website: www.ine.es; Office for National Statistics (U.K.) Contains public sector information licensed under the Open Government Licence v3.0; National Institute of Statistics and Economic Studies (France); Banque de France; Statistics Canada; China Statistical Information Network www.stats.gov.cn; Italian National Institute of Statistics; Effects of the corona pandemic on the economy and business activity in Germany, Statistisches Bundesamt (Destatis), 2020. https://www.destatis.de/EN/Themes/Cross-Section/Corona/Economy/context-economy own calculation; Parliament of Australia; Association of American Railroads; Associated General Contractors of America; Mortgage Bankers Association (U.S.); Trading Economics;; Ibis World; Statista; NPD Group; STR; analyst research; etc.*

FIGURE 4: U.S. Real Value Added to GDP by Industry, 2019



Source: Bureau of Economic Analysis, Microsoft Analysis

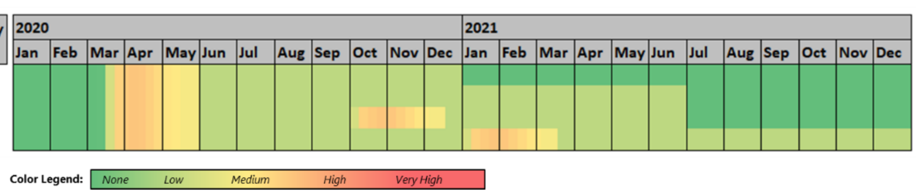
2.3 Response Scenario Timeline

The final variable is how the magnitude of response varies over time as the pandemic evolves. Our model allows for complete flexibility to define custom scenarios around mitigation strategies down to a week-by-week level. For historical parts of the timeline we have primarily used Google mobility data to determine the actual level of response (supplemented by Apple mobility data[5] where Google mobility data is unavailable).

For the U.S. we have evaluated four scenarios that capture variation across three dimensions: 1) when do we expect widespread availability of a vaccine, 2) will a second wave occur and when, and 3) how aggressive will the recovery be. Figure 5 summarizes our four scenarios and the associated response timelines.

FIGURE 5 : Timeline of Response by Scenario

Scenario	Vaccine timing	Second wave	Recovery speed
Optimistic case	Jan 2021	None	Fast
No second wave	July 2021	None	Medium
Fall second wave	July 2021	Oct '20	Slow
Winter second wave	2022+	Jan '21	Slow



- **Optimistic Case:** We have modeled out the current U.S. response based solely on announced measures as of June 8 with an end to most statewide shelter-in-place/stay-at-home orders in June. In the optimistic case, we assume economic recovery will be relatively fast, with consumer confidence and expenditure rebounding quickly. We also assume lighter mitigation measures remain in place (together with contact tracing and widespread testing) as we will still have

[5] Apple Mobility Trends Reports. https://www.apple.com/covid19/mobility.

infections we need to manage until a vaccine is broadly available. We assume broad vaccine availability in early 2021 at which point magnitude of response returns to normal. This is generally viewed as optimistic, but this scenario provides the upper bound of our estimates.

- **No Second Wave:** We have also modeled out the same scenario with a moderate economic recovery and a later vaccine timing of mid-2021. This is more consistent with the consensus on when a vaccine will be widely available.
- **Fall Second Wave:** Most epidemiology models predict the virus will see a second wave. This scenario takes the prior case but adds a second wave in the fall due to a combination of poor ongoing mitigation, lack of herd immunity, and/or viral mutations. We also assume that economic recovery will be slower driven by increased bankruptcy and unemployment risk from the second wave.
- **Winter Second Wave:** This represents a more bearish second wave scenario by combining a second wave (beginning in early 2021 as opposed to fall of 2020) with slower recovery as well as delayed vaccine timing to 2022. This provides a lower bound to our estimates from a two-year growth perspective (2019-21 CAGR).

2.4 GDP Forecast

The above produces our forecast of U.S. Real GDP growth (Fig. 6). In our "Optimistic" scenario, we see a 2020 decline of 5% and 2021 growth of 9%. Given the early vaccine timing and fast recovery this represents our most optimistic scenario.

For the "No second wave" scenario we assume a more consensus-based broad vaccine availability of mid-2021. This scenario therefore pushes out the recovery due to longer mitigation and slower return to "business as usual," which results in an estimated GDP impact of -6% for 2020.

FIGURE 6: Forecast US Real GDP Growth (Y/Y%)

Scenario	Scenario parameters			Real GDP Growth		
	Vaccine timing	Second wave	Recovery speed	2020	2021	2019-21 CAGR%
Optimistic case	Jan 2021	None	Fast	-5%	9%	2%
No second wave	July 2021	None	Medium	-6%	5%	0%
Fall second wave	July 2021	Oct '20	Slow	-7%	4%	-1%
Winter second wave	2022+	Jan '21	Slow	-6%	0%	-3%
Analyst Average				-6%	5%	-1%

Analyst average is average of 8 forecasts from Morgan Stanley (5/29/20), JPMorgan (5/29/20), Conference Board (6/10/20), Deutsche Bank (5/5/20), Goldman Sachs (6/7/20), UBS (6/5/20), OECD (6/10/20), and Federal Reserve (6/10/2020)

Both second wave scenarios result in a "W-shaped" or "double-dip" recession, with an initial downturn followed by false signs of recovery and eventually a second downturn. These second wave scenarios are our most bearish in terms of GDP impact and result in a -6% to -7% impact to 2020 GDP. Because the "Winter Second Wave" scenario's impact extends deeper into next year and involves a later vaccine timing, we see a much slower return to growth in 2021 for this case (0% growth in 2021 versus 4% growth in 2021 for the earlier "Fall Second Wave" scenario).

Over time we continue to track how our model performs against actual economic data as well as analyst forecasts, and at the moment our scenarios are in line with the consensus. We have also benchmarked our model output against the released Q1 GDP Second Estimate[6] resulting in < 0.3% difference.

[6] Bureau of Economic Analysis

Although we present U.S. data in this paper, we have expanded this work to a global model that covers about 75% of global GDP. This has also enabled us to further calibrate the model across countries. We have also been getting feedback from policymakers and non-governmental organizations (NGO's). We plan to refine this work in several ways:

- **Regional views:** For the U.S. we plan to add a view by state; for the U.K. we plan to add regions.
- **Industry-specific reopening:** Given much of the conversation has shifted toward opening the economy, we are adding the capability to specify a reopening timeline specific to each industry.
- **Indirect / spillover effects:** We plan to add the impact of spillover effects across industries to account for the fact that the output of some industries provides the input for others. This will ensure we are properly modeling supply-side effects (e.g., supply chain disruptions).
- **Covering low- and middle-income countries:** We are discussing a LMIC view with NGO's (which may require additional model changes given their structural differences).
- **Long-term scarring:** Although we have modeled variable recovery driven by factors such as bankruptcy risk and long-term unemployment by industry, our current model does not incorporate structural "scarring" or the long-term shifts in growth trajectory for certain industries, which we plan to incorporate in the future.

Policymakers are not merely in the business of predicting GDP, but also help to shape it. In the rest of this paper we outline an overall framework and a data-driven approach on how to think through the recovery decisions that minimize GDP impact.

3. SOCIAL CONTACT AS THE NEW SCARCE RESOURCE

Our modeling of the impact to GDP from various intervention scenarios shows that preventing a second wave of infections has benefits for both public health and the economy. As such, there will be a continued need to manage the spread of COVID-19 until a vaccine has become broadly available or herd immunity has been built. Until then, policymakers face the difficult task of determining how and when portions of the economy can be opened in such a way that reduces the risk of a second wave of infections.

As this pandemic has highlighted, containing the spread of the infectious disease required trade-offs in the form of reduced economic activity. However, economic activity and the disease transmission rate "R" are not directly linked. They are both driven by a third factor that we never consider under "normal" circumstances: social contact.

Without the threat of a pandemic, social contact has essentially no cost (in fact, it is usually seen as a positive), and therefore we have had little reason to limit it. However, the emergence of COVID-19 has suddenly put a high cost on social contact in the form of higher rates of disease transmission. Because social contact does not have a "price" that would allow the market to find an efficient equilibrium between economic activity and disease transmission, reducing social contact relies on government intervention and/or self-initiated behavior changes. In economics this is referred to as a negative externality, a (negative) byproduct of economic activity not accounted for in its cost.[7]

To control the spread of infections and limit the negative impact of social contact, governments have enacted a variety of restrictions on businesses and individuals. In the upper part of Figure 7, we chart the impact of these restrictions and self-imposed behavior change on social contact (as measured by Google

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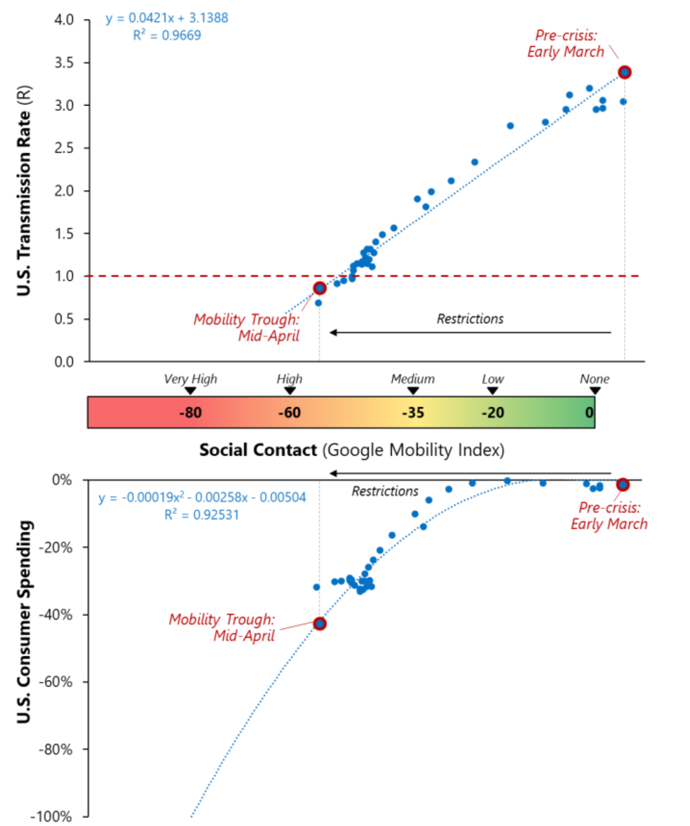
[7] This is very similar to pollution, which also has no inherent price. To reduce pollution, some governments have imposed artificial prices that attempt to reflect the cost of its negative externalities.

mobility data as a proxy) and transmission (as measured by R)[8] over the initial containment period of the crisis (early March to the trough of U.S. mobility in mid-April). As the data show, transmission rate has declined as social contact has been reduced. This relationship remains directionally consistent regardless of which estimates of R used and we have provided alternative estimates of R in the appendix.[9]

Because social contact is also a critical component of the economy, these restrictions have also led to a reduction in economic activity (as measured by Consumer Spending[10] in the lower part of Fig. 7). As we will discuss later, the relationship between social contact and economic activity varies by activity/industry. For example, closing bars leads to greater social contact reduction compared with its economic contribution than closing manufacturing.

As the focus of policy discussions shifts to recovery, managing social contact is the key lever that governments can use to maintain a balance between transmission rates and economic activity. Therefore, the goal of recovery policy is threefold:

FIGURE 7: Social Contact Restrictions (U.S.)



Source: Google, Imperial College London, Opportunity Insights, Microsoft Analysis

1. Determining a "Social Contact Budget" based on assessment of current level of containment and R-Values
2. Determining the most efficient way to spend that Social Contact Budget by prioritizing areas of the economy to reopen that yield the highest value or "Return on Social Contact"
3. Identifying opportunities to increase our budget by weakening the link between social contact and disease transmission (i.e., reducing the cost of social contact).

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[8] *Report 23: State-level tracking of COVID-19 in the United States, Samir Bhatt, et al*

[9] *R-values are both difficult to accurately estimate (especially in real time) and can vary significantly even within a country or state (e.g., urban versus rural areas). Because of this, estimates of R-values for a given area can vary significantly which makes it challenging to confidently define a Social Contact Budget that ensures R will remain below 1. This requires policymakers to take a conservative approach toward reopening (discussed further in section 6.2). We have provided alternative views of U.S. R-value in the Recovery Policy Appendix (Fig. 20-22).*

[10] *Opportunity Insights Economic Tracker*

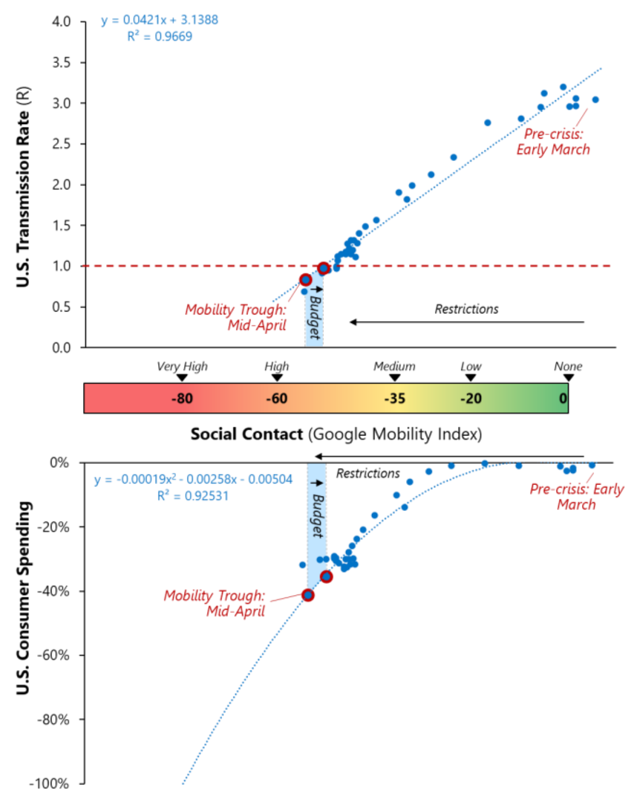
4. DETERMINING THE SOCIAL CONTACT BUDGET

With infections growing exponentially in the earlier stages of the pandemic, governments initially focused exclusively on reducing the rate of disease transmission by implementing a variety of restrictions that reduced social contact. The goal of these interventions was to reduce the transmission rate (R) below 1, so that the number of new cases would drop. These interventions have been largely successful with significant reduction in R-values across almost all geographies leading to select countries and U.S. states now seeing R-values <1.

This focus on reducing transmission rates has had a devasting effect on economic activity as discussed in Section 2. As countries and U.S. states see R-values below 1, it creates an opportunity to relax some of the restrictions on social contact to limit economic damage.

Relaxing these restrictions must be done in a way that maintains the transmission rate below 1 to prevent the risk of a second wave of the pandemic (which, besides the big health implications, would also be more damaging economically). For these areas, the amount of social contact can be increased from current levels up to the point where the transmission rate approaches 1, thus forming our Social Contact Budget as seen in the upper part of Figure 8. This budget in turn can be used to reopen portions of the economy and recover some economic activity as seen in the lower part of Figure 8.

FIGURE 8: Social Contact Budget (U.S.)



Source: Google, Imperial College London, Opportunity Insights, Microsoft Analysis

In the next section we will discuss how to best spend this Social Contact Budget.

5. SPENDING SOCIAL CONTACT BUDGET

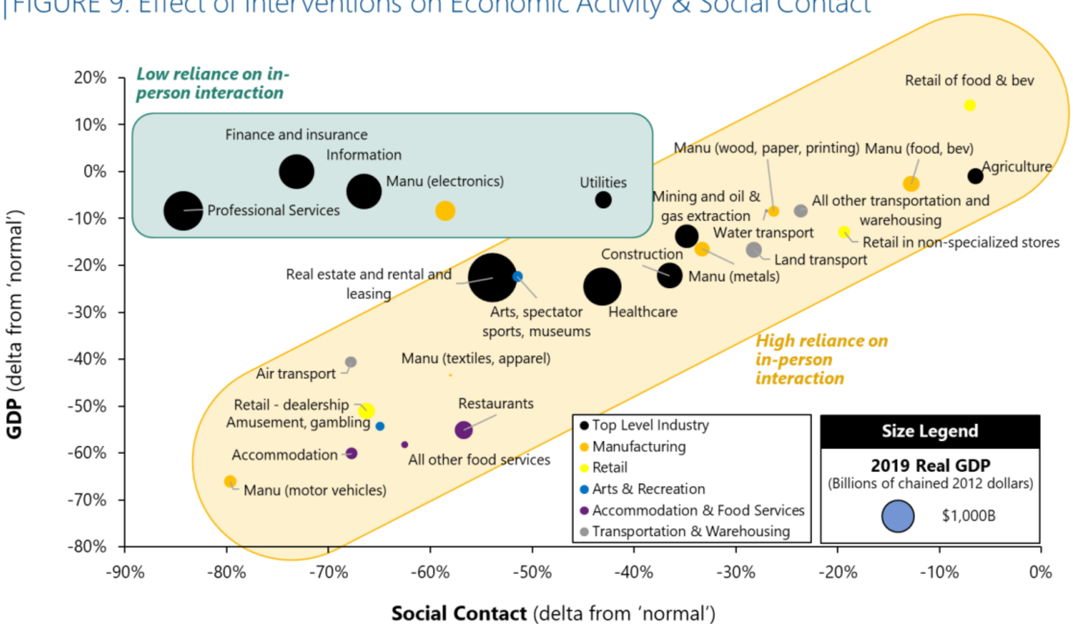
The Social Contact Budget provides an opportunity to increase economic activity while limiting the risk of a resurgence in COVID-19 infections. The challenge, however, is to spend this budget in a way that yields the highest benefit to society. In other words, identifying the portions of the economy to reopen that provide the best trade-off between increased social contact and increased economic activity. Several proxies for economic activity can be taken such as GDP, employment, and bankruptcy risk, depending on policy objectives. We will first use GDP as the objective function.

5.1 Maximizing GDP

To determine the best actions to take to maximize GDP, we first need to identify the industries most dependent on in-person interactions to conduct business. Although some industries (e.g., retail, accommodation & food services)[11] rely heavily on social contact to conduct business, others (e.g., professional services, information tech) can largely operate remotely. Figure 9 maps both classes of industries. The vertical axis shows the projected reduction in GDP for each industry given the peak of U.S. mobility reduction, based on our economic impact model described in Section 2.

The horizontal axis shows the estimated reduction in social contact for each industry under this same level of lockdown. Because the Google Mobility data we used previously does not provide sufficient industry granularity, we have estimated this by first reducing social contact by the proportion of employees that can work remotely[12] (e.g., if 20% of the workforce in an industry can work remotely we reduced social contact by 20 percentage points from "normal") and then further reducing social contact proportional to the amount GDP has declined (e.g., if GDP declined 5 percentage points from "normal," we reduced social contact by an additional 5 percentage points).[13] The industries in the yellow portion of the chart represent what you would generally expect: Reduction in social contact leads to reduction in GDP. The industries in the green portion represent industries that have been able to reduce social contact with far less impact on GDP due to better ability to rely on remote work.

FIGURE 9: Effect of Interventions on Economic Activity & Social Contact



Note: Industries listed are not exhaustive
Source: Microsoft Analysis, Bureau of Economic Analysis, U.S. Bureau of Labor Statistics, "How Many Jobs Can be Done at Home" by Jonathan I. Dingel and Brent Neiman

To further illustrate this point, it is helpful to zoom in on a representative industry from each category in Figure 9: Green — professional services and Yellow — retail in nonspecialized stores (e.g., department stores). Figure 10 shows that by going virtual, professional services has been able to maintain a large portion of its economic value (8% reduction from normal) while reducing social contact significantly (84% reduction from normal). Retail in nonspecialized stores on the other hand has seen a similar drop in GDP

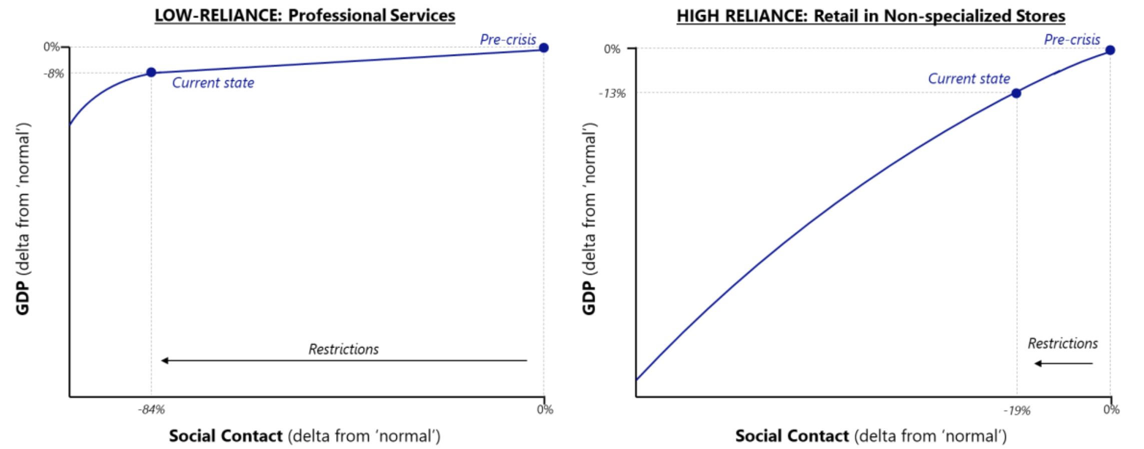
[11] *Mentions of 'Food Services' refer to restaurants, bars, and other eating establishments but not grocery*

[12] *"How many jobs can be done from home," Jonathan I. Dingel and Brent Neiman*

[13] *This approach implicitly relies on the following assumptions: 1) that 100% of those who can work remotely are doing so, 2) that the transition to remote work has no direct impact on GDP contribution of the industry, and 3) that reductions in GDP occur proportionally with additional reductions in social contact beyond remote work*

compared with professional services (13% reduction from normal), but a much more moderate drop in social contact (19% reduction from normal) as brick and mortar retail requires a relatively high level of

FIGURE 10: Impact of Interventions on Professional Services & Retail in Non-Specialized Stores



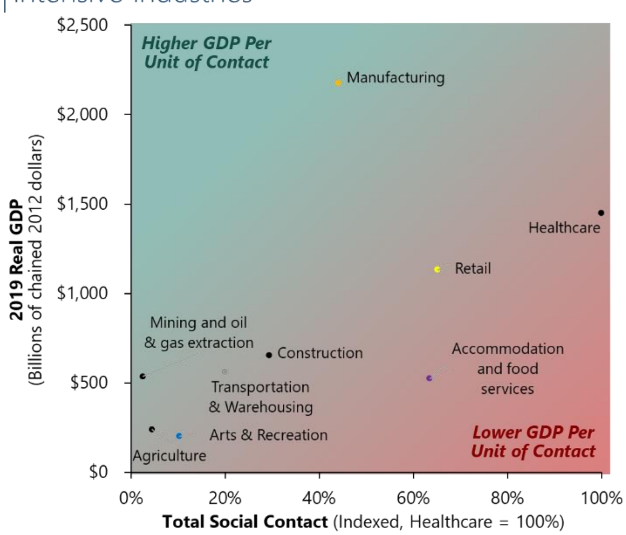
Note: "Professional Services" includes professional, scientific, and technical services
Source: Microsoft Analysis, U.S. Bureau of Labor Statistics, "How Many Jobs Can be Done at Home" by Jonathan I. Dingel and Brent Neiman

social interactions to be maintained.[14]

As a result, recovery policies should primarily target industries for which in-person interactions are critical, because increasing social contact in these industries will most directly lead to greater GDP (i.e., the relationship between GDP and Social Contact has a steeper slope in Fig. 10). However, within this group of industries we can further prioritize by looking at which industries yield the highest GDP per unit of social contact (i.e., a high 'return on social contact').

This is shown with real data in Figure 11. The vertical axis shows total GDP contribution[15] for each industry. The horizontal axis shows Total Social Contact for each industry, which represents the level of physical proximity driven by a given industry. We calculated Total Social Contact based on survey data that indicates the level of physical proximity required of workers to perform work tasks by job, which then we mapped to our industry taxonomy and weighted by employment.[16] Industries in the top left/green zone represent better Return on Social Contact than industries in the bottom right. For example,

FIGURE 11: Social Contact vs. GDP for Contact-Intensive Industries



Note: Industries listed are not exhaustive
Source: Microsoft Analysis, O*NET, Bureau of Economic Analysis, U.S. Bureau of Labor Statistics

[14] *We have used estimates of social contact reduction based on University of Chicago data rather than Google Mobility data here due to the lack of industry granularity. We assume employees who can work from home will do so.*

[15] *U.S. Bureau of Economic Analysis*

[16] *O*Net Survey Data, U.S. Department of Labor, Employment and Training Administration, U.S. Bureau of Labor Statistics*

reopening industries such as manufacturing will produce significantly more GDP for our contact budget than would reopening accommodation & food services (healthcare while "inefficient" on this metric is obviously critical for public health).

It is also important to note that the relationship between social contact and GDP may evolve over time. Many industries are already adapting to increase the portion of their business processes that can be done from home (more on this in section 6.2). Furthermore, reopening does not necessarily have to be a binary decision and we may find optimal outcomes that involve partial reopening (e.g., opening restaurants at reduced capacity) that strike a good balance between minimizing social contact while enabling economic activity.

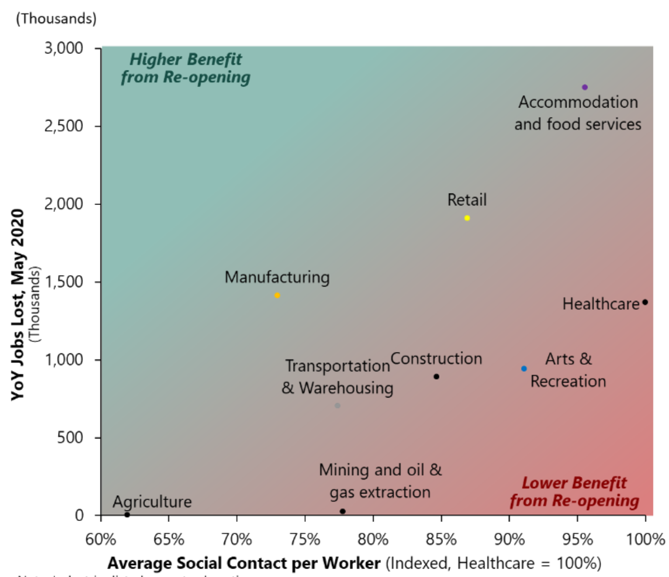
5.2 Additional Recovery Objectives

So far, we have looked at this from a "maximizing GDP" perspective. As we highlighted, this approach can also be taken for other economic objectives such as maximizing employment or preventing widespread bankruptcies. Both are also typically associated with more long-term economic "scarring." Here we will present a data-driven view on unemployment.

Although this objective would still mean prioritizing industries heavily dependent on in-person interactions, it would emphasize relaxing interventions for sectors hardest hit from an unemployment perspective instead of those with the greatest GDP contribution. Because many businesses in these sectors were closed entirely, allowing them to reopen even in a limited capacity allows many employees to return to work.

Figure 12 represents a data-driven view on this form of Return on Social Contact. This chart is similar to Figure 11, except that this shows a "maximizing employment" lens. The vertical axis represents change in unemployment between May 2019 and May 2020[17], and the horizontal axis represents average social contact per worker (i.e., not weighted by employment). We see some key differences relative to the GDP view in Figure 11, with industries like accommodation & food services as well as retail moving toward the "green." Although the level of social contact remains high for these industries, the value of reopening has increased significantly when viewed from an employment lens given the high number of jobs lost in those industries. We also see that Manufacturing scores high from an employment view as well as a GDP view.

FIGURE 12: Social Contact vs. Jobs Lost for Contact-Intensive Industries



Note: Industries listed are not exhaustive
Source: Microsoft Analysis; O*NET, U.S. Bureau of Economic Analysis, U.S. Bureau of Labor Statistics

Although the steps above provide a way of prioritizing which portions of the economy to reopen first to maximize economic benefit, it may also be important to spend a portion of the Social Contact Budget on noneconomic activities that improve quality of life. Activities such as exercise and participating in social gatherings may not have a clear economic benefit

[17] *U.S. Bureau of Labor Statistics*

but can contribute significantly to people's well-being. Although these could be thought of as an "indulgence" better spent on reopening more of the economy, allowing some leisure activities will in turn make adherence to the other/future restrictions more bearable and ultimately more sustainable. Just as with economic activities, these leisure activities should be prioritized based on the degree to which they increase quality of life relative to increasing social contact.

6. INCREASING SOCIAL CONTACT BUDGET

In addition to spending the existing Social Contact Budget in the most effective way, there are also opportunities to increase this budget over time.

6.1 Increasing Social Contact Budget

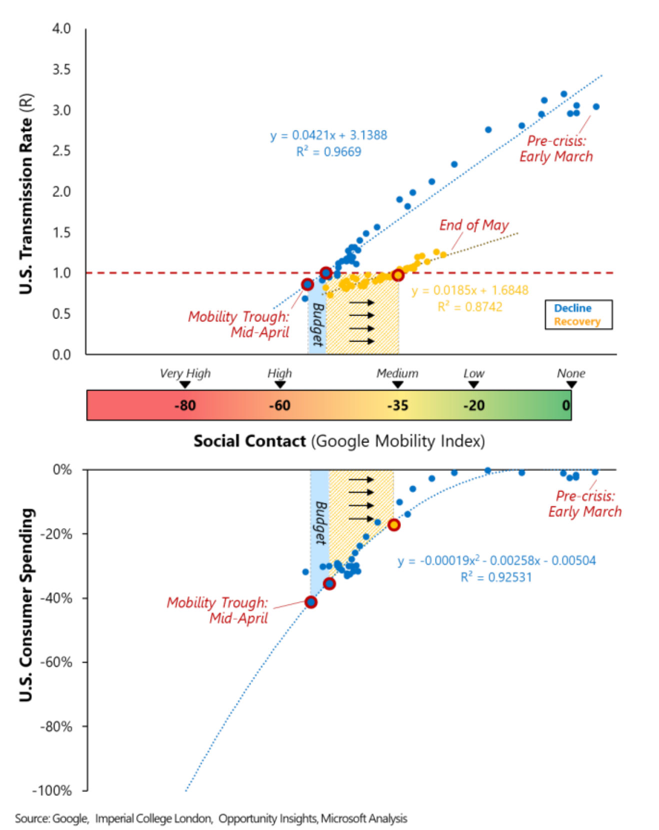
Although most of the interventions thus far have focused on reducing the transmission rate via reductions in social contact (i.e., moving along the curve), we can also reduce transmission rates for any given level of contact by weakening the relationship between social contact and the Transmission Rate (R) and thus shifting the curve down.

The most effective means for achieving this is by identifying and quarantining infected individuals so that social contact only happens between healthy people. This will require the continued expansion of testing and the introduction of more contact tracing capacity.

Of course, it is unlikely, at least in the U.S. and Western Europe, that testing and tracing will be accurate and ubiquitous enough to identify every infected person. This is especially true for COVID-19, given the high proportion of asymptomatic or mildly symptomatic cases. Accounting for this will require the widespread use of physical barriers (e.g., plexiglass between cashiers) as well as behavior change as an additional line of defense to ensure that even if infected individuals are not properly identified, the spread of infection is still reduced.

Looking at some of the early recovery data coming out of the US, we can see the relationship between mobility and R values has already begun to evolve. The top part of Fig. 13 shows a similar view as Fig. 8, but adds additional data in orange for the last ~6 weeks to show what has happened as mobility has gradually recovered.

FIGURE 13: Increasing Our Budget (U.S.)



In this data we can see that for a given level of mobility, the transmission rate is significantly lower during recovery (orange dots) relative to the initial drop in mobility (blue dots). This shift suggests that some of the behavioral changes (e.g., 6 feet rule) and additional preventative measures businesses are taking (e.g., wiping down shopping carts) have already started to have an effect. The end result is an increase in our social contact budget out to the yellow dot outlined in red which in turn allows us to open up a greater portion of the economy (bottom half of Fig. 13).

As an additional benefit, weakening the link between social contact and transmission rate can also help reduce the fear and anxiety that the pandemic has created. This is critically important, because reopening portions of the economy is only possible and effective if people feel safe enough to actually return to work (increase supply) and engage in in-person purchases (increase demand).

We may also see the relationship between social contact and consumer spending evolve similar to what we see with Transmission Rate. For example, unemployment or reduced income during the pandemic could lead to decreased purchasing power and drive down spend per trip. Conversely factors like pent-up demand could increase spend per trip during initial reopening. So far, early data suggests recovery in spending may be slower for a given change in social contact than in the initial drop, but further work is needed to build confidence in this shift.[18] We will update our perspective on this dimension as more data becomes available.

6.2 The Importance of a Conservative Approach

Although this recovery policy framework provides a systematic way of prioritizing areas of the economy to reopen, it is important to emphasize the need for a conservative approach toward recovery. There are several reasons for this. First, because R-values are inherently difficult to measure in real time and the relationship between social contact and R-values can vary over time (e.g., weather may affect disease transmission rates), it is challenging to define a precise amount that social contact can be increased without R becoming >1. Second, the amount that social contact that will be increased by loosening certain restrictions will depend on people's level of fear about the virus, which will likely decrease over time. Third, adherence to existing restrictions may decrease over time (e.g., people are more likely to leave their houses as the weather improves), which will increase social contact even with no change in official policy.

We can already see several of these forces at play in Figure 13, which suggests the U.S. was near or has already breached the R-value threshold of 1 towards the end of May. This implies that we may have already exhausted the social contact budget freed up with our initial efforts from early March to the mobility trough in mid-April. It is important to note that this is an early trend and there is significant variance and uncertainty in R value estimates. As such we will continue to track the latest studies to see whether this pattern holds. For now, this signal only reinforces the importance of taking a conservative approach to ensure a clear, consistent progression of reopening (and utilizing the feedback from early steps to inform additional actions).

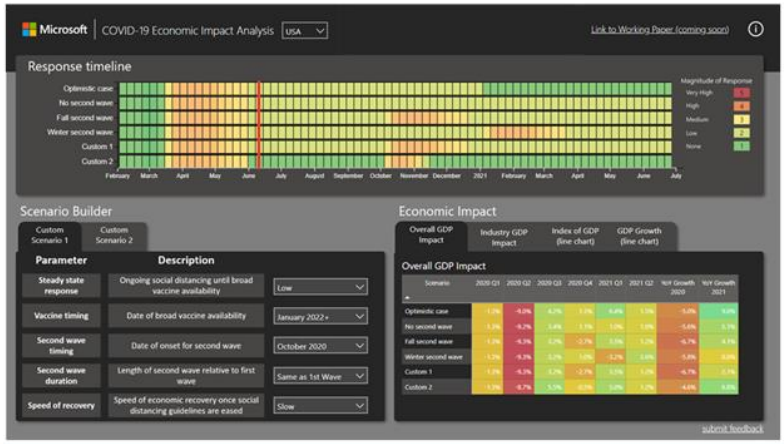
[18] *Data towards the end of May suggests that the relationship between social contact and consumer spending may also be evolving towards a shallower slope for recovery than the initial decline. This implies that as more of the economy opens up, consumer spending will recover more slowly than it declined. We have provided a preliminary view in the Appendix, but we feel that more data and analysis is needed to confirm this early trend.*

Microsoft

7. CONCLUSION

The path of the pandemic will influence both the government strategies and people's behavioral changes, which in turn will determine macroeconomic impact. We built a model that calculates GDP impact for 2020 and 2021. We configured four scenarios which indicate a 2020 GDP impact from -5% to -7%, depending on the presence of a second wave, steady state social distancing, and speed of recovery. We also built a [Power BI Dashboard](https://aka.ms/covid-economicimpact) (which can be found at: https://aka.ms/covid-economicimpact) that enables users to configure any custom scenario and see resulting GDP impact (Fig. 14)[19].

FIGURE 14: GDP Impact Power BI Dashboard



Policymakers will be focused on shaping GDP. At this stage we will have to keep managing the curve until a vaccine has been developed or herd immunity has been built. Until then, we have to carefully manage social contact so that we maximize economic recovery while mitigating risks of additional waves. This will involve three key steps:

1. Assessing how much room or Social Contact Budget we have
2. Determining the most efficient way to spend that Social Contact Budget by prioritizing areas of the economy to reopen that yield the highest value or return on Social Contact
3. Increasing our Social Contact Budget through measures such as contact tracing and massive testing, thus reducing the likelihood that social contact leads to an increase in R

Our model is highly flexible, and we are ingesting new economic data, R-values, and mobility data continuously as it is released. We are also expanding the work in several directions based on feedback (e.g., state-level views, low- to middle-income countries).

[19] *Data in dashboard screenshot is illustrative*

8. APPENDIX: ECONOMIC IMPACT MODEL

The economic damage inflicted by the combined supply-and-demand-side shocks hitting the economy will depend significantly on the duration and severity of the COVID-19 pandemic. In this appendix we provide additional detail on the economic model.

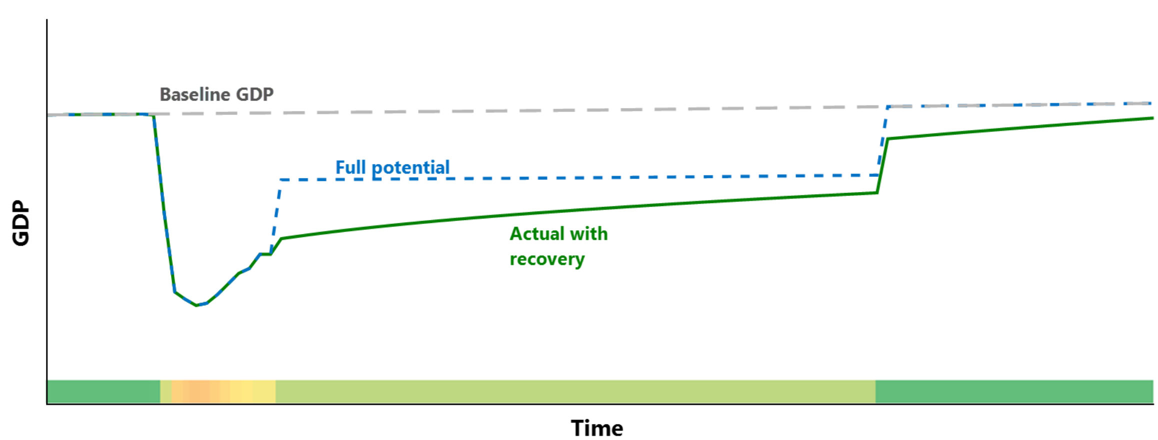
8.1 Approach to Economic Recovery and Industry Scarring

The combination of 1) magnitude of response informed by mobility data, 2) industry susceptibility, and 3) the response timeline scenarios are the key inputs to forecasting the initial drop in GDP. In the model we assume that the drop in GDP from these factors occurs immediately as mobility data declines due to government lockdown and changes in people's behavior (left-hand side of Fig. 15).

However, as measures are lifted, and people's behavior begins to return to normal, it is unreasonable to assume industries will snap back immediately. To account for this behavior, we take a different approach to modeling recovery once mobility data bottoms out by flipping the model into "recovery mode."

In recovery mode, mobility data is used to dictate the recovery curve used for periods where we have historical data (i.e., April 12th to May 23rd). Thus as mobility slowly recovers, so does the economy. For the remainder of recovery (i.e., May 24th onwards) the model calculates GDP in every period based on the three factors above to estimate the "full potential" of the economy in that period (blue dashed line in Fig. 15). "Full potential" remains below 100% until a vaccine is broadly available because of factors such as reduced capacity limits and suppressed consumer confidence. This full potential estimate doesn't flow straight through to our forecast output (green line in Fig. 15). Rather, we assume only a portion of full potential is achieved. Over time as the recovery progresses, that portion of full potential grows to reach 100%, at which point full potential GDP = actual GDP forecast for that period. The right-hand side of Figure 15 illustrates this with the green line (actual forecast) converging with the blue dotted line (full potential) over time as the recovery reaches maturity.

FIGURE 15: Example Forecast with Recovery Ramp (Illustrative)



We also recognize that not all industries will recover at the same speed and that some industries may go through economic scarring (e.g., widespread bankruptcies), which slows their recovery. To incorporate variation in speed of recovery by industry, we examined both industry performance in prior recessions and COVID-specific factors impacting recovery and assigned industries to one of three recovery speeds. Specifically, we looked at bankruptcy risk, early signal from China's recovery, level of unemployment, and share of unemployment that is temporary versus long term. Our findings are summarized in Figure 16.

FIGURE 16: Impact of Scarring on Industry Recovery

Industry	Nature of Recovery	COVID-Specific Factors				General Factors
		Bankruptcy Risk	Early Signal from China Recovery	Overall Unemployment	Permanent Unemployment	Performance in Prior Recessions
Healthcare	Faster	Low	n/a	Low	Low	Medium
Finance and insurance	Faster	Medium	n/a	Low	Low	Medium
Education	Faster	Medium	n/a	Low	Low	Medium
Utilities	Faster	Low	Faster	Low	Medium	Medium
Information	Faster	Low	n/a	Medium	Medium	Medium
Professional services	Faster	Medium	n/a	Medium	Medium	Faster
Real estate and rental and leasing	Medium	Medium	Faster	Medium	Medium	Faster
Agriculture	Medium	Medium	n/a	Low	Medium	Slower
Manufacturing	Medium	Medium	Medium	Medium	Medium	Medium
Construction	Medium	Medium	Medium	Medium	Medium	Slower
Mining	Medium	Medium	n/a	Medium	High	Medium
Arts & recreation	Slower	Medium	Slower	High	Medium	Faster
Retail and wholesale trade	Slower	Medium	n/a	Medium	Medium	Slower
Transportation and warehousing	Slower	High	Slower	Medium	Medium	Medium
Accommodation and food services	Slower	High	Slower	High	Medium	Slower

Sources: UK Office of National Statistics, Goldman Sachs Investment Research, National Bureau of Statistics China, U.S. Bureau of Labor Statistics, U.S. Bureau of Economic Analysis, Microsoft Analysis

It is important to note that here we do not yet model any structural changes to the economy after COVID-19. It is already becoming clear that there will be a structural acceleration toward virtualizing many parts of the economy (e.g., meetings, doctors' appointments, parties, shopping). We have separate work underway on this topic but do not model it here.

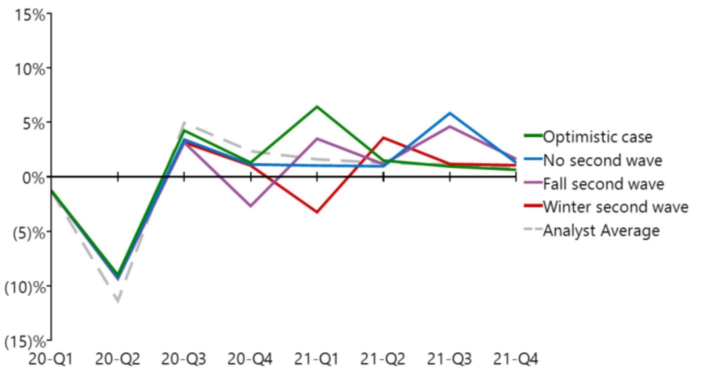
8.2 GDP Forecast

Multiplying the GDP value added by industry and the economic impact under varying levels of response over time produces our forecast of U.S. Real GDP growth quarter-over-quarter (Fig. 17).

The second wave scenarios are real possibilities if we look back at history: the Spanish Flu, which had its main spike in cases in 1918 followed by a deadly second wave in 1919. Figure 18 shows real GDP growth in the U.K. over this period, and we can see the impact of the initial onset of the virus, a brief period of recovery, followed by another period of more aggressive GDP contraction ("W-shaped recession").

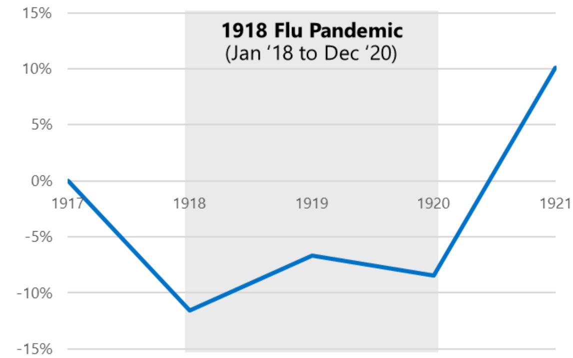
Finally, to translate these changes in GDP growth into a cumulative impact, we also looked at how U.S. GDP by quarter is affected in each scenario relative to a pre-crisis baseline (Fig. 19). This shows a large peak-to-trough drop of ~10% with a return to pre-COVID baseline between Q1'21 to beyond Q4'21, depending on the scenario.

FIGURE 17: Forecast US Real GDP Growth (Q/Q%)



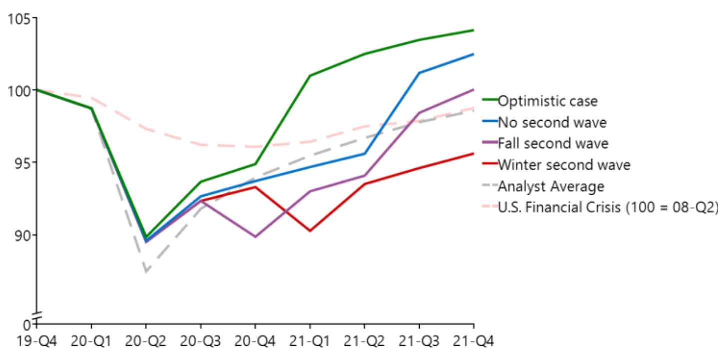
Analyst average is average of 7 forecasts from Morgan Stanley (5/29/20), JPMorgan (5/29/20), Conference Board (6/10/20), Deutsche Bank (5/5/20), Goldman Sachs (6/7/20), UBS (6/5/20), and OECD (6/10/20)

FIGURE 18: UK Real GDP Growth During 1918 Flu



Source: The Maddison Project (2018)

FIGURE 19: Index of U.S. Real GDP by Scenario (4Q19=100)

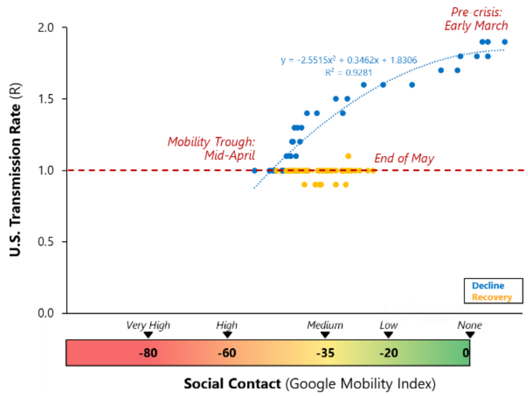


Analyst average is average of 7 forecasts from Morgan Stanley (5/29/20), JPMorgan (5/29/20), Conference Board (6/10/20), Deutsche Bank (5/5/20), Goldman Sachs (6/7/20), UBS (6/5/20), and OECD (6/10/20)

9. APPENDIX: RECOVERY POLICY

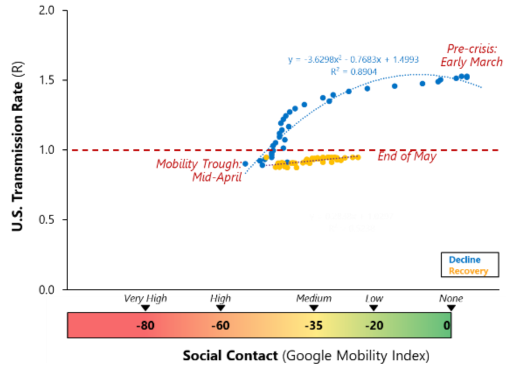
9.1 Alternative Views for R Values[20]

FIGURE 20: U.S. Transmission Rate (EpiForecasts)



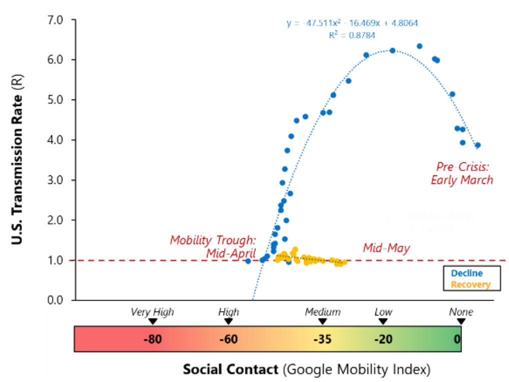
Note: Decline & Recovery periods loosely based on when mobility & R value trends start to shift directions, and do not tie to specific re-opening policies
Source: Google, EpiForecasts, Microsoft Analysis

FIGURE 21: U.S. Transmission Rate (Rt.live)



Note: Decline & Recovery periods loosely based on when mobility & R value trends start to shift directions, and do not tie to specific re-opening policies
Source: Google, Rt.live, Microsoft Analysis

FIGURE 22: U.S. Transmission Rate (CHOP)

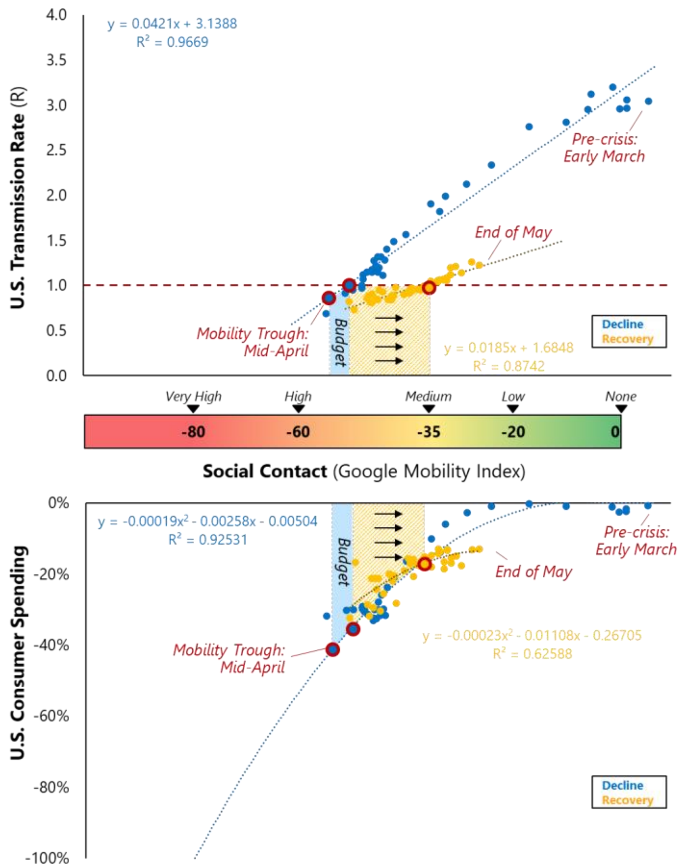


Note: Decline & Recovery periods loosely based on when mobility & R value trends start to shift directions, and do not tie to specific re-opening policies
Source: Google, Children's Hospital of Philadelphia PolicyLab, Microsoft Analysis

[20] *EpiForecasts License, Children's Hospital of Philadelphia, PolicyLab. Available at: http://www.policylab.chop.edu. [Accessed: May 20, 2020], Rt. Live, Google LLC "Google COVID-19 Community Mobility Reports"*

9.2 Consumer Spending Recovery Curve (Preliminary)

FIGURE 23: Increasing Our Budget (U.S.)



Source: Google, Imperial College London, Opportunity Insights, Microsoft Analysis